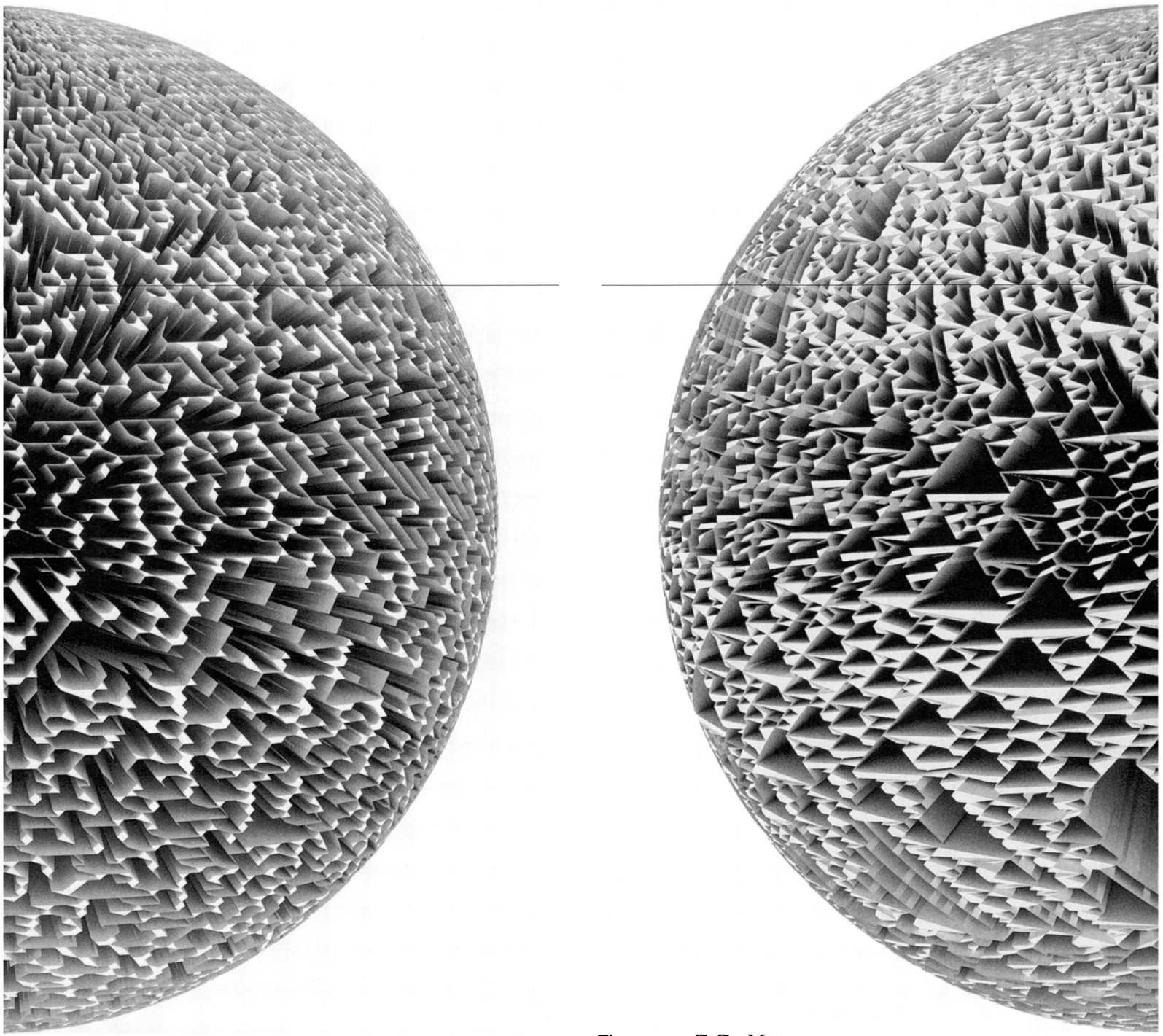
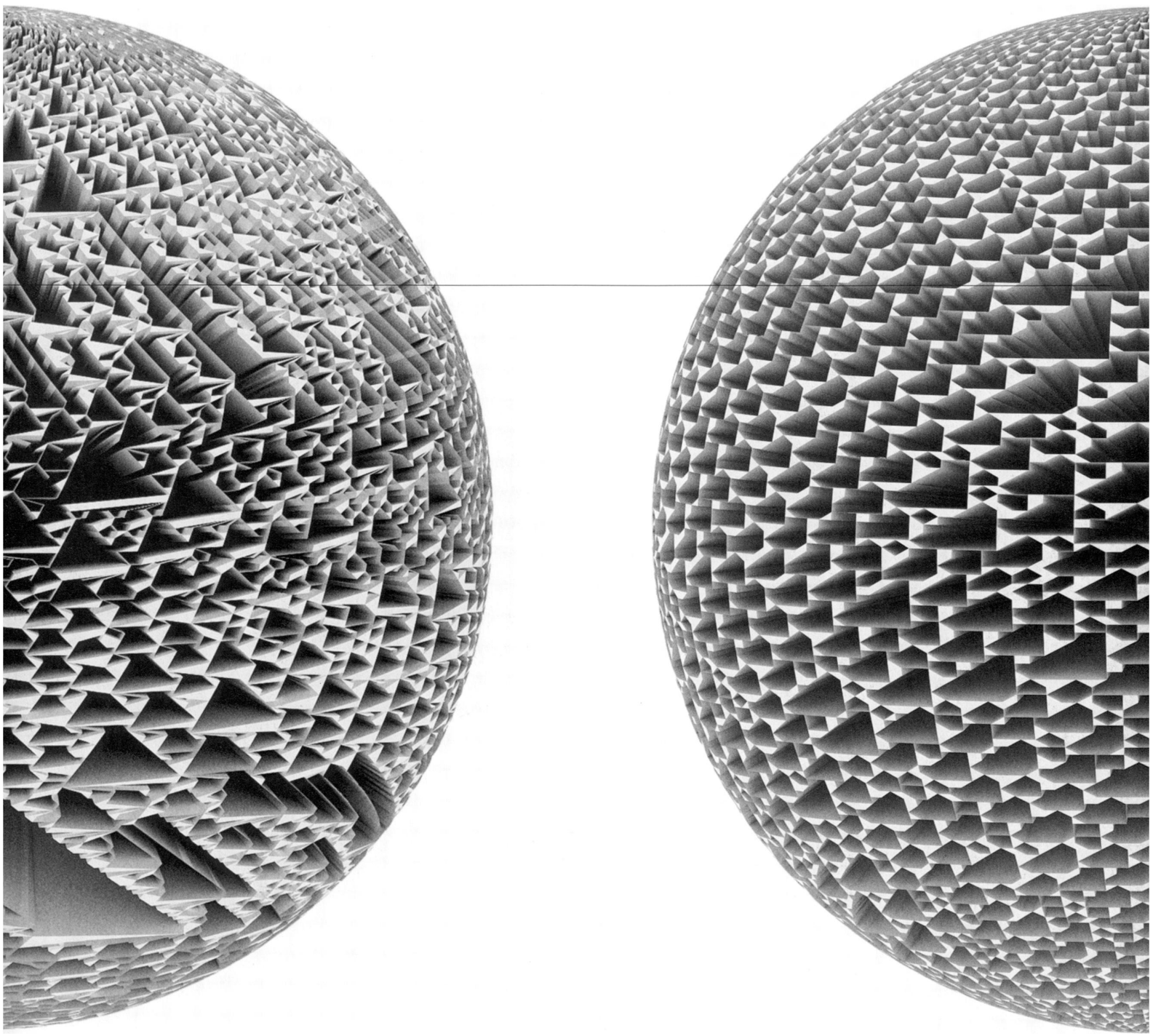
Karl Chu

Metaphysics of Genetic Architecture and Computation



Figs. 1, 2, 3 *ZyZx*, MetaXY.
ZyZx symbolizes a sampling from the set of configuration spaces of architecture inherent within the universe of cellular automata. Karl Chu would like to thank Chris Sandes for programming cellular automata and Christian Lange for assisting with digital constructions.



All is algorithm! Gregory Chaitin[1]

With the dissolution of the last utopian project of Man in the name of Communism, the great specter that once haunted Europe and the rest of the world has all but vanished, leaving in its wake an ideological vacuum that is now being filled by the tentacles of globalization with its ecumenical ambition. As humanity has become mesmerized by the triumphant spell of capitalism, what remains less apparent in the aftermath of this dissolution is that the world is moving incipiently toward a threshold that is far more radical and fantastic than any utopic vision since the dawn of the Enlightenment. Once again, the world is witnessing the rumblings of a Promethean fire that is destined to irrupt into the universe of humanity, calling into question the nature and function of life world relations as they so far have existed. These rumblings, stemming in large measure from the convergence of computation and biogenetics in the latter part of the twentieth century, have already begun to invoke gravid visions of the unthinkable: the unmasking of the primordial veil of reality.

The evolution of life and intelligence on Earth has finally reached the point where it is now deemed possible to engender something almost out of nothing.[2] In principle, a universe of possible worlds based on generative principles inherent within nature and the physical universe is considered to be within the realm of the computable once quantum computing systems become a reality. For the first time, mankind is finally in possession of the power to change and transform the genetic constitution of biological species, which, without a doubt, has profound implications for the future of life on Earth. By bringing into the foreground the hidden reservoir of life in all its potential manifestations through the manipulation of the genetic code, the unmasking or the transgression of what could be considered the first principle of prohibition—the taking into possession of what was once presumed to be the power of God to create life—may lead to conditions that are so precarious and treacherous as to even threaten the future viability of the species, *Homo sapiens*, on Earth. At the same time, depending on how mankind navigates into the universe of possible worlds that are about to be siphoned through computation, it could once again bring forth a poetic re-enchantment of the world, one that resonates with all the attributes of a pre-modern era derived, in this instance, from the intersection of the seemingly irreconcilable domains of logos and mythos. Organically interconnected to form a new plane of immanence that is digital, computation is the modern equivalent of a global alchemical system destined to transform the world into the sphere of hyper-intelligent beings.

