Bios Theory of Innovation

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Abstract

An innovation is the materialization of a novel idea. The individual mental creation must be followed by institutional and social processes. Also the mental creation is not purely individual but emerges within a culture and an economic milieu. Innovative change could be serendipitous, even serendipity, however, Pasteur remarked, is not fortuitous, but requires readiness to capture it and transform it into insight. Innovation is the capturing of a creative idea and its maturation as a useful object or procedure. Novelty (i.e. measurable, causal creativity) defines bios. The Bios Theory of Evolution (Sabelli, 2005, 2007) provides a model to promote creative innovation. While the empirical bases of the theory cannot be developed here, the article includes references to relevant scientific publications.

Key words: Asymmetry, Bios, Complexity, Computation, Creativity, Cyclic engines, Dialectics, Levels of Organization, Logic.

Bios Theory of Innovation

Identifying and defining creative and life-like (biotic) processes

Natural, social, and human processes continually create anew (Moreno, 1977; Prigogine, 1980; Sabelli, 2005; Goertzel, 2006). They are creative and life-like (biotic) --not driven to equilibrium, cycling, or chaos. Equilibrium and periodic processes are like chaotic processes in being stable and therefore not innovative iu spite of all the press given to the unpredictability of chaos which might make the latter seem a well-spring of innovation. Yet, a theory of causal creation can suggest how to promote innovation, while random, equilibrium, periodic and chaotic models cannot.

The discovery of Bios (Kauffman and Sabelli, 1998), an aperiodic pattern with the features of creativity (diversification, novelty, complexity) and the 1/f spectrum of natural processes provides a model to study creative processes. Bios is chaotic as being aperiodic, causal, and highly sensitive to inputs ("sensitivity to initial conditions") but typical chaotic processes do not show diversification, novelty, complexity and 1/f spectrum. As creativity is fundamental, bios cannot be reduced to chaos.

Bios is to chaos as random walks (e.g. Brownian motion) are to random series. Bios and chaos are causal, as expected from the conservation of energy and the transmission of action, while stochastic models posit the occurrence of chance events independent from ongoing processes, i.e. without cause. Complex non-periodic patterns are often labeled "noise". As "noise" implies meaningless variation generated by chance, it is not appropriate to speak of "noise" unless chance has been demonstrated and meaning can be excluded.

Bios is a process of causal creation characterized by novelty, ubiquitous in natural and human processes, and generated by the cyclic, repetitive interaction of opposites, as embodied in electromagnetic waves and in cyclic engines at higher levels of complexity.

Causal: Whether physical or human, actions are flows of physical energy, and energy is conserved; thus every action has a consequence, and it occurs in the context of ongoing actions. Processes are sequences of actions, and actions are causal; as they can also be creative, we prefer "causal" over "deterministic". There are no isolated chance events, except as models designed for statistical modeling. (While standard statistics assumes that a process is random unless cause is demonstrated, scientific parsimony advises and common sense cautions to **assume cause unless chance has been proven**). Innovations are creations, not accidents, and they always spring forth from the conjunction of many concurrent forces, conscious and unconscious.

Creation: Biotic patterns are creative, i.e. generate diversity, novelty, and complexity. All processes, including human decisions, occur in the context of evolution from simple to complex --cosmological, biological, social, organizational, and psychological. A human organization is not a fixed structure, but an evolutionary process. Human innovation is an integral part of ongoing creative processes.

Novelty: Because it will be shown here that novelty as such is measurable, so the conjecture that a process is biotic is falsifiable, as required for scientific hypotheses. Stability means repetition, ranging from the minimum of variability inherent in quantum flux and increased by random noise, to long and complex patterns of repetition (periodic or chaotic) that can only be detected with recurrence methods. Conversely, one can measure novelty by quantifying the scarcity of recurrences (Sabelli, Abouzeid, 2003). Periodic and chaotic series show greater recurrence than random (*order*) while creative processes (physical, biological, economic, and

mathematical bios) are less recurrent than random (*novelty*). Human innovations occur in a background continually changing processes. Change is unavoidable; we can only be active or passive participants in ongoing transformations.

