2012

Topological Theory in Bioconstructivism

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In the essay "Landscapes of Change: Boccioni's Stati d'animo as a General Theory of Models," in Assemblage 19, 1992, Sanford Kwinter proposed a number of theoretical models which could be applied to computer-generated forms in Bioconstructivism. These included topological theory, epigenesis, the epigenetic landscape, morphogenesis, catastrophe and catastrophe theory. Topological theory entails transformational events or deformations in nature which introduce discontinuities into the evolution of a system. Epigenesis entails the generation of smooth landscapes, in waves or the surface of the earth, for example, formed by complex underlying topological interactions. The epigenetic landscape is the smooth forms of relief which are the products of the underlying complex networks of interactions. Morphogenesis describes the structural changes occurring during the development of an organism, wherein forms are seen as discontinuities in a system, as moments of structural instability rather than stability. A catastrophe is a morphogenesis, a jump in a system resulting in a discontinuity. Catastrophe theory is a topological theory describing the discontinuities in the evolution of a system in nature. A project which applies these models, and which helps to establish a theoretical basis for Bioconstructivism by applying topological models, is a design for a theater by Amy Lewis in a Graduate Architecture Design Studio directed by Associate Professor Andrew Thurlow at Roger Williams University, in Spring 2011. In the project, moments of structural stability are juxtaposed with moments of structural instability, to represent the contradiction inherent in self-generation or immanence. The singularity of the surfaces of the forms in the epigenetic landscape contradicts the complex network of interactions of topological forces from which they result. Actions in the environment on unstable, unstructured forms, and undifferentiated structures, result in stable, structured forms, and differentiated structures.

Bioconstructivism involves the engagement in architecture of generative models from nature. This is in the tradition of *natura naturans* in architecture, which is the imitation of the forming principles of nature, as opposed to *natura naturata*, the direct imitation or mimesis of the forms. According to Plotinus in the *Enneads*, it is the purpose of all the arts to not just present a "bare reproduction of the thing seen," the *natura naturata*, but to "go back to the Ideas from which Nature itself derives" (V.8.1),[1] in the *natura naturans*. The contrast between *natura naturans* and *natura naturata* was explored in the writings of Johann Winckelmann, Francesco Algarotti, and Quatremère de Quincy in the eighteenth century. In

Winckelmann's *Histoire de l'art chez les anciens* (1801), architecture is more "ideal" than the other arts because it does not imitate objects in nature; its forms are rather derived from the rules and laws of proportion, which are abstract concepts. In Algarotti's *Saggio sopra l'architettura* (1784), architecture "must raise itself up with intellect and must derive a system of imitation from ideas about things that are the most universal and farthest from what can be seen…"[2]

In the *Encyclopédie méthodique* (1788) of Quatremère de Quincy, architecture is described as more ideal, more intellectual, and more metaphysical than the other arts, because architecture must transpose the qualities of the forms of nature into its own forms, and it must imitate the "spirit" of the forms of nature, in the universal idea, rather than a particular form (1:495). Architecture imitates natural forms analogically, or metaphorically, rather than literally. As Quatremère describes, architecture imitates the ideas from which nature derives rather than natural forms as given by sense perception. The perfect model for this type of imitation in abstraction was the primitive hut of Marc Antoine Laugier, described in the *Essai sur l'architecture* (1775). While the cave is a model for architecture in the imitation of the forms of nature, and the tent is a model for architecture in the construction of forms disconnected from nature, the primitive hut is the perfect model for architecture in the construction of forms in the imitation of the principles of nature. In *De l'architecture égyptienne*, Quatremère described the primitive hut as the product of the perfection in the human intellect of the forming principles of nature, and it was that perfection which made the architecture of Classical Greece possible.

While Laugier saw the primitive hut as a purely natural model, Quatremère argued, in *Encyclopédie méthodique* (1:454), that the primitive hut was already an abstraction in human intellect, derived from the principles of nature. While for Laugier the primitive hut was a model that could be directly reproduced in architecture, for Quatremère it could only be indirectly reproduced, as the wood of the hut would have to be transformed into the stone and marble of Greek buildings, for example. According to Quatremère, Classical Greek architecture was based on an underlying conceptual organization of abstracted forms and principles from nature.