1 Gregory Chaitin, "Leibniz, Information, Math and Physics" [online text], <http://www.cs.auckland.ac.nz/CDMTCS/chaitin/kirchberg.pdf> (2003), 9.

2 Stephen Wolfram, *A New Kind of Science* (Champaign: Wolfram Research, 2002), 41.

3 Alan Turing, "On Computable Numbers with an Application to the Entscheidungsproblem," *Proceedings of the London Mathematical Society*, 2:42 (1936). Alan Turing developed for the first time the conceptual blueprint for an abstract machine noted as the Turing machine in the above mentioned paper.

4 Stuart Kauffman, *Investigations* (New York: Oxford University Press, 2000), 142–4. Kauffman's concept of the Adjacent Possible was applied in the context of his investigations into the origin of life based on autocatalytic systems, which are derived from random interactions of nodes within Boolean networks.

5 "Life Is Inevitable in Stuart Kauffman's Creative Universe," *The Paula Gordon Show* [website], <http://www.paulagordon.com/shows/kauffman/> (posted date unknown; accessed February 13, 2004).

6 Alan Turing developed the Universal Turing Machine, an abstract machine in the logical sense of the term, in response to David Hilbert's call for the resolution of the decision problem, or *Entscheidungsproblem*, in mathematics.

7 Paolo Rossi, *Logic and the Art of Memory: The Quest for a Universal Language* (Chicago: University of Chicago Press, 2000), 145–94.

8 John Wheeler, "Information, Physics, Quantum: The Search for Links," in Wojciech Zurek (ed.), *Complexity, Entropy, and the Physics of Information*, proceedings of the SFI workshop of the same title, held May 29 to June 10, 1989 (Redwood City: Addison-Wesley, 1990), VIII. 5.

The power of computation is already evident in the fact that in less than seventy years since the inception of the Universal Turing Machine,[3] it has ushered in the Information Revolution by giving rise to one of the most significant and now indispensable phenomenon in the history of communication: the Internet, or, what could also be characterized as the universe of the Adjacent Possible.[4] Stuart Kauffman defines the Adjacent Possible as the expansion of the networks of reaction graphs within an interactive system into the neighborhood domain of connectivity which until then remains only in a state of pure potentiality. Kauffman suggests, "The Universe has not explored all possible kinds of people, legal systems, economies or other complex systems," and that "autonomous Agents tend to arrange work and coordination so that they are expanding into the Adjacent Possible as fast as they can get away with it."[5] Like every phase transition, the Internet marks a new world order by re-configuring the planet with a virtual, albeit an interactive matrix that is becoming increasingly spatial, intelligent and autonomous: a global self-synthesizing organ bustling with neural intelligence possibly detectable from every corner of the Milky Way and beyond. It is at the level of the construction of possible worlds that the implications for architecture are most pronounced. The thesis that will be advanced at the latter part of this paper is that architecture is becoming increasingly dependent on genetic computation: the generative construction and the mutual coexistence of possible worlds within the computable domain of modal space.

Yet, what is the nature of computation that is destined to change the world including architecture? No instrumental concept or logic of implementation since the invention of the wheel has fostered so much enthusiasm and promise as computation has. Beyond the normative conception of computing machines as mere instruments for calculation, fabrication and communication, it is important to recognize the nature of the underlying ambitions of computation and its relation to architecture. As controversial and provocative as it may seem, the underlying ambitions of computation are already apparent: the embodiment of artificial life and intelligence systems either through abstract machines or through biomachinic mutation of organic and inorganic substances, and, most significantly, the subsequent sublimation of physical and actual worlds into higher forms of organic intelligence by extending into the computable domain of possible worlds. At the most prosaic level however, computation, like natural languages, deals with information in its most general form. Computation functions as manipulator of integers, graphs, programs, and many other kinds of entities. In reality, however, computation only manipulates strings of symbols that represent the objects. It should also be pointed out that, according to the late Richard Feynman, computing systems could be constructed at the atomic scale: swarms of nanobots, each functioning in accordance to a simple set of rules, could be made to infiltrate into host organisms or environments including the human body. In its simplest form, computation is a system that processes information through a discrete sequence of steps by taking the results of its preceding stage and transforming it to the next stage in accordance to a recursive function. Such an iterative procedure based on recursion has proved to be astonishingly powerful and is classified as belonging to a class of machines having universal properties.

It is not surprising that the origin of computation lies in an attempt to embody instrumental reason in an abstract machine[6] along with the attendant drive to encode the logic of life and the world around us in all its manifestation. The quest for a Universal Language[7] which could encapsulate all the attributes and functions necessary to inscribe the form and structure of all computable worlds is becoming one of the most persistent endeavors in the short history of computation. Since computation is about information processing at the most fundamental level, John Wheeler, the prominent American scientist influential to a whole generation of physicists in the latter half of the twentieth century, initiated an information-theoretic conception of the world by stipulating that every item in the universe has at bottom—at a very deep bottom, in most instances—an immaterial source and explanation that is information-theoretic in origin.[8] The fact that computation is a physical process further stipulates the existence of a self-consistent logical loop: the laws of physics define the allowed mechanical operations and the possible activities of a Universal Turing Machine, which in turn determine which mathematical operations are computable and define the nature of solvable mathematics. In other words, the laws of physics generate the very mathematics that makes those laws computable. This discovery of the inextricable linkage that exists between computation and physics has led to the awareness that physical processes are in fact forms of computation, and, nowhere is this understanding made more explicit than in Stephen Wolfram's formulation of the Principle of Computational Equivalence. Wolfram remarks, "All processes, whether they are produced by human effort or occur spontaneously in nature, can be viewed as computa-

tions."[9] This proposition reflects a fundamental shift in the way we think about the nature of the physical universe; it is nothing short of a paradigm shift, which would not have been conceivable without an underlying thesis that enables the construction of such a world view: the Church-Turing Thesis as formulated by Alfonso Church and Alan Turing in the early part of the twentieth century. According to Turing, "Every 'function which would naturally be regarded as computable' can be computed by the universal Turing machine."[10] Although the absolute veracity of the thesis cannot be decided by logical means, all attempts to give an exact analysis of the intuitive notion of an effectively calculable function have turned out to be equivalent. Each analysis offered has been proven to pick out the same class of functions, namely those that are computable by the Turing machine.[11]

Parallel to the development of computation is the discovery of the DNA code in the early part of the twentieth century, the significance of which has only begun to be realized with the completion of the Human Genome Project. Finally, with the convergence of computation and biogenetics, the world is now moving into the so-called Post-Human Era, which will bring forth a new kind of bio-machinic mutation of organic and inorganic substances. Information is the currency that drives all these developments and nowhere is this more apparent than in the words uttered by Craig Venter, the ex-CEO of Celera Corporation, which completed the human genome sequence: "The goal is to engineer a new species from scratch."[12]

This statement bluntly announces the unadulterated ambition of the biogenetic revolution. It is only a matter of time before the world will witness bio-machinic mutation of species proliferating into every facet of what so far has been the cultural landscape of humanity. Architects take note: this is the beginning of the demise, if not the displacement, of the reign of anthropology, which has always subsumed architecture. Architecture, especially from the standpoint of its mythical inception, has always been a subset of anthropology: the expulsion of Minotaur, the beast, by entrapping it into the labyrinth built by Daedalus, the mythical architect at Knossos. The potential emancipation of architecture from anthropology is already affording us to think for the first time of a new kind of *xenoarchitecture* with its own autonomy and will to being. In order to break through the barrier of complacency and self-imposed ignorance on the part of the discipline, what is needed is a radicalization of the prevailing paradigm of architecture, beyond retroactive manifestoes, by developing a

9 Wolfram, Stephen, *A New Kind of Science* (Champaign: Wolfram Research, 2002), 715.

10 David Deutsch, "Quantum Theory, the Church-Turing Principle and the Universal Quantum Computer," *Proceedings of the Royal Society of London*, A:400 (1985), 3.

11 Apart from the analyses defined in terms of lambda-definability by A. Church and recursiveness, there are analyses in terms of register machines by J. P. Shepherdson and H. E. Sturgis, E. L. Post's canonical and normal systems, combinatory definability by M. Schönfinkel and H. B. Curry, Markov algorithms, and Gödel's notion of reckonability.

12 Craig Venter, "Supermicrobe Man," *Wired*, 10:12 (December 2002), 191.

13 Rem Koolhaas, "Junk Space," *October*, 100 (Cambridge, Mass.: MIT Press, 2002), 175–90.

new concept of architecture that is adequate to the demands imposed by computation and the biogenetic revolution.

Even though architects have incorporated computing systems in the design and construction of buildings and environments, the phase of transmodernity that we are now in is perhaps best characterized by the use of computation still operating under the vestiges of the old paradigm. In other words, architecture has still yet to incorporate the architecture of computation into the computation of architecture. Within the contemporary landscape of architectural discourse there are two divergent trends with theoretical motivations: the morphodynamical and the morphogenetic systems approaches to the design and construction of buildings. These two systems are reminiscent of a strikingly similar problem that exists in modern biology, which is still attempting to synthesize the differences that exist between molecular biology, on the one hand, and developmental biology on the other. What is needed in architecture also is a similar synthesis of the two. After more than half a century of engagement with the avant-garde, the practice of architecture has become increasingly conscious of its embeddedness within the general economy of forces, relationships, and the global economy. The morphodynamical approach, which has spurred two different methodological orientations in dealing with programmatic issues, is the more dominant of the two at the moment. The morphogenetic system is still more or less

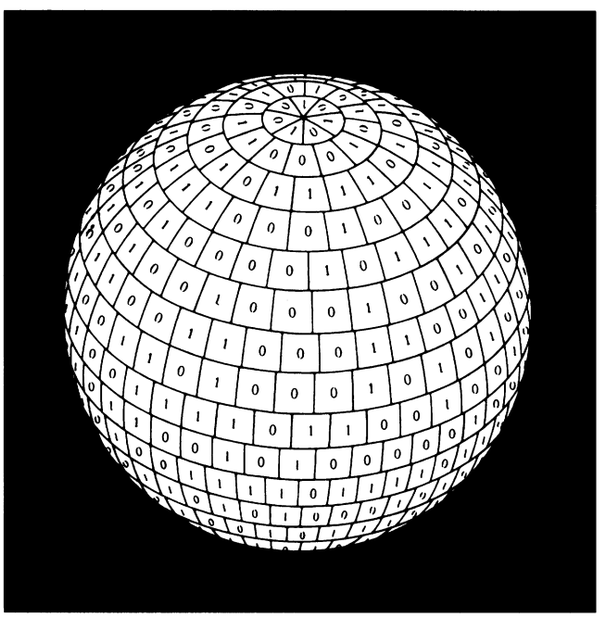


Fig. 4 *It from Bit*. Representation of the Universe in terms of binary digits by John Wheeler

in its embryonic stage even though it is by far the more fundamental and necessary since it deals with the construction of objects directly. What follows is a brief excursion into conceptual issues that motivate the two approaches in architecture before providing a brief sketch of Genetic Architecture in the latter part of this article.