Ubiquitous: In support of Bios Theory as a tool for innovation, it is cogent to point out that biotic patterns are found at all levels of organization: (1) Mathematics: prime numbers (Sabelli, 2007) and the related Riemann equation (Kauffman and Sabelli, 2007). (2) Quantum physics: Schrödinger wave function (Sabelli and Kovacevic, 2006) and its relativistic version, the Klein-Gordon-Fock equation (Thomas *et al*., 2006). (3) Cosmology: temporal distribution of galaxies (Sabelli and Kovacevic, 2006) and quasars (Thomas *et al*., 2006). (4) Planetary: air and ocean temperature, river levels, river and shore fractal forms (Sabelli, 2005). (5) Molecular biology: sequences of bases in DNA (Sabelli, 2005). (6) Physiology: heartbeat series and respiration (Carlson-Sabelli et al, 1994; Sabelli, t al., 1995. Sabelli and Carlson-Sabelli, 2003). (7) Biology: population size of several animal species (Sabelli and Kovacevic, forthcoming). (8) Economic series (Patel and Sabelli, 2003; Sugerman and Sabelli, 2003; Sabelli, 2005). (9) Music (Levy et al, 2006). The production of novelty thus is the rule, not the exception.

Cycling of opposites: Mathematically, Bios is generated by recursions of sinusoidal functions that represent the cycling of diametric opposites that together form a circle (see below). A sine wave combines the unidirectional flow of action in time with the cycling of opposites, the arrow and the wheel. Trigonometric models of opposition fit wave theories of nature (from Pythagoras to Fourier, Maxwell, Einstein, and Schrödinger), as well as the helical models of dialectic philosophy. The trigonometric Bios model thus recognizes the leadership that physics should have as a guide for human logic. Physical waves are fundamental constituents of the universe and play a creative role. Electromagnetic waves bond structures and embody and carry information at the atomic, molecular, and biochemical levels, as well as in brain and computers. Their helical pattern embodies a harmonic (sinusoidal) cycling between opposites. Positive and negative electrical charges embody a fundamental opposition. Also gravitational and nuclear forces are waves; gravitation is unipolar, but gravitational attraction is accompanied by its opposite, the expansion of the universe; the nuclear forces that create and transform nuclei are both bipolar also tripolar (see later).

Apparently, also at higher levels of organization biotic patterns are generated by the interaction of multiple pairs of bipolar opposites, such as accelerating and decelerating nerves in the heart, and supply and demand in economics. Here, opposites are understood as synergistic and antagonistic, similar and different, not polar extremes in linear schemes or mutually exclusive classes separated by fixed or fuzzy boundaries. Opposites are multiple, so they connect through intermediate steps in a cycle, not only through gradual transformation in a linear continuum. Innovation occurs in the context of multiple oppositions, and can be fostered by taking advantage of this dynamics (see later).

Cyclic engines: The helical pattern is evident in proteins, DNA and RNA. Multiple bipolar oppositions are likewise essential at higher levels of organization, as illustrated by rotations and cycles, cosmological, meteorological, biological, economic, and many others. Electrical charge, biological sexes, the digital encoding of information, and true and false logical values, illustrate the fundamental role of opposition at all levels of organization. Anabolism and catabolism, cooperation and conflict, supply and demand, abundance and scarcity, each occurs in conjunction with its opposite. We walk with two legs, see with two eyes, and think with two hemispheres. Woman and man make children. Social roles often are paired: manager / employee; teacher / student; doctor / patient. Symbiosis, endosymbiosis and multicellularity are as important as the struggle of species in evolution; history is moved by cooperation and solidarity not only class

struggle; progress results from production and invention more than by competition as pretended by standard economics and logistic models. Concepts are often paired (tall and short, content and form, quantity and quality). Opposite sides processes form and transform each other: content determines form and vice versa; quantitative changes are accompanied by qualitative ones; partially false ideas become truer but still partially false truths; innovations become solidified into structures, and structures serve as templates for innovation.

Complexity: Cycles have at least two dimensions (planar, non-linear); the creation of complexity means the generation of at least one more dimension, i.e. tridimensional patterns and material structures. Material structures are relatively stable nucleations, indicating two important ways to foster innovation: conserve and nucleate. It is essential to conserve nature and culture; progress without conservation is ineffectual and even destructive. Nucleating to form systems occurs spontaneously ("attraction"); e.g. flow of wealth and population (immigration) to centers. Material structures are at least triadic: they have three macroscopic spatial dimensions and they are constructed by quarks of three polarities ("colors") that nucleate to form the atomic nucleus. Threeness is a generic feature of structures also at higher levels of organization, biological (DNA codons, primary visual colors), psychobiological (conflictual emotions, anger, fear and depression), political (executive, legislative and judicial powers), conceptual (thesis, antithesis and synthesis; id, ego and superego; mother, father and child; Trinitarian concept of God), literary (three musketeers, three stooges, three wise men). Mathematically, Sarkovskii's theorem (Peitgen et al, 1992) (period 3 implies infinite harmonies, often reported as "period three implies chaos") suggests the need to involve at least three components to foster innovation; in contrast, two opposites tend to conflict or merge to neutral and neuter equilibrium (e.g. two party systems).