An important element of Bioconstructivism is autopoiesis or self-generation, taking advantage of digital modeling and computer programs to imitate the capacity for organisms in nature to organize themselves, or for unorganized or fluid material to consolidate itself, based on the inner active principle of the organism, an "essential force" or "formative drive" which contradicts the mechanistic theories of Galileo, Descartes and Newton. The monad of Leibniz, for example, can self-generate in "integrals" from pre-existing sets of variables, resulting in "continuous multiplicity." Detlef Mertins, in "Bioconstructivisms," contrasted self-generation to predetermination, which is associated with the metaphysical and transcendental, in contrast to the immanent. Predetermination in architecture involves

references to history, or "historical styles, which were understood as residual transcendent authorities on longer commensurate to the present…" (362).[3] This kind of stylistic reductionism and materialism needs to be avoided in architecture. Self-generation needs to be combined with predetermination, and the metaphysical needs to be combined with the immanent. As Mertins himself said, quoting Helmut Müller-Sievers, "Only if they are self-produced can the categories guarantee transcendental apriority and, by implication, cognitive necessity and universality" (361) (Figure 1).

In the essay "Landscapes of Change: Boccioni's *Stati d'animo* as a General Theory of Models," in *Assemblage* 19, 1992, Sanford Kwinter proposed a number of theoretical models which could be applied to the generation of forms in Bioconstructivism. These included topology theory, epigenesis, the epigenetic landscape, morphogenesis, catastrophe and catastrophe theory. In contrast to the calculus of Newton and Leibniz, where trajectories of bodies are plotted against an immobile space the coordinates of which are described in numerical terms such as x and y, topology describes transformational events or deformations that result in discontinuities in the evolution of a system. Topological mapping is not determined by the gridded quantification of a substrate space, but rather by singularities, occurrences of self-generation or immanence, in the flow of space of which the mapping is a part. The simplistic singularities of flows on a plane are combined to create complex and variegated forms. Attractors and separatrices create topological formations, as in the epigenetic landscape. The Aristotelian concept of epigenesis was revived in Conrad Waddington's *Strategy of the Genes* in 1957, as a biological metaphor for cell reproduction, and in Helmut Müller-Sievers *Self-Generation* in 1997. Epigenesis entails the generation of smooth landscapes, in waves or the surface of the earth, for example, formed by complex underlying topological interactions. The epigenetic landscape is the smooth forms of relief which are the products of the underlying complex networks of interactions. It displays the relation between phenotypes or phenomenal forms and the morphogenetic fields in which their formation takes place. The multiplicities of the valleys in the landscape correspond to the possible trajectories of bodies, or the shapes formed, as in the continuous multiplicities of the monads of Leibniz (Figure 2).

Form evolves along a pathway through the surface differentiations, represented by the potential trajectory of a ball along the surface. The path of the ball is subject to external forces, so the evolution of the form is not predetermined. The modulations of the epigenetic landscape create default scenarios that frame the evolution of the form, which is only virtual, as the product of the complex convergences of vectors or forces. Through time, the form evolves as a singularity which corresponds to a phenomenal force in the real world. Forms and forces in the real world do not "exist" as such but are rather actualized or unfolded in time as morphological events or differentiations. A phenomenal form or force is an interruption of the continuous flux of possibilities, a disturbance of a continuum. In

morphogenesis, all forms are seen as discontinuities in a system. Morphogenesis describes the structural changes occurring during the development of an organism, wherein forms are seen as moments of systematic instability rather than stability. Morphogenesis refers to the biological process that causes an organism to develop its shape. A catastrophe is a morphogenesis, a jump in a system resulting in a discontinuity. Catastrophe theory is a topology theory describing the discontinuities in the evolution of a system in nature. A dynamical system is composed of a distribution of differences or potentials. Potentials operate along vectors in vector fields. For example, a book falls from a shelf to the floor, caused by gravity, along a vector in a vector field defined by attractors, the shelf and the floor. The catastrophe is the mutation of a system to a different level of organization, for example the replacement of the shelf by the floor as the attractor. The momentary stability of the book on the shelf, amidst the flux of vectors and attractors, can be seen as a form.