The opera of globalization

The first and most influential of the two directions within the morphodynamical approach is Rem Koolhaas's reformulation of architecture as the spatial registry for the new world order engendered by International Capital. Long dispensed with the heroic spirit of modernity and the attendant need for salvation, Koolhaas resembles a man who fell to Earth, saturated with the discrete charm of a nihilist who nonetheless preoccupies himself with the problems of the world. He is essentially an idealist wearing the cloak of realism, which allows him to embody the perceptive intelligence of a surveyor with a vision of the world that is at once pragmatic and cynical. Concerned primarily with the organization and modulation of forces operative within the global market economy, his detachment allows him to engage in a mannerist critique of 1) modern architecture by deploying the very language of the modernist ethos that he is critical of, and 2) various pretensions and absurdities of life which find such compulsive expressions within the cultural domain including architecture. A thinly veiled impatience if not a lack of tolerance accompanies this demeanor: "It's the economy, stupid! Get on with infrastructure and the flow of Capital." A realist presentiment that is all the more reasonable when viewed from the standpoint of the practice of architecture embedded within the capitalist system. But, what is left unsaid or remains unthought is that architecture, especially with the demise of the USSR and the subsequent opening of the market economy into Russia and the People's Republic of China, which has embraced the wild and unruly side of capitalism far more than the United States of America, has become the instrument of the ontological destiny of Capital: a truly prolific system capable of transcending national boundaries and ideologies.

The stakes, no doubt, are supremely high. This approach, however, is not without merit. The Koolhaasian outlook calls attention to the proliferation of wastelands and Junk Space[13] as well as to the general economy of abstract machines that regulate monetary flux, systems of production, supply chains, modes of distribution, new markets, shopping, shifts in demography, traffic patterns, etc. We should not overlook the fact

that, unlike real dynamical systems that are found in nature, Koolhaas's framing of architecture as a consequence of the market economy does not lead to the dynamical construction of architecture per se. This approach places emphasis on the performative aspect of cultural programming and alludes, in some rare instances, to an architecture of reactive sublimation. This is most vividly displayed in the compression of Cool Space[14]: the heightened arrest of immanent forces by bracketing the drama of life within the system as a quasi-transcendental zone, at once liminal and erotic, strangely detached and yet simultaneously belonging to the world. Its operative modality: the eye of the architect projecting his cool light, tinged with sublime irony, into the Space of Capital.

With his persistent reminder of the regime of ¥€$ and references to geo-political events as part of the ever-shifting global matrix that governs and constrains the design of buildings, Koolhaas offers a critical realism that deals with the imperatives of the given. Not unlike the art of political dramatization, these social, political and economic issues are framed strategically by Koolhaas in a condensed fashion, with the aim to provoke and shatter the decrepit mind of a stubborn architect who still indulgently holds onto the defunct formalism of the avant-garde. Due in part to his eloquence, which tends to be laconic and pungent, his pronouncements are almost always accompanied by seductive images designed to heighten the surrealism of facts and events. Consequently, they are all the more effective, especially for those architects who have become disenchanted with the avant-garde and who have either lost the desire or are encumbered by the sense of futility in developing new ideas—which in their eyes will inevitably be smoothed over by the capitalist machinery, in framing conditions of possibility or impossibility for the programmatic genesis and construction of architecture within the capitalist system of axiomatization. Given this intention, it is understandable yet unfortunate that such a venue relies exclusively on the default language of modern architecture and its typology with its attendant semiology to organize and frame its dramatic form. By appealing to the generic, Koolhaas takes on an objective stance with a minimalist vocabulary without indulging in extraneous design solutions or idiosyncratic embellishments. The generic affect, especially when subordinated solely to the dictates of the commercial, is liable to be co-opted and blended into what Marshall Blonsky, a professor of semiotics at the New School in Manhattan, refers to as "the indifferent equivalence of everything with everything else, for an audience that has no concern for that

14 *Cool Space* is a term that I coined to refer to the cool and translucent nature of minimalist aesthetics.
15 Constance L. Hays, "The Wal-Mart Way Becomes Topic A in Business Schools," *The New York Times*, July 27, 2003, Section 3, 10.
16 Rem Koolhaas, "The New World," *Wired*, 11:6 (June 2002), 115–37.
17 See the cinematic aesthetics of *Alphaville*, directed by Jean-Luc Godard (1965). *Alphaville*, a story which unfolds in a utopian world of the future, is governed by a totalitarian system in which the individual counts for almost nothing, and an alienated society has no use for art, poetry, love, or even thought. People are reduced essentially to the level of robots.
18 Jaegwon Kim, *Supervenience and Mind* (Cambridge: Cambridge University Press, 1994), 92–5.
19 Kim, *Supervenience and Mind*, 101–2.
20 A kynic, stemming from Diogenes, is the provocative but stubborn moralist with a plebian intelligence, who lets out a satirical laughter, unlike the cynic who, according to Sloterdjik, harbors the smile of an enlightened false consciousness on his lip. Peter Sloterdjik, *Critique of Cynical Reason* (Minneapolis: University of Minnesota Press, 1988).

difference, and no discernment of quality" and where "America's least common denominators gathered together."[15] Based on the reductive rationality befitting a bureaucrat, of which Koolhaas is fully aware of the concealment of the irrational by the rational—a very special delirium inherent to the regime of money, according to Deleuze—architecture is now in a position to concentrate, even in the context of his acute awareness of this madness, on modulating the flow of programmatic issues driven by the ever-expanding capitalist system of circumlocution.

As such, the locus of force is situated neither in the material or formal cause but posited exclusively in the efficient cause, i.e., programmatic determinants engendered by the system, which, for Koolhaas, constitutes the fundamental reason for being of architecture. The main interest therefore is not in the formal genesis or in the search for the autonomy of architecture but to grasp the dynamics of the capitalist regime, which comes replete with a new zodiac for a new world order[16] represented by the ever shifting constellation of corporate logos collectively standing in to frame the cosmography of Capital. Machinic assemblages of this regime are then channeled, coalesced and constrained appropriately through a spatial medium charged with a quasi-transcendental aesthetics reminiscent of *Alphaville*.[17] The impotence of architecture therefore is inversely related to the cosmology of the power system that subsumes it; architecture, at best, according to this position, can do nothing more than to invert this inversion through irony while sublimating Junk Space into a flattened and translucent Cool Space. His position is one of reactive sublimation, which contents itself with the mere accomplishment of sublime irony as opposed to getting involved in the messianic projection of possible worlds to come.

The Koolhaasian approach therefore is that of a journalist who relishes an *extensional* description of architecture where the entire universe of relevant objects is captured under the sign of ¥€$. His method is a top-down analysis of the brutality of facts, of the reality of the given based on epiphenomenal causation,[18] which reveals dependency relations that exist at the macro level rather than on the internal structure of causal relations that connect facts and events. It is a version of mereological supervenience,[19] a generalized appeal to the operations of the macro-economy where the characteristics of wholes supervene on the properties and relationships characterizing their proper parts. The alchemical transformations occurring within these objects—the hidden micro-economy of internal relations and interactions that exist at various scalar and specification regimes of matter, energy, and information that lead to complex organizations—remain outside the scope of his surveillance and penetration. Being all too comfortable with the fashionable display of charts and figures, as if they alone adequately explain the inner complexity of the world, Koolhaas seems resigned to making enlightened remarks on just about everything: from Largos to Shanghai via 9/11. Far from being a stalemate, this is only the beginning of the capitalist version of alchemy: the incarnation and mutation of affects produced by Capital into the mind and body of Man as well as into the organic and inorganic substances of reality, an inevitable fatalism that is destined to fundamentally alter the very definition of Man, along with it, the category of the species—*Homo sapiens.* Koolhaas, for the moment, represents an index of consciousness, a critical facet of neo-conservatism which expands architecture outside of its parochial limitations and allows it to be subsumed, undoubtedly at a price, by the restricted economy of Capital.

Finally, accompanied by the ambivalent smile of a kynic[20] who has become adept at playing with the flux of Capital, the message disseminated by Koolhaas is clear: be a capitalist with the moral prerogatives of a skeptic who, in his case, is tinged with a heavy dose of asceticism where the principle of salvation, ever an unacknowledged sentiment which constitutes such a monastic or repressed aesthetics of architecture, converges with that of the accrual of surplus value, neither contradictory nor regrettable especially when it comes to life and architecture. It is this proposition—a massive rhetorical adumbration if not an apologetic for the capitalization of architecture, which unabashedly subordinates, subsumes and suppresses the autonomy of architecture and its internal will to freedom by locking its interiority into the restricted economy of Capital, not leaving any room for the messianic exploration of worlds to come—that is most problematic with this orientation. In other words, it is the dissipation of the will to architecture through a transfusion of that will into the cartography of branding: the end of architecture and the beginning of the presumed enlightened Space of Capital, at least up to the stage of transmodernity. Such is the militant nature of an ontological commitment to naïve realism, an epiphenomenalist drama based on apparent causation that characterizes the work of Rem Koolhaas and his disciples—thoughtful architects who, far from being sleepwalkers from the late modernist era, are nonetheless all too willing and eager to be caught in a uniquely Western version of *feng shui*, albeit without their being aware of it, which literally means *wind and water*—

elements that constitute, in this instance, the fluid dynamics of an esoteric belief system. In other words, it is the *smoothing* of the flow of *oracles* induced by the master into the flow of MM&M—Money, Matter, and Meaning—as if this magnificent confluence is the only theater of the world worth enacting on the plane of consistency which has no place for the irruption of the untimely or the intrusion of the unexpected, notwithstanding the catastrophic events of 9/11, and much less the caesura that momentarily pauses the sound and the fury of everything. This is the Koolhaasian rendition of the Opera of Globalization.