Biotic complexity (as defined by the pattern of living processes rather than by the compressibility of computer programs that paradoxically misrepresent it as randomness (Chaitin, 1987) includes fractality, as observed in chaos, and **diversification, novelty, temporal complexity** (changes in pattern with time), **asymmetry**, and **1/f power spectrum** (Patel and Sabelli, 1993), five fundamental properties of bios absent in chaotic attractors. Bios, but not chaos, may thus account for the widespread occurrence of 1/f patterns in natural and human processes; as also chaos is fractal, fractality does not account for 1/f power spectrum, as often claimed. Diversification is central to creativity. In creative processes, the variance is "infinite" but measuring how the standard deviation grows with time and embedding (diversification) (Sabelli, and Abouzeid, 2003), far from being meaningless, serves to distinguish biotic and stochastic creative processes from static periodic or chaotic series. Promoting diversification thus seems a useful strategy to foster potentially creative innovation.

The demonstration of these multiple properties of Bios is significant. Bios Theory predicts that the multiple properties of biotic patterns (novelty, diversification, temporal complexity, asymmetric statistical distribution, 1/f power spectrum) are associated. This has been found in many different processes (e.g. primes, quantum, cosmological, and economic series). Thus Bios Theory is confirmable, i.e. it advances new predictions, as a scientific hypothesis should do.

While it would be forceful to define Bios by a single, readily measurable property such as novelty, the concept of Bios refers to actual processes, not to mathematical constructs, so empirical detection and description is more important than definition. Bios is part of a theory regarding the generation of creative processes, in contrast to the use of the term "theory" for the vast field of connected studies on chaos and complexity that do not advance specific hypotheses.

The generation of biotic patterns as a model for creative innovation

The generation of biotic patterns serves as a beacon to identify what processes are necessary to innovate creatively. Bios theory suggests how to promote innovation, while stochastic models cannot. We may develop strategies for creative innovation by observing the ways in which we can generate bios mathematically with recursions of trigonometric functions modeling bipolar feedback such as the process equation (Kauffman and Sabelli, 1998):

$$\mathbf{A(t+1) = A(t) + g * \sin(A(t)).}$$

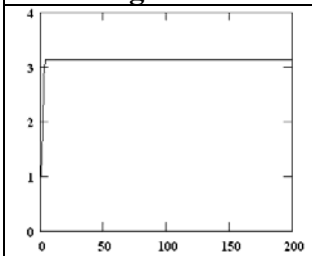
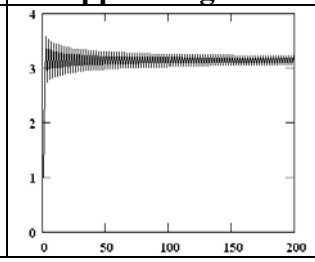
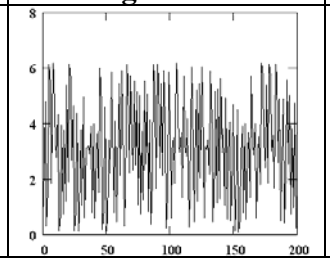
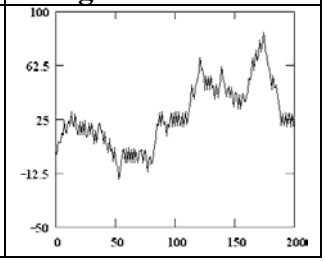
The next value of A, at the next time t+1, equals the value of A at the previous time t (conserved tem) plus a change term g * sin(A(t)), which is a feedback function of the ongoing process; g is the energy of the feedback process.