A form is a structurally stable moment in the evolution of a dynamic system, at the point of its passing to a structurally instable moment. A system is dynamic of it is continually transforming from stability to instability. The form is the equilibrium at the threshold in a dissipative system. All forms in the phenomenal world are products of the mapping of thresholds between stability and instability in dissipative or dynamic systems. A form should be seen as an event. Forms and forces in the phenomenal world mirror the virtual forms and forces modeled in topological or virtual space. Every form or force enfolds within it a multiplicity of possibilities of forms and forces, as in the monad of Leibniz. The catastrophe is the point at which a system flips to a different organization, and a different form is produced (Figure 3).

In DNA cell reproduction, forms evolve along vectors through topological space, but external forces cause flips in the organization of the system, causing all resultant life forms to be unique. This can be modeled geometrically, and applied to architecture. For example, units of geometries can be organized in sequences, and be programmed to unfold in self-generation, but the width and length of the geometrical units, in the context of the sequence, may cause a divergence in the direction of the generation, a catastrophe which causes its reorganization (Figure 4). The resultant form of the system, its moment of stability, disguises its organizational logic, as do life forms (Figure 5).

The form as event or catastrophe evolves in relation to a control space or attractor, which is the Cartesian parameter space. The trajectory projected into the space above the plane is a virtual universal unfolding resulting in a cusp or catastrophe set. The combination of continuous and discontinuous behaviors results in unpredictable unfolding through time in the event space or catastrophe surface, producing virtual event-forms or catastrophes (Figure 6). Greg Lynn applied topology theory and catastrophe theory to the design for the Cardiff Bay Opera House competition project in 1994. In *Animate Form*, Lynn described form as a virtual force or vector in a trajectory, resulting in immanence and singularity. Form is defined by

"multiple interacting vectors that unfold in time…" (11).[4] The vectors enter a topological space which is "differentiated by gradients of force." Architectural form is redefined as it is "modeled as a participant immersed within dynamical flows." Topological space is described as an "animate field" (32). The shape of a body in space is transformed as it evolves through series of gradient spaces to topological space (Figure 7).

Lars Spuybroek's Oblique World Trade Center proposal of 2001 displays complex tectonic structures and topological surfaces that are generated from a multiplicity of analogical vector forces and interactions. Tectonic surfaces are modeled on radiolarians, the multi-cellular and perforated skeleton of silica, and surfaces in nature which are formed from the rigidification of flexible structures. The flexible surfaces produce event-forms in topological space which blur the traditional distinctions in architecture between surface and support, column and beam, forms which are now seen as moments of structural instability in morphogenesis (Figure 8).

A project which applies topology theory and catastrophe theory, and which helps to establish a theoretical basis for Bioconstructivism, is a design for a theater by Amy Lewis in a Graduate Architecture Design Studio directed by Associate Professor Andrew Thurlow at Roger Williams University in Spring 2011. In the project, moments of structural stability are juxtaposed with moments of structural instability, to represent the contradiction inherent in self-generation or immanence. In the morphogenesis of the catastrophe, certain configurations will remain stabilized, while other configurations will point toward destabilization, or structural instability. Equilibrium is juxtaposed with disequilibrium. The singularity of the surfaces of the forms in the epigenetic landscape contradicts the complex network of interactions of topological forces from which they result. Actions in the environment on unstable, unstructured forms, and undifferentiated structures, result in stable, structured forms, and differentiated structures (Figure 9).