Morphing matter

The second direction within the morphodynamical approach is represented by a host of young architects working in the digital domain. They are concerned with the architecture of so-called soft morphology and, for some, biomorphic representation. Influenced by Greg Lynn's interest in animate form, on the one hand, and, to compensate for the lack of kinematical use of force in Koolhaas on the other, these architects, being playfully enthusiastic with the use of dynamical features such as particle systems and inverse kinematics available within animation software such as Maya, Softimage and Houdini, instantiate interactive morphing based on dependency graphs that are spuriously linked to contextual forces that exist within a given site or condition. Mobility and flow are once again at the top of the agenda. Unaware of the fundamental difference that exists between modeling and simulation, not to mention the occasionally ambiguous relation that exists between representational and non-representational modes of computation, they thrive on the confusion derived from mistaking the behavior of forces enacted within the virtual environment as being identical and isomorphic to the complex behavior of forces and relations that occur in the physical world. In most cases, they are examples of misplaced concreteness staged on a virtual plane of consistency without, on the most part, the necessary rigor required in the modeling of complex adaptive behavior that approximates real world situations. In addition, neither are they involved in the simulation of pure dynamical possibilities, or *bodies without organs*, in the words of Deleuze and Guattari echoing Antonin Artaud, without the attendant trauma of being bondaged to representation. Instead, they are deployments of the same set of animation features that post-production companies, both in Hollywood and elsewhere, use to generate virtual affects for TV advertisements and films, and in a few cases, the manipulation of parametric

21 Stuart Kauffman, *Investigations*, 131.

constraints within engineering software to instantiate complex morphing. Unfortunately, some of these animations, more often than not, tend to lapse into comical display of animated forces represented by the flow of particles as they contort and distort Nurb surfaces enacted within the virtual environment. These contortions are then augmented by narratives already stipulated and rehearsed by Koolhaas.

The characteristic feature of dynamical systems in general is that they are fundamentally not equipped with constructive processes. The formal constitution of these systems is predicated on the quantitative properties and couplings of interacting elements which are construed as *unformed matter* and they fail to represent elements as objects with distinct internal structures that can give rise to behavior. Objects therefore disappear into arrays of structureless variables confined to holding numerical values that quantify properties of an object class. These values represent intensive ordinates that map changes in time, density and space: the frequency of a gene, the concentration of a chemical, the position and velocity of an aircraft, the pressure of a gas, the rate of change in interest rates, the fluctuations of the dollar, the density of population, the earnings of a firm, the rise and fall of stocks, the diagrammatic flow of traffic, etc. As a consequence, interaction is understood as the temporal or spatial change in the numerical value of quantitative variables. This change is captured by a set of (deterministic or stochastic) differential (or difference) equations and the solutions of these equations may then be viewed as a flow in phase space, which then can be characterized as a manifold that governs the set of possible trajectories. In Nature, however, interaction involves objects directly and never by a numerical value describing them. With regard to having too much faith in statistics, a caution by Kauffman made in a different context is appropriate: "there is no finite prestatement of the configuration space of a biosphere."[21] Neither is there one for a truly radical conception of architecture that is open to the future.

Going outside of the framework of conventional dynamical systems requires taking this observation seriously. Given the inherent limitation of dynamical systems, which is an abstraction of one aspect of the behavior of nature, the application of this conceptual apparatus as an expository system for architecture inevitably leads to the assumption that architecture has no interiority of its own since the very notion of interiority presupposes the construction of objects and their genesis over time. The emphasis placed by the dynamical approach therefore is in the interaction of forces within a given context which is consistent with the notion of architecture conceived as an adaptive discipline predicated on weaving, critically or otherwise, into a given fabric of urban condition that is already infused with a set of social, political and economic reality. What is left behind, and this is the crucial point to remember, is the very logic of construction whereby the internal structure of an element or a group of elements causes specific actions to occur, such as the replication, mutation, construction, modification, substitution or deletion of other objects, all of which are part of the grammatical functions of a language that participates in the genesis of an internal *will to architecture*. Unfortunately, some architectural theorists and critics who are vehemently supportive, almost to the point of being militant, of the morphodynamical approach, especially with its appeal to the flow of Capital, are unduly obstinate in avoiding formal issues that are internal to these systems, which, in fact, give impetus to their arguments. Concerned primarily with the inductive use of associative reasoning, the nature and function of metaphoric import that give explanatory power to these concepts, which are derived from the science of dynamical systems, remain largely unthought.

Parallel to this is a corresponding lack of critical stance concerning the hegemonic influence of software systems that are made all too "user-friendly" by software manufacturers. The uncritical use of pre-determined functions within these systems tend to produce architectural affects and morphologies that are recognizably homogeneous and predictable. What is most problematic is the unconscious propagation of a pre-constituted set of functions that invariably lead to architectural traits devoid of any critical import or will to being: the multifaceted novelty of the ready-made which engenders, through the manipulation of parametric constraints, inexhaustible variations of the same—another newfound lease on life for architecture under the regime of Capital.

The art of rewriting

In contrast to the morphodynamical systems approach to architecture, the morphogenetic orientation has its premise in the idea of an internal principle that generates architectural form and organization. It is an investment of the will to architecture that is clearly lacking in the morphodynamical approach, which depends exclusively on exogenous issues to regulate the composition and packaging of architectural form. Dynamical systems are generative systems endowed with the capacity for self-organization but not self-replication.

They contain neither a description of its logic and

template of its organization nor mechanisms for copying hereditary information onto subsequent generations. In contrast, a genetic system contains a description of itself that is necessary for self-replication. Of the two uses of computation, representational and non-representational, non-representational procedures allow for the development and emergence of forms that are intrinsic to genetic systems. The representational concept of modeling instead relies on references that exist outside of the computational process, such as in computer simulation. In non-representational modeling, there is no a priori reference to any pre-existent model or condition that exists outside of itself; it models its own reality by exploring generative possibilities inherent within an axiomatic rule set. It is the purest form of information processing that is based on inherent possibilities and limitations.

Among the few architects[22] who are involved in the morphogenetic approach, there have emerged three complementary directions: 1) a genetic hermeneutics of architecture as represented by Peter Eisenman, 2) algorithmic architecture explored by Cecil Belmond, John Frazer, and a few others who rely on fractal systems, Lindenmayer systems, and genetic algorithms to generate recursively defined geometric objects, and, 3) a genetic monadology of architecture, which takes on *symbiogenesis* as the *modus operandi* for the construction of possible worlds. As it is presented here, this last approach is implicitly related to the first and explicitly connected to the second.

All these approaches take as their central idea the concept of *rewriting*. The difference in the interpretation and use of this concept essentially differentiates Eisenman's methodology and the other two positions which are based on recursion. Even though Eisenman does not rely on formal axioms, he can be considered a precursor to the morphogenetic orientation. His early interest in the deep structures of Chomsky's grammar is indicative of his later but abiding interest in the interiority of architecture and the autonomy of the generative, twin concepts that are fundamental to the development of a theory of genetic architecture. It must be mentioned that Chomsky's grammar paved the way for Aristid Lindenmayer to develop a mathematical theory of plant formation called Lindenmayer System, or simply, L-system, which is based on the logic of string rewriting: a technique for defining complex objects by successively replacing parts of a simple initial object using a set of *rewriting rules*.[23] Genetics also presupposes the concept of rewriting within its system. Eisenman has introduced a less formal concept of rewriting: the diagram. The

22 John Frazer, *An Evolutionary Architecture* (London: Architectural Association, 1995). Some of the engineering work done by Cecil Belmond relied on fractal systems.
23 Aristid Lindenmayer and Przemyslaw Prusinkiewicz, *The Algorithmic Beauty of Plants* (New York: Springer-Verlag, 1990), 1.
24 Betty Rojtman, *Black Fire on White Fire* (Berkeley: University of California Press, 1998), 1.
25 Rojtman, *Black Fire on White Fire*, 1.
26 Ernst Haeckel's well known assertion that "Ontogeny is the short and rapid recapitulation of phylogeny" is based entirely on mechanical causes which are physical-chemical in nature. His position, unfortunately, led him to the ideology of National Socialism in Germany. In the case of Eisenman, there is no appeal to such mechanical causes or physical substances that provide the basis for such recapitulation. It is purely a hermeneutical gesture that attempts to address the interiority of architecture through the diagram, which has none of the absolute certainty that Haeckel implied with his assertion. Stephen J. Gould, *Ontogeny and Phylogeny* (Cambridge: Belknap Press, 1977), 76–85.

difference in the two conceptions of rewriting is fundamental: the one that I am proposing is formal, which is based on *recursion*, and Eisenman's version is founded upon hermeneutical inscription. This distinction essentially differentiates Eisenman's approach, which I am referring to as a *genetic hermeneutics of architecture*, derived from exegetical procedures, and a *monadology of genetic architecture* that I am proposing, which is an extension and transformation of Leibniz's *Monadology*, albeit without his theogony. From a philosophical point of view, both approaches operate in the void opened up by the absence of the Word, in the fertile space that is now being traversed by computation which, as mentioned earlier, is involved in the search for the code of existence—even in the oblique sense that it has imparted to architecture since time immemorial.