The feedback is bipolar, positive and negative, sometimes increasing and sometimes decreasing the value of A (synergism and antagonism), as modeled by the sine function. The generation of Bios requires bipolar feedback, which is widely observed in biological and economic processes. In contrast, unipolar feedback (as in the logistic equation), generates chaos but not bios; as economic time series demonstrate biotic pattern, unipolar scarcity cannot account for economic processes, as postulated by standard economics.

Also conservation is necessary to generate bios; recursions without a conserved term generate only chaos, not bios, diversification and novelty. And of course only recursions (repetitive actions), not static equations, generate patterns. Thus the generation of novelty requires three components: **action**, **bipolar opposition**, and **conservation**. This is significant because natural processes, in which the generation of biotic diversification and novelty is the rule, involve the same universal components: (1) physical action (flow of energy in time), (2) bipolar and bidimensional electromagnetic waves, and (3) connection / conservation in spacetime (conservation of energy, stability of matter).

Figure 1 shows the generation of asymmetric equilibrium (one attractor), bifurcation, chaos, and bios by the process equation. Biotic processes are highly **sensitive to inputs** ("initial conditions"), even more than chaos because changes are not restricted to the basin of an attractor. Sensitivity to initial conditions implies that relatively small innovations can have major consequences, supporting the possibility of individual personal action, and giving the lie to the notion of iron laws of behavior determined by biological or economic imperatives.

Figure 1. Patterns generated by bipolar feedback A(t+1) = A(t) + g * sin(A(t))

Stable flow of action g > 2	Bifurcation into opposites g = 2	Chaos g = 4.5	Bios g > 4.6035…
			

Bios contains much greater diversity of properties than chaos, and thereby continually displays novelty. There also are abrupt changes in quality, both within and before bios, as the quantitative value of the feedback gain g increases. Notably, biotic patterns are generated by the (apparently) simple process of accumulating quantity. Numbers and number series abstract fundamental properties of action; prime numbers epitomize causal novelty in the intuitive sense that they are not multiples of any other number. The biotic pattern of the prime series (Sabelli, 2007) demonstrates the role changes in quantity in the generation of novelty and complexity (Sabelli, 2007). However the generation of primal novelty also involves harmonic processes similar to those present in physical waves, as implicit in the Riemann hypothesis and made evident by time series analyses (Kauffman and Sabelli, 2007).

Homologous processes of unipolar action, bipolar opposition and tripolar structure occur at all levels of organization (Table 2), accounting for the widespread occurrence of biotic and other creative processes. Physical, biological, social and personal actions, oppositions and structures are "homologous" (a concept used to describe how arms, legs, fins and wings have a common origin and a similar function). One may metaphorically say that levels of organization are "fractal", although forms obviously do not repeat at quantum, atomic, biochemical, biological and social levels. These generic processes of unipolar action, bipolar opposition and tripolar structure can be tapped to foster creative innovation. But, being creative, they generate new more complex levels of organization with new, more complex processes of creation.

Table 2. Primary processes of creation

	1. Oneness of flow	**2. Opposition**	**3. Structure**
Geometry	Arrow	Cycles (helix, spiral)	Bodies.
Physics	Action. Radiation created matter and matter converts into energy [Einstein].	Energy: positive and negative charge; helical (sinusoidal) waves.	Matter: 3 colors of nuclear force, tri-dimensional stable structure.
Creative processes	Causal, consecutive change	Harmonic opposites (2 poles, 2 dimensions)	Formation and conservation
A[t+1] =	Iteration t+1.	g * sin(A(t))	+ A(t)
Innovative actions	Spontaneity. Unity: interaction of all levels of complexity and of hierarchy.	Modulate energy. Oppose: cooperation and conflict, not only synergy / adaptation, or competition / struggle.	Conserve nature, culture. Templates. Third options.

Hierarchical feedback, an alternative to reductionism and to top-down hierarchy

An innovation is the materialization of a novel idea. Creativity by individuals is only the starting point for innovation. To advance from a novel idea to its materialization as an innovation requires institutional and social processes. To foster innovation is necessary first to foster the development of novel and useful ideas and second to set up general organizational processes for considering and acting on such specific ideas leading to improved or new products, services, or internal processes. Finally the innovation's success depends on the public response. We must turn our attention from the generation of ideas to the collective creative processes. Creative processes involve the *formation and transformation of material structures.* Creative processes thus generate new and more complex levels of organization. As physical and biological processes are creative, all processes and structures are organized in levels:

Physical < Chemical < Biological < Social < Psychological,

From larger and older to smaller and newer; each level is included within the larger simpler process, and includes within its complex pattern the simpler processes that form them.