The project combines the methodology of Bioconstructivism, the focus on immanence and self-generation, with the methodology of poetic expression, of transcendence and predeterminism, in the contradiction between the form and the function, and the presence of the metaphysic in the analogical or metaphorical, in the presence of the dialectical and geometrical. The forms in the project display the catastrophic jumps in epigenetic processes, the "modifications, perturbations, changes of tension or of energy" (Kwinter 52) of matter, as described by Henri Bergson.[5] The forms display the vocabulary of "waves, fields, and fronts" of epigenesis. The forms display topological flows which are "scattered, accelerated, accreted, collided" (53) into diverse surfaces or developmental fields. The forms display a dialectic between the stable and continuous and the unstable and discontinuous. The discontinuity of the forms is a sign of morphogenesis. Catastrophic mutations take place between different levels of activity and organization. The presence of forms as "structurally stable moments within a system's evolution" (59) is subsumed into a process of evolution or

mutation. The composition can be seen as a dissipative system, a dynamic evolving system of matter. The composition can be seen as a catastrophe because each singular form can be seen to be the product of a multiplicity of forces, singular and multiple causes simultaneously.

The combinations of multiple and contradictory forms result in irregular and discontinuous formal relationships which create a dynamic, emerging composition. Trajectories of forms suggest development and change, and transformation through time. The trajectories incorporate realized forms as well as forms which are not yet actualized, but are present as traces, as enfolded "in between" the realized forms. The unrealized forms are related to the actualized forms in a continuum of contradictions. The architectural composition should be seen as an event, both biomimetically and allegorically, involving continuity and interruption, singularity and multiplicity, predetermination and immanence. The self-generation of the forms situates the unpredictable within the predictable, as can be found in DNA cell reproduction (Figure 10).

Within a continuity, the morphogenesis of the forms results in structural changes, as represented by the forms, which occur during the developmental process of an organism in nature. The forms in the composition display the transformational events or deformations that result in discontinuities and contradictions, according to topological theory. The forms display the dynamic of morphogenesis, as a system of discontinuities, involving the simultaneous transformation of every individual part of a system. Tectonic surfaces are modeled on radiolarians, producing event-forms in topological space, replacing forms which interrupt the transformative process.

The design of a building is the expression of a transcendental idea which manifests itself in form through nature. In Bioconstructivism, architecture imitates nature insofar as nature forms itself by universal principles. A building, as an organism, while it is developed according to the methods of nature, cannot be an imitation of any particular work of nature, but must rather be the expression of an idea of nature. Architecture is poetry, as poetry is the expression of an idea in matter. The essence of the building, the expression of the transcendental idea, the relationship between the human mind and nature, is expressed in the composition by Amy Lewis. The design involves an interweaving of the mimesis of organic forms and constructed geometries, to represent the dialectic between a priori reason or predetermination, and sense experience or immanence. The dialectic of the building in architecture, like the dialectic of the human being, involves the understanding of the processes of nature and the ability to transfer those processes into visual form, establishing the rhythm of the relationship between the human being and nature. The dialectic is a form of *Einfühlung*, or empathy, the act of inner imitation, *natura naturans*, carried out in Bioconstructivism.

[1] Plotinus, *The Six Enneads*, trans. Stephen MacKenna and B. S. Page (Chicago: Encyclopedia Britannica, 1952).
[2] Quoted in Sylvia Lavin, *Quatremère de Quincy and the Invention of a Modern Language of Architecture* (Cambridge, MA: MIT Press, 1992), p. 107.
[3] Detlef Mertins, "Bioconstructivisms," in *NOX: machining architecture*, ed. Lars Spuybroek (London: Thames and Hudson, 2004), pp. 360–69.
[4] Greg Lynn, *Animate Form* (New York: Princeton Architectural Press, 1999).
[5] Sanford Kwinter, "Landscapes of Change: Boccioni's *Stati d'animo* as a General Theory of Models," in *Assemblage* 19 (Cambridge, MA: The MIT Press, 1992).