Archaeology of the future

Peter Eisenman's architecture over the last thirty years consistently relies on some form of generative process, at times highly idiosyncratic, to arrive at architectural form. Although Eisenman deploys morphing techniques in some of the projects done in the last few years, what is significant is that he is motivated by the desire to uncover a phenomenology of interiority and autonomy within the discipline of architecture by inscribing his own theoretical work within the same tradition in order to disclose the nature of that autonomy that he so wishes to perpetuate. This is a move that is not without a degree of paradoxical relation to its subject matter. Correspondingly, he is consciously involved in the chain of interpretation that includes dialogical relations with certain select architects from history. His work therefore can be characterized as a genetic hermeneutics of architecture. In contrast to genetic systems, a genetic hermeneutics is a generative modality based principally on the interpretation of the sense of interiority embedded within a series or tradition. By subsequently re-investing the results of its interpretation back into the structure, it attempts to maintain and further propagate the unfolding of the series. This move allows him to acquire a dimension of singularity and autonomy with regard to the series. However, the condensation and perpetuation of this series, which constitute the history of architecture, is done without the benefit of any appeal to formal logic or axiomatics. Correspondingly, a genetic hermeneutics of architecture is grounded in the tradition of interpretation which attempts to decipher and unfold an original presence whose inexhaustibility is both testified and investigated by the exegetical tradition. The paradigm for such a hermeneutical approach is offered by Bette Rojtman in her study on Jewish hermeneutics. In her book *Black Fire on White Fire*, Rojtman recounts and situates the origin of the infinite series propagated by textual exegesis as follows:

> The Torah that God gave to Moses opens with the second letter of the alphabet, the 'beth' of plurality. The Law of truth, the charter of the world's foundation, is thus presented first of all as disseminated 'Word' at the heart of the unique.

This is the original scene of inscription that deliberately sidesteps any coincidence and instantiated "a deep rent in the fabric of an absolute pronouncement, it marks the entire range of history to come, the place allowed for the living within an essential Word."[24] Furthermore, "Exegesis repeats this paradox by positing a true univocal meaning that nevertheless opens out toward the world and 'plays' between writing and orality, between the interpreted word and the transmitted word."[25]

Let it be stated without too much preamble that Peter Eisenman's architecture must be understood as a similar attempt to situate architecture as part of the inner unfolding of an exegetical tradition and the hermeneutical role that the architect plays within such a process, which is highly nuanced, complex and synthetic without being dialectical. To judge his architecture outside of the context of the tradition of interpretation is to miss a fundamental thesis of his work: architecture is a form of inscription or *rewriting* situated at the intersection of a past which constitutes its tradition and possible futures. It is mediated, at this juncture, by the diagram which folds and unfolds the textual tradition of architecture, an archaeology of the future that resembles an arithmetical series: infinite but secretly calculated and, in the case of Eisenman, mediated by an active renewal of signification in the very act of inscribing the diagram—writing that opens up the futurity of writing.

The diagram therefore re-presents by rewriting traces of the interpreted word and the transmitted word. It is at once diachronic and synchronic with regard to the simultaneous registration of latent trajectories that eventually unfold into the configuration space of buildings. This is the genetic aspect of Eisenman's theoretical work which, in the process of unfolding, gives structure and organicity to the interiority of architecture, a singularity that, by virtue of its reference to an original presence, is endowed with the imperatives of a messianic force directed toward the future unfolding of the world. Ontogeny, in this context, is understood as the development of an organ of architecture by recapitulating the traces of interiority that constitutes the lineage of a phylogenetic branch.[26] Herein lies the logic of the infinite

series, a genetic hermeneutics of architecture engendered by languages of the unsayable. The spirit of the exegetical tradition is the call to read the unwritable and follow the movements of the hidden traces of interiority, which is virtually identified with the logic and structure of the series itself. As can be seen, the theoretical position taken by Eisenman is profound even though its archaeological dimension is less than transparent in his built projects. At the same time, it is extremely fragile, given the context of globalization where the specificity of an exegetical tradition is already threatened by the capitalist system of axiomatization. If Eisenman offers a genetic hermeneutics of architecture by tapping into the lineage of a phylogeny with an interiority of its own, the concept of genetic architecture that is offered here will implicate Eisenman's phylogenetic deferrals into the distributive networks of computing systems, which may allow for the rhizomatic proliferation of a jungle, at once superposed onto and co-extensive with the desert of existence: a monad.

Monadology of genetic architecture

Having identified some of the salient features that are integral to dominant trends within contemporary architecture as well as the nuanced relations that each of these trends have with regard to the phenomenon of globalization, which is increasingly augmented and driven by the gift of Promethean fire that is now saturating the cultural universe of humanity with all forms of transgenic mutation, we are now in a position to articulate a more comprehensive theory of architecture, one that is adequate to the demands imposed by the convergence of computation and biogentics in the so-called Post-Human Era: a monadology of genetic architecture that deals with the construction of possible worlds. As we now approach what Ray Kurzweil refers to as the Singularity,[27] the myth of matter, which underlies most theoretical and practical discussions of architecture, is about to be displaced by the myth of information. Contrary to Mies van der Rohe's oft-quoted remark that architecture is the art of putting two bricks together, the emerging conception is that architecture is the art of putting two bits together, at least bits that are programmed to self-replicate, self-organize and self-synthesize into ever new constellations of emergent relations and ensembles.

The use of the term *monadology* is based on the fact that genetic architecture is an extension and transformation of some of the propositions, especially those that define attributes and properties of relationships among monads, contained in Gottfried W. Leibniz's

27 Ray Kurzweil, "The Singularity" in John Brockman (ed.), *The New Humanists: Science at the Edge* (New York: Barnes & Noble, 2003), 215–32.
28 Chaitin, "Leibniz, Information, Math and Physics."
29 Juan Alvarez de Lorenzana, "The Constructive Framework and the Evolutionary Systems," in Stanley N. Salthe, *Development and Evolution: Complexity and Change in Biology* (Cambridge, Mass.: MIT Press, 1993), 298–9. Note: de Lorenzana's deployment of these principles is, *prima facie*, not based on computation. I have instead chosen to interpret these principles as being applicable to monadology of genetic architecture based on recursion.
30 Martin Davis, *The Universal Computer: The Road From Leibniz to Turing* (New York: W. W. Norton, 2000), 180–7.
31 William Poundstone, *The Recursive Universe: Cosmic Complexity and the Limits of Scientific Knowledge* (Chicago: NTC / Contemporary Publishing, 1985). See also: <http://www.zyvex.com/nanotech/selfRepJBIS.html#vonNeumann Architecture>.
32 John Divers, *Possible Worlds* (London: Routledge, 2002).

Monadology, albeit without its theogony, into an architectural theory of world making. *Monadology* is one of the earliest attempts in sketching out a *system of principles* that generalizes the nature of the world from an abstract point of view; it shares conceptual properties that are now deemed to be fundamental to the science and philosophy of computation. Even though Leibniz was impeded by the lack of conceptual and technical resources at the time, his ideas nonetheless paved the way for subsequent development of computation and, according to Gregory Chaitin, Algorithmic Information Theory[28] in the twentieth century. Leibniz's *Monadology* is arguably the earliest endeavor to propose what is now known as an open-source architecture based on the principles of philosophical genetics: the principle of generative condensation, the principle of combinatorial expansion, and the principle of the conservation of information.[29] *Monadology* is a metaphysical treatise; Leibniz defines each monad as a metaphysical point, an irreducible concept of an atomic entity that is endowed with an immaterial substance. Contrary to Leibniz and without the reference to God as the supreme creator of monads, a computational theory of monadology would instead qualify each monad as one *bit* of information at the most irreducible level, and by extension, a unit of self-replicating system. It is based on this conception of a monad as a minimal unit of self-replicating system that a monadology of genetic architecture is developed here.

Historically, genetic architecture can be seen as an extension and transformation of utopic ideas implicit within the avant-garde to create new worlds by drawing on new sciences and technologies. Genetics is a name coined by William Bateson in 1905 to encompass the whole of the study of heredity but the term *gene* was introduced by the Danish botanist Wilhelm Johannsen, also around the same time, to account for the units within sex cells that determine the hereditary characteristics. The meaning of both terms, genetics and gene, are sufficiently abstract and general enough to be used as concepts that have logical implications for architecture without being anchored too explicitly to biology. Implicit within the concept of genetics is the idea of replication of heritable units based on some rule inherent within the genetic code, and embedded within the mechanism for replication is a generative function: the self-referential logic of recursion. Recursion is a function or rule that repeatedly calls itself or its preceding stage by applying the same rule successively, thereby generating a self-referential propagation of a sequence or a series of transformation. It is this logic encoded within an internal principle which constitutes the autonomy of the generative that lies at the heart of computation.

Even though *genetic* is a term derived from biology, it is used here as a generic concept based on the interconnected logic of recursion and self-replication whose philosophical underpinnings go far beyond the confines of molecular biology. It should therefore be noted that genetic architecture is neither a representation of biology nor a form of biomimesis; instead, its theoretical origins, insofar as genetic architecture is concerned, can be traced to John von Neumann's invention of the cellular automaton and the so-called "von Neumann Architecture" for self-replicating systems. From the early stages of the development of modern computing systems, the idea of self-replication was put forward by John von Neumann.[30] Even though he participated in discussions leading to the development of the first electronic computer ever built—the ENIAC—von Neumann eventually came up with what is now known as the von Neumann Architecture—the prototype for modern computing systems with its stored memory program. The von Neumann Architecture managed to address the idea of a machine that could manufacture itself: a robot that self-replicates and self-constructs copies of itself.[31] This is a notion that lies at the heart of biology: the essence of self-reproduction is organization—the ability of a system to contain a complete description of itself and use that information to create new copies. The von Neumann Architecture for a self-replicating system is the ancestral and archetypical proposal which consisted of two central elements: a Universal Computer and a Universal Constructor. The Universal Computer contains a program that directs the behavior of the Universal Constructor, which, in turn, is used to manufacture both another Universal Computer and a Universal Constructor. Once finished, the newly manufactured Universal Computer was programmed by copying the program contained in the original Universal Computer, and program execution would then begin again. The von Neumann Architecture therefore is a precursor to the architecture of a genetic system.

While most experiments done so far using various kinds of algorithmic systems tend to be reductive and literal in their appropriation of manifest identity or self-expression contained within these systems, genetic architecture has a two-fold ambition: co-evolutionary construction of complex ensembles or possible worlds[32] (*partial universes* in the language of set theory) based on *symbiogenesis*, and disclosure of the sublime *other* within the *same* without identity. The first ambition is concerned with the development of a general theory of world

making based on symbiogenesis: co-construction of possible worlds by autonomous agents within a symbiosis. A symbiosis is an ecology where different agents and organisms interact and live in close proximity with each other. In biology, long-term stable symbiosis that leads to evolutionary change is called symbiogenesis.[33] Here, symbiosis is conceived in terms of a world generated and constructed through viral dissemination: the clustering and mutation of genomic spaces engendered by viral agents. With the capacity for genetic propagation that is neither intrinsically good/bad nor primarily destructive in its function, as it is commonly understood, an architectural virus is a parasitical unit of self-replicating system, a micro-computational monad with built-in mechanisms for absorption and conversion of a given host organism—be it virtual or actual—into a new state of affairs or a possible world. It is predicated on the logic of micro-intervention that leads to macro-transformation at various scalar and specification regimes of transaction, mutation and organization. Viruses usually operate collectively as a distributive system within a symbiotic whole—swarms of infectious monads infiltrate into a given host environment and genetically propagate each of its built-in function(s) in order to alter, modify and transform the information content of both the intertextual as well as the intratextual networks of host organisms. In the process, viruses re-configure and re-organize the metabolism of a host organism into a new organizational entity with a different set of interstitial vestibules and vestigial traces, which, in turn, establish conditions of possibility for further transformation and differentiation into future organisms. New forms of power structures and organizations have shown to emerge through viral interventions that are symbiotic in nature. Even though viral interaction is aleatory in scope, it is deterministic in function. Consequently, autocatalytic reactions of viruses could lead to the conjunctive synthesis of emergent morphology that is fundamentally cohesive. A viral theory of architecture therefore is based on the premise that collective transformation derived from distributive systems whose internal elements or population is embedded with a high degree of generative autonomy could potentially lead to the emergence of a new kind of possible world, one that is intrinsically democratic in its performance and aspiration. The meaning of globalization is radically incomplete and inadequate without an architectural theory of viral infection.

The concept of *world* is a philosophical abstraction transcribed into the idea of a computational entity, which can be scaled to any desired level of manifestation.

33 According to Lynn Margulis and Dorion Sagan, these mergers, long-term biological fusions beginning as symbiosis, are the engine of species evolution. See: Lynn Margulis and Dorian Sagan, *Acquiring Genomes* (New York: Basic, 2002).

34 *Physiovirtual* is a word that I coined, for lack of a term, to address the inextricable linkage and dependency of the physical with the virtual.

35 Eric Steinhart, "Digital Metaphysics," in Terrell Ward Bynum and James H. Moor (eds.), *The Digital Phoenix* (Oxford and Malden: Blackwell, 1998), 117–34.

36 Simulated annealing, neural nets, genetic algorithm and genetic programming all fall under the category of evolutionary algorithm.

37 See Ray Kurzweil's *The Age of Spiritual Machine* (New York: Viking, 1999).

38 Wolfram, *A New Kind of Science*, 392.

As such, it does not presuppose any a priori reference to size or scale. In a general sense, a *world* can be thought of as an emergent phenomenon, an *inconsistent multiplicity*, with its own symbiosis at different scalar and specification regimes of organization. At the level of architecture, a world is an heterogeneous ensemble generated by the symbiotic cooperation of freedoms between monads and human societies. Each monad can be a genotype, a unit of self-replicating system or a phenotype as a collective ensemble with a global morphology. As genotypes, monads exist on the plane of content, and as phenotypes, they are emergent morphology on the plane of expression engendered by massive clusters of micro-monadic interactions. As such, monads exist at various scalar and specification regimes of organization: an object, an aggregation of objects, a building, a group of buildings, a proto-species of genetic architecture, a bionic being, a *physiovirtual* environment, etc.[34]

genotypes → **computation** → phenotypes

the plane of content → **computation** → the plane of expression

Computation is the medium for *in vitro* fertilization of genetic architecture; computing systems are mechanisms in which things build other things. Such things are essentially processes and functions that generate symbolic strings within a computing machine. A string is a list that represents a grouping of atoms such as $((a1, a2, a3)(b1, b2\ (c1)))$ where the symbols '*a*,' '*b*' and '*c*' are *elements* which can also take the role of *functions* within a system of combinatorial interactions based on recursion. As mentioned before, at the core of genetic computation is a recursive engine that calls itself repeatedly; at the heart genetic architecture is an algorithm that constitutes its internal principle. An algorithm is a software program that is more than an instruction set; it should also be understood as a dynamic rational pattern. Software programs may be exceedingly complex but at the level of hardware, only a few operations are repeated over and over again. Programs therefore are orderings of *abstract transformations of abstract states of affairs* and their executions are series of *concrete transformations of concrete states of affairs* that constitutes *histories*. According to Eric Steinhart, "The set of all executions of a program is its 'extension'. As a set of histories, the extension of a program defines its 'nature'. A program is true of a thing exactly to the extent that its nature is co-extensive with the nature of the thing."[35] As opposed to a clockwork or a steam engine, computation is inherently constructive: it is a formal system that enables symbolic structures to build further symbolic structures in a consistent way; these symbolic structures have information content that convey the internal structures of objects.

Given the nature of computation, what is needed in architecture is a theory of the construction of objects in a many-body dynamical setting. It allows for the co-construction of possible worlds based on symbiotic corporation of viral agents within the Sphere of Hyper-virtuality: the global network of computing machines that constitute a monadic organism. The infrastructure of the global system is mirrored and nested within each monad or computing system. Complex organization emerges from the interactions and the synthesis of combinatorial activities within such a constructive dynamical system. It is within such a setting that interactions of symbolic strings can be performed in a manner that lead to the construction of complex symbolic strings, which can then be mapped into geometric expression. It is in this sense that a universal computing system or a network of computing engines can be thought of as a cohesive monad. Although emphasis is given to an internal principle, an organization has many *generators* which are either subsets of an axiom or a compilation of axioms which together constitute the logic of an internal principle. In general, a genetic or an evolutionary algorithm is a well-defined mathematical procedure that generates contingency via some chance process and sifts it via some lawlike process.[36] Even though evolutionary algorithms constitute the mathematical underpinnings of Darwinian theory, most of these systems, so far, are incapable of generating specified complexity without having to smuggle in fitness criteria from the outside. Defining fitness is tantamount to bringing in pre-existing notions of specified complexity: it requires the input of intelligence from outside of the system. This may change in the future, however.[37] Wolfram has gone so far to say that the Darwinian approach to natural selection, contrary to accepted wisdom, reduces rather than generates complexity.[38]

At the crux of the problem lies the efficacy and power of genetic codes. Leibniz's Principle of Sufficient Reason provides the basis for comparing two contemporary approaches, which appear, on the surface, to be diametrically opposed to each other: Wolfram's theory of cellular automaton and Chaitin's Algorithmic Information Theory. Leibniz stipulates that for every truth whatsoever, there is a sufficient reason for its being so rather

than otherwise. Wolfram's idea of the physical universe as generated by a simple set of cellular automaton rule affirms Leibniz's stipulation. Chaitin, based on the idea of program-sized complexity, suggests that it is theoretically impossible to prove the absolute sufficiency of an algorithm. Since computation is about the ordering of information, Chaitin's formulation of Algorithmic Information Theory establishes close connection between the physics of entropy, which is a probability measure of the amount of disorder or randomness within a system, and information. Chaitin remarked that while his own research deals with software "complexity," Wolfram is concerned with hardware "simplicity."[39]

Echoing Leibniz's Principle of Sufficient Reason,[40] Wolfram remarks that the existence of such a simple program "would validate the idea that human thought can comprehend the construction of the universe."[41] Wolfram's use of cellular automata is perhaps the clearest, purest and most effective in exposing the unadulterated behavior of generative systems: one dimensional cellular automaton. Based on his experiments, Wolfram arrived at the counter-intuitive notion that simple rules can generate complex outcomes, and the physical universe is one such outcome[42]: a totally deterministic system without randomness. Any random phenomenon that we see in nature, according to Wolfram, is merely pseudorandom.[43] In other words, it is the clearest example of the Principle of Sufficient Reason manifested through cellular automaton. The formal sufficiency of reason behind a rule set, Wolfram argues, cannot be given ahead of time due to computational irreducibility:[44] there is no way to predict the outcome of computational processes ahead of time by traditional methods based on mathematical formulation; the only way to find out is to let the system run and then wait to see what the results are.

Gregory Chaitin, on the other hand, formulated the Algorithmic Information Theory[45] based on program-size complexity. In consonant with Wolfram's computational irreducibility, the following set of diagrams illustrates his thesis:

> The basic idea of algorithmic information theory (AIT) is that a scientific theory is a computer program, and the smaller, the more concise the program is, the better the theory!
>
> [...] The central idea of algorithmic information theory is reflected in the belief that the following diagrams all have something fundamental in common. In each case, ask how much information we put in versus how much we get out. And everything is digital, discrete.

39 Gregory Chaitin, "On the Intelligibility of the Universe and the Notions of Simplicity, Complexity and Irreducibility" [online text], <http://www.umcs.maine.edu/~chaitin/bonn.pdf> (2002).

40 The Principle of Sufficient Reason stipulates that for every truth whatever, there is a sufficient reason for its being so rather than otherwise. See section 32 in Nicholas Rescher, *G. W. Leibniz's Monadology* (Pittsburgh: University of Pittsburgh Press, 1991), 116.

41 Wolfram, *A New Kind of Science*, 465.

42 Wolfram, *A New Kind of Science*, 23–41.

43 In addition, Wolfram arrived at the provocative insight that computation will eventually dispense with Calculus once and for all since computational processes, especially cellular automata, can emulate any thing that exists in nature without having to rely on differential equations.

44 Wolfram, *A New Kind of Science*, 737–49.

45 Chaitin, "Leibniz, Information, Math and Physics."

46 Chaitin,"On the Intelligibility of the Universe and the Notions of Simplicity, Complexity, and Irreducibility."

47 Gödel came up with his monumental treatise titled, "The Theory of Incompleteness and Undecidability," in 1931 for his PH.D. thesis. The theory is in response to David Hilbert's call for the completion of the entire field of mathematics once and for all. Alan Turing later provided a constructive interpretation of Gödel's results by placing them on an algorithmic foundation: there are numbers and functions that cannot be computed by any logical machine.