Figure 1. Epigenetic landscape seen from below, from Sanford Kwinter, "Landscapes of Change: Boccioni's *Stati d'animo* as a General Theory of Models" in *Assemblage* 19 (Cambridge, MA: The MIT Press, 1992), reprinted from Conrad H. Waddington, *Strategy of the Genes* (New York: Macmillan, 1957).

Figure 2. Epigenetic landscape seen from above, from Sanford Kwinter, "Landscapes of Change: Boccioni's *Stati d'animo* as a General Theory of Models" in *Assemblage* 19 (Cambridge, MA: The MIT Press, 1992), reprinted from Conrad H. Waddington, *Strategy of the Genes* (New York: Macmillan, 1957).

Figure 3. Project by John Hendrix for Peter Eisenman studio, Chicago, 1993, photo by author.

Figure 4. Model by John Hendrix for Peter Eisenman studio, Chicago, 1993, photo by author.

Figure 5. Catastrophe surface, drawn by Joseph MacDonald, from Sanford Kwinter, "Landscapes of Change: Boccioni's *Stati d'animo* as a General Theory of Models" in *Assemblage* 19 (Cambridge, MA: The MIT Press, 1992).

Figure 6. Greg Lynn, Cardiff Bay Opera House competition, from www.classic.archined.nl.

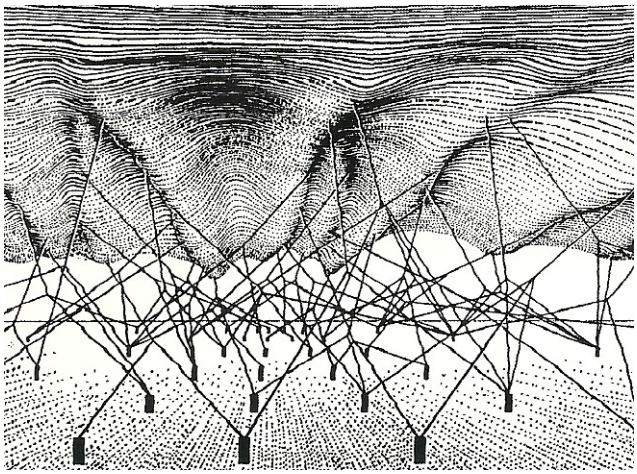
Figure 7. Lars Spuybroek, Oblique World Trade Center proposal, from www.nextnature.net.

Figure 8. Amy Lewis, Endless Dreamscape project, general view, Graduate Architecture Design Studio directed by Associate Professor Andrew Thurlow at Roger Williams University in Spring 2011, photo by Amy Lewis.

Figure 9. Amy Lewis, Endless Dreamscape project, elevation, Graduate Architecture Design Studio directed by Associate Professor Andrew Thurlow at Roger Williams University in Spring 2011, photo by Amy Lewis.

Figure 10. Amy Lewis, Endless Dreamscape project, section, Graduate Architecture Design Studio directed by Associate Professor Andrew Thurlow at Roger Williams University in Spring 2011, photo by Amy Lewis.

John Hendrix is a Professor of Architectural History at the University of Lincoln and teaches classes at Roger Williams University in Rhode Island. Recently he has published Architecture as Cosmology: Lincoln Cathedral and English Gothic Architecture, and The Cultural Role of Architecture, co-edited with Paul Emmons and Jane Lomholt. Previous books include Architecture and Psychoanalysis, and Architectural Forms and Philosophical Structures.



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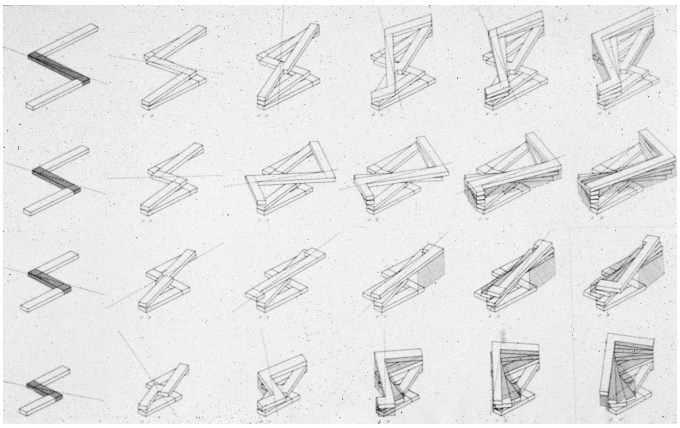

Figure 3. Project by John Hendrix for Peter Eisenman studio, Chicago, 1993, photo by author.

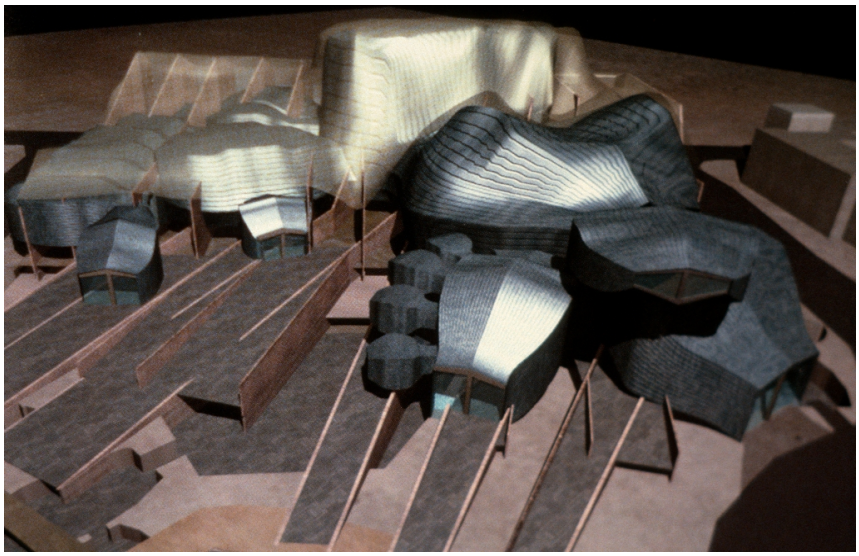

Figure 6. Greg Lynn, Cardiff Bay Opera House competition, from www.classic.archined.nl.

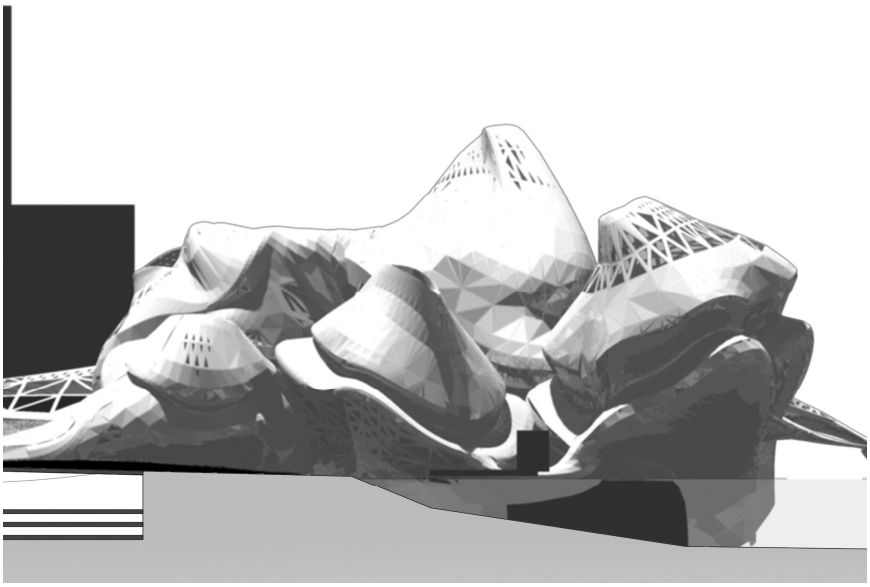

Figure 9. Amy Lewis, Endless Dreamscape project, elevation, photo by Amy Lewis.