48 Gregory Chaitin, *The Limits of Mathematics* (London: Springer-Verlag, 1998), 1–27.

49 Chaitin, "On the Intelligibility of the Universe."

50 Chaitin, *Exploring Randomness*, 21.

51 Zurek (ed.), *Complexity, Entropy and The Physics of Information*, 137–48.

52 Krzysztof Czarnecki and Ulrich W. Eisenecker, *Generative Programming: Methods, Tools, and Applications* (Upper Saddle River: Addison-Wesley, 2000).

Shannon information theory (communications engineering), noiseless coding:

encoded message → **decoder** → original message

Model of scientific method:

scientific theory → **calculations** → empirical/ experimental data

Algorithmic information theory (AIT), definition of program-size complexity:

program → **computer** → output

Central dogma of molecular biology:

DNA → **embryogenesis/ development** → organism

Turing/Post abstract formulation of a Hilbert-style formal axiomatic mathematical theory as a mechanical procedure for systematically deducing all possible consequences from the axioms:

axioms → **deduction** → theories

Contemporary physicists' efforts to find a Theory of Everything (TOE):

TOE → **calculations** → universe

Leibniz, *Discourse on Metaphysics*, 1686:

Ideas → **Mind of God** → the World

In each case the left-hand side is smaller, much smaller, than the right-hand side. In each case, the right-hand side can be constructed (re-constructed) mechanically, or systematically, from the left-hand side. And in each case we want to keep the right-hand side fixed while making the left-hand side as small as possible. Once this is accomplished, we can use the size of the left-hand side as a measure of the simplicity or the complexity of the corresponding right-hand side.[46]

Building on the results of Gödel and Turing's analysis on the logic and limitations of computing programs,[47] Chaitin makes the provocative assertion that the mathematical universe is intrinsically random and infinitely complex. There are mathematical truths that are true for no reason; they are true by accident.[48] Therefore, there is no hope of ever compressing the entire universe of mathematics by an elegant code as Hilbert suggested.[49] He proposed a definition of a random sequence as one that cannot be algorithmically compressed: the shortest description of a random sequence is simply the sequence itself. On the other hand, Chaitin's program-sized complexity enabled him to discover a real number for the Alan Turing's halting probability: Ω, whose numerical value is maximally unknowable.[50] "Ω is the probability that an arbitrary computer program will eventually halt. Ω is computable in a weak sense, but its binary digits or bits are algorithmically random and cannot be distinguished from the result of independent tosses of a fair coin," remarked Chaitin. Ω has no pattern or structure. What is interesting is that Ω shares two apparently irreconcilable properties: "algorithmic randomness" and "computable enumerability." Related to this, Charles Bennett has coined the term *logical depth* to designate the problem of time-complexity involved in computation.[51] Since randomness pervades everywhere in mathematics as well as in nature, there is no choice but to add new axioms to an existing set of axioms within a program in order to generate specified complexity. Even if there exists such a Principle of Sufficient Reason, it is theoretically impossible to prove that a particular program in question is, in fact, the shortest string or the most efficient and optimal one.

Given such a situation, Chaitin's discoveries necessitate the principle of combinatorial expansion on the grounds that no software program is ever complete or absolutely decidable with regard to its potential affects. In other words, a genetic program is an open-ended system that can incorporate new axioms and fitness criteria into its existing matrix of axioms in order to generate specified complexity. Ideally, a generative program should be a self-reproducing and self-organizing system with the capacity to generate and evolve other self-reproducing programs.[52] Furthermore, this principle is reflected yet on another level in the concept of the Adjacent Possible: a multiplicity that grows through viral dissemination and mutation over time. The Adjacent Possible is bidirectional: expansion into the networks of interiority as well as extending into the global matrix outside of a monadic organization or agency. In addition to combinatorial activities and synthesis of symbolic

strings within a computing environment, it also applies to the infiltration of nanobots[53] into the body of Man. Everything that is both inside and outside of the body becomes intertwined to form a social organon: an interconnected plenum that forms the world-wide Web of Existence. In other words, genetic architecture is that aspect of process cosmology which involves the generative construction and weaving of *physiovirtual* environments, each of which is a world unto itself. In other words, the principle of combinatorial expansion is essentially about part/whole relationships where the increase in magnitude of the whole is a function of the multiplication of parts.

In this respect, there are two kinds of aggregation with regard to combinatorial expansion: the first is a heap or a grouping with no internal connection; the second is an organized clustering of units having a regulatory network of some kind. An interconnected aggregation of computing monads is a set of entities that continuously regenerates itself by transformation pathways; the matrix that provides connectivity is irreducible. A monadic ensemble can be either one of these two kinds of aggregation or a combination of both. A point to note is that monads are patterns that supervene on other patterns. Each monad is a fractal system and the clustering of monads thereby leads to the emergent patterns of organization. These patterns, in turn, supervene onto other patterns in order to arrive at the autogenetic construction of a monadic ensemble or a possible world: proto-species of genetic architecture. Such a possible world of architecture can be a complex object or building, evolutionary games, interactive virtual environments, etc. The complete overall coordination of monadic agents are so many representations of one single complex world system, each depicting this common universe from its own point of view. Clearly, there is nothing more fundamental to the construction of possible worlds than the principle of the conservation of information.

Given the abstract nature of genetic architecture, it would be helpful to illustrate the concept of genetic space by providing a glimpse into the sublime world of a fiction that has inspired many a theoretician involved with the phenomenon of computation: *The Glass Bead Game* by Herman Hesse. *The Glass Bead Game* can be interpreted as the embodiment of the ambitions of computation. By encapsulating the logic of the universe, which Wolfram is currently attempting to do, it exemplifies the fulfillment of instrumental reason in a monadic *organ*. As a novel, it clearly establishes precedent for the concept of the world understood as a simulacrum, which

53 Kurzweil, *The Age of Spiritual Machines*, 139–40.

54 *The Matrix* (1999), directed by Larry Wachowski and Andy Wachowski, is the story of a world generated by computation and the protagonists who try to escape from the hegemonic control of the system. The story however distinguishes the real world from the virtual world.

55 *eXistenZ* (1999) is directed by David Cronenberg. It has a plot that seems to blur "what's real and what's not real?" The world of *eXistenZ* is in the future, and it is about a video game controlled by a joystick that looks something like an internal organ. You interface directly with the game by inserting a umbilical cord like tube into your "bio-port," a small hole in the small of your back. Once plugged in, the game takes you to a virtual reality without leaving the confines of your own room.

56 Hermann Hesse, *The Glass Bead Game: Magister Ludi* (New York: Bantam, 1972), 6.

57 It should be noted that such a monadic system does not necessarily entail a despotic regime built up on a hierarchical system as implied by Deleuze. It is more the case that monadic systems of organization are intrinsically free and self-organize themselves without dependency on a given hierarchical system.

58 David Deutsch, *The Fabric of Reality* (New York: Allen Lane, 1997), 3.

59 Deutsch, *The Fabric of Reality*, 3.

60 Deutsch, *The Fabric of Reality*, 132.

61 Rudy Rucker, *Infinity and the Mind* (Princeton: Princeton University Press, 1995), 194.

can be reproduced ad infinitum. It is therefore not surprising to find resonance of this idea in such sci-fi films as *The Matrix*[54] and *eXistenZ*.[55] Bear in mind that this quotation is interpreted as an extrapolation of a possible world based purely on the metaphysics of computation.

> All the insights, noble thoughts, and works of art that the human race has produced in its creative eras, all that subsequent periods of scholarly study have reduced to concepts and converted into intellectual property—on all this immense body of intellectual values the Glass Bead Game player plays like the organist on an organ. And this organ has attained an almost unimaginable perfection; its manuals and pedals range over the entire intellectual cosmos; its stops are almost beyond number. Theoretically this instrument is capable of reproducing in the Glass the entire intellectual content of the universe.[56]

The Glass Bead Game is a magisterial exposition of a fictional world by Herman Hesse, who was unmistakably influenced by Leibniz among others. The Game, of course, is an idealization of a possible world in which the logic of universal computation is embedded and folded into its matrix of social organization: the embodiment of machinic intelligence into the social organon whose internal organ(s) could model the behavior of itself as well as the entire universe. Leibniz was careful to acknowledge the incompleteness and imperfection of monads with regard to the embodiment of absolute reason. The *organ* in Hesse's novel however is endowed with the capacity to engender the entire intellectual content of the universe. It exemplifies, in fictional form, the fulfillment of the dream of instrumental reason couched in the organic, albeit musical body of a *socius* or social body-with-organs, in contradistinction to Deleuze and Guattari's notion of body-without-organs.[57] *The Glass Bead Game* is an example of a world order that has completely saturated the information content of the entire universe into its system of organization and transformation. The premise of the story lends support to John Wheeler's argument that the world, at a very deep bottom, has an immaterial source and explanation that is information-theoretic in origin. As such, the *organ* in *The Glass Bead Game* is a universal computing system with built-in genetic properties whose theoretical orientation, albeit augmented by Kurt Gödel's Theory of Incompleteness and Undecidability, is central and necessary for a philosophical genetics of architecture.

The basis for such an *organ* is not without theoretical support, at least in principle, from the science of computation: the Church-Turing Hypothesis as mentioned earlier. This hypothesis as proposed by Turing, according to David Deutsch, a physicist working on quantum computation, is "a quasi-mathematical conjecture that all possible formalizations of the intuitive mathematical notion of 'algorithm' or 'computation' are equivalent to each other."[58] This is a non-physical view that has been re-formulated by Deutsch as a physical principle. Correspondingly, Deutsch reframed it as the Church-Turing Principle: "Every finitely realizable physical system can be perfectly simulated by a universal model computing machine operating by finite means."[59] Deutsch further re-interprets the above interpretation by calling it the Turing Principle, which states that, "There exists an abstract universal computer whose repertoire includes any computation that any physically possible object can perform."[60] This is an astonishing proposition that is founded on the paradigm of quantum computation as opposed to the classical model of computation which is based on the Universal Turing Machine. The Turing Principle establishes the equivalence between the universe generated by the laws of physics and the universe engendered by the laws of computation, as implied by the Principle of Computational Equivalence. In other words, the universe is a computational monad. So are the outputs of genetic architecture.

As a compliment to this co-evolutionary construction of possible worlds, the second ambition of genetic architecture deals primarily with sublimation. Sublimation is a high level notion that has, at this stage, no clearly defined relation to computation. Monadology of genetic architecture seeks to accomplish this by sublating factual as well as counterfactual states of affairs into a phenomenology of non-objective being. In other words, it is the condensation and the figuration of anonymity which points to the sublime threshold as represented by the noumenal *it* of existence. Sublimation, therefore, is about the overcoming of manifest identity contained within an object/species by further disclosing the *other of itself* within itself. Another way of understanding the paradox of the *other* within the *same* is from the principle of genetic formation of sets[61] in set theory: no set is a member of itself. The universe of set theory, like architecture, is a *Many* that does not allow itself to be thought of as a *One*. Architecture, seen in this light, is conceived as a *quasi-transcendental* notion, an indefinable singularity that is in excess of the set of all possible worlds. As a global concept that signifies an inconsistent multiplicity, *architecture* is pure excess to every specific appropriation of architecture. Every instance of architec-

ture is already implicated in a quasi-transcendental appropriation of the *other*, understood as the Absolute, which, paradoxically, is co-extensive with the *same*. The other is pure excess within the Absolute, which, in principle, cannot be totalized by the same. The reality of nonobjective being situated at the sublime threshold is arrived at by means of a negative dialectics that progressively engage in the transformation of affects produced at every stage of developmental organization. In so doing, the logic of sublimation enables architecture to overcome semiological references to identity, objects and meaning.

the plane of content → **sublimation** → the plane of nonobjective being

Finally, in the attempt to develop a new metaphysics of genetic architecture, we should not lose sight of the fact that what was originally a metaphysical desire to attain omniscience through abstract reasoning has now acquired the garment of the Emperor's new clothing: the instrument of geo-political power and globalization through genetic computation. Computation can be considered genetic to the extent that it is based on the logic of recursion and recursive functions are self-referential procedures that call themselves over and over again, thereby engaging in the propagation of hereditary characteristics inherent within a system. Let it suffice for the moment to say that computation is not only the medium but the power behind the message. The Nietzschean will to power has become synonymous with the power of computation, which can also be translated as the computation of power. Computation therefore is not merely another technological innovation but ultimately a consequence of the metaphysical desire to uncover the Code of Life, and along with it, the invention and the construction of abstract machines that could engender possible worlds. Given this orientation, computation is now increasingly looked upon as the reality engine channeling out that most abstract of immaterial substances—information—into the world. Such an outlook, as provocative and controversial it may seem, points to the undeniable fact that information occupies a far more fundamental position than the other two parameters of physical existence: energy and matter.

Correspondingly, value will be defined in terms of information. Since the concept of value is intimately connected to the source and sustenance of power, it is being defined not in terms of quantity but instead in

62 Kevin Kelly, "God is the Machine," *Wired*, 10:12 (December 2002), 180–5.
63 Frank Tipler, *The Physics of Immortality: Modern Cosmology, God and Resurrection* (New York: Doubleday, 1995). See also David Deutsch's interpretation in *The Fabric of Reality*, 347–59.
64 See Jorge Luis Borges, "The Library of Babel," in Donald A. Yates and James E. Irby (eds.), *Labyrinths: Selected Stories and Other Writings* (New York: New Directions, 1964), 51–8.
65 Kurzweil, *The Age of Spiritual Machines*, 119.
66 Friedrich Wilhelm Joseph von Schelling, *The Ages of the World* (Albany: SUNY Press, 2000), 4.
67 Kauffman Stuart, *At Home in the Universe: The Search for Laws of Self-organization and Complexity* (New York: Oxford University Press, 1995). See also Mark Buchanan, *Nexus: Small Worlds and the Groundbreaking Science of Networks* (New York: W. W. Norton, 2002).
68 Howard Bloom, *The Global Brain: The Evolution of Mass Mind from the Big Bang to the 21st Century* (New York: John Wiley & Sons, 2000). Even though Bloom was concerned with the general interconnected nature of knowledge, culture and history from pre-historic times to the present without emphasizing the mediation of networks enabled by computation, what is significant here is the interconnected nature of a global organic intelligence embedded within the virtual matrix, of which the Internet is an early precursor.
69 Kurzweil, *The Age of Spiritual Machines*.

terms of "logical depth" and "algorithmic complexity." In other words, value is a function of how difficult it is to generate the information that is deemed desirable. In this context, nothing is more desirable than the Code of Life, which could at least give the illusion of determination and control of infinite life: the potential fulfillment of the dream for immortality itself. As such, one of the latent ambitions of capitalism is to put into motion the value of Information Capital as that which gives sustenance to the capitalist system of axiomatization. The new locus of power therefore resides within the code. In the midst of the resurgence of what could be considered a logocentric world view, now increasingly understood as an algorithmic conception of reality, all signs are now pointing toward a renewed metaphysics where the plane of immanence is being re-defined in terms of the domain of the computable. Correspondingly, the transcendent dimension of alterity beyond being is that which is beyond the pale of computation: the radically non-computable as demarcated by the principles of computation. Given the power and promise of computation, some have gone so far as to literally identify God with the Machine, albeit a universal computing system, as Kevin Kelly did,[62] which is profoundly misplaced. Be that as it may, this lends further support to the fact that at the heart of computation lie the yearnings of a metaphysical desire,[63] which is inexhaustible.

As mentioned before, one of the ambitions of computation is in establishing conditions of possibility for the embodiment of information simultaneously both inside and outside of our bodies by virtue of being interconnected to the matrix of the social organism at large. Consequently, it would require us to re-conceptualize architecture from one that depends predominantly on the construction of hardware as container and modulator of events and activities to that of intelligent network systems which carry as well as engender bionic information recursively. In this regard, the provocative but insightful question raised by Borges, "Is the book in the library or the library on the book?"[64] calls into question the possible inclusion of one in the other in a manner that defies common sense if not wisdom. Notwithstanding the metaphysical and theological implications inherent in Borges's interrogation, the question discloses the fundamental problem of representation: the ancient antinomy that exists between theory and practice, on the one hand, and the Cartesian split of the mind and body, on the other, is now couched in the form of the difference between software and hardware, and the privileged position that software has over hardware. Finally, after having ushered in the dawn of a new era by computation, speculations such as those once entertained by medieval monks concerning the number of angels that can dance on the tip of a pin no longer appear to be as strange, bizarre and esoteric as we once thought, for the simple reason that all the information content contained in all the books that have ever existed since time immemorial could be compressed, in principle, onto the size of a thing that is at least as small as the tip of a pin.[65]

Unlike preceding attempts at overcoming this dichotomy, which tend to privilege materialist/phenomenological conceptions of the body and its mobility, the reality of simulation promises to eliminate this dilemma with a vanishing mediator by blurring the boundary between the two with feed-back and feed-forward mechanisms, thereby weaving all the nested interconnections of both domains to form a singularity, a virtual monad or an incomplete totality. Lurking within these symbiotic correspondences is the age-old metaphysical desire that drives the phenomenon of computation from its very inception: the search for the *code* that would contain a maximum of possible affects or possible worlds. Lest we forget Schelling's precaution that "the world is not a riddle whose solution could not be given with a single word,"[66] a premonition that is finally confirmed in Chaitin's Algorithmic Information Theory, the physical and logical limits of computation will nonetheless temper and constrain this insatiable desire for omnipotence and total communion with the Absolute. Despite the limitations, and lest we also forget that we are all travelers in the nocturnal abyss of the intergalactic space on a miniscule planet we called Earth, this ambition is now being fueled by the spell of instrumental reason which has taken on the scope of a tragic euphoria, or tragic transport, that seems limitless with regard to its possibilities.

In the meantime, as computing machines are weaving the global network of communication and exchange into an inexorable matrix via the Internet, capitalism is being transformed into a demiurgic system that is destined to become virtually intelligent and alive. Kauffman and others have shown that when the connectivity of nodes within a network reaches a critical threshold or singularity, it takes on an emergent behavior that is akin to an organic entity.[67] Such a global application of neural network systems derived from biocomputation will invariably lead to what at the present seems unthinkable: the emergence of a global brain[68] or intelligence with an internal will to being:[69] a self-organizing and self-synthesizing monad. Consequently, capitalism is in the process of being sublimated from a restricted economy to

a general economy predicated on the transvaluation of all values into the value of Information Capital.

The Principle of Computational Equivalence implies that the physical universe is a simulacrum engendered by computation. With the eventual proliferation of bionic beings and proto-species of genetic architecture populating the Sphere of Hypervirtuality, where the Internet will eventually be transformed into a self-synthesizing and self-organizing organ, virtual artifacts and ghostly phantoms will co-evolve with human societies in a symbiotic cooperation of freedoms. Long after she has departed from this material world, her DNA patented, encrypted and transcribed into digital archives, Madonna—the material girl—will most likely continue to sing and dance, at various scalable regimes of organization and transmutation, with all her provocative passion and seductive gestures augmented by her perpetually renewed sense of immortality. This phenomenal performance, however, will neither take place solely in the corporeal library of Borges nor represented in the incorporeal pages of the book of simulacra, but somewhere in-between—a phantasmagoric chamber of bionic proclivities that would be indistinguishable, if not undecidable, from the global Sphere of Hypervirtuality: an *interconnected but discrete plenum*,[70] which will be propelled, sustained and modulated by the evolutionary dynamism of a demiurgic capitalism that is poised to flourish, with all the vicissitudes that accompany a fantasmatic dramatology of a brave new world, on the horizon of expectation. Welcome to monadology of genetic architecture on the Turing Dimension.[71]

70 Sander Olson, "Ray Kurzweil: Technologies of *The Matrix* Could Soon Be Real" [online text], <http://www.geek.com/news/geeknews/2003Mar/bch20030305018948.htm> (2003).

71 Karl S. Chu, "The Turing Dimension," in Frédéric Migayrou and Marie-Ange Brayer (eds.), *ArchiLab: Radical Experiments in Global Architecture* (London: Thames & Hudson, 2001), 490–4.

Fig. 5 *Outside-in*, collage by MetaXY