Evolution proceeds from the simple and universal physical level to progressively more complex and localized levels (*priority of the simple and global*), but in turn the more complex process feedback on the simple ones and predominate locally as result of their greater density of information and creativity (*ascendancy or supremacy of the local and complex*) (Sabelli, 1989). The global is primary, not the result of the collective action of individuals, but the manifestation of primary processes common to all individuals and that creates them. In turn the individual and collective action of individuals generates a still more complex level; self-organization results from co-creation among many. In turn the complex modifies and controls the simple. There are hence creative cyclic interactions not only within each of these levels of organization but also between them ("hierarchical feedback").

The central nervous system (CNS) provides a model for natural systems because, as all others, it embodies and makes material the fundamental processes. The human body itself and the CNS in particular, illustrate these fundamental organizations in three anatomical axes. The front and back axis is associated with movement (action) and is characterized by asymmetry. So one can walk forward very easily, but one cannot so easily walk backwards. Sensory information reaches the back of the CNS, and motor information exits it from the front. Within the CNS, the each synapse transmits information unidirectionally. Having discovered that all biological molecules are asymmetric, Pasteur proposed that fundamental cosmic processes are asymmetric. Indeed time is asymmetric and changes are irreversible, even if current microphysics has not as yet demonstrated time asymmetry; all macroscopic actions demonstrate asymmetry and irreversibility, herein including innovative actions.

The second horizontal axis- right and left- is associated with duality, opposition and symmetry. For instance, one has two eyes, two arms, two legs, etc. In the CNS, symmetry is evidence at the lower spinal level, and asymmetry emerges at the higher more complex, brain levels. Symmetries are evident in fundamental physical processes, and oppositions occur in practically all processes. The coexistence, similarity, and union of opposites has been considered since antiquity (Heraclitus, Lao-tzu) and explored in our times (Hegel (Trans.) Miller, 1989; Engels 1960; Bohr, 1987; Sabelli, 1989, 2005); it led us to interpret the generation of bios by trigonometric functions as bipolar feedback and subsequently identify bipolar feedback as a creative process in biological and social processes. All processes demonstrate symmetry, so attending to them may foster innovation. In fact opposing what is taken as standard is a simple way to design innovation.

Finally, the third axis- the vertical, is characterized by its progression from the simple to the complex, i.e. one's feet are far less complex than one's head, and brain is more complex than the spinal cord. Pavlov stressed "cortical supremacy". This vertical hierarchy, its division into levels, and the fact that higher levels control and often inhibit the lower ones, while the latter provide their input and mediate their output, was highlighted by the British neurologist Hughling Jackson, who related it to evolution. Indeed evolution generates levels of organization in nature. Based on Jackson-Pavlov views on the CNS, we developed the notion of hierarchy as a bidirectional process, where the simpler, older and more global levels run the processes because of their priority while newer, local, and complex processes govern as result of their greater creativity and complexity. The hierarchy turns out to be a two- way interaction. Applying this concept to

clinical practice we proposed the notion of *biological priority and psychological supremacy as a principle of clinical medicine* (Sabelli and Carlson-Sabelli, 1989).

In its relation to one's brain to the heart can be said to have priority where the brain has supremacy. The heart is necessary for life, but it is the information that the brain processes and sends to the heart that communicates to it *how* to beat in response to behavioral and physiological needs. This information that is communicated by the brain to the heart passes through two nerves serving opposite function; one of which transmits to the heart the orders to slow down while the second transmits the orders to accelerate.

The *principle of priority of the simpler and older and supremacy of the newer and complex* (Sabelli, 2005) is central to social, organizational, and psychological hierarchies: social roles are determined before psychological individuation; e.g. a newborn has a determined age, sex, family, community, class, race, and religion *before* developing as an individual. The principle of global priority is also evident at the physical level, where physical regularities are universal laws and include phenomena such as quantum entanglement. The supremacy of the local and complex in turn implies that individuals can overcome global processes. This is so because many complex processes are chaotic or biotic, both patterns being extremely sensitive to small actions such as human interventions. However there are no individual solutions to organizational or social (environment, poverty, health care) issues. Creation is a collective process. Innovations are naturally developed by those who work directly in production, so rational and creative management foster their active participation.

Unfortunately class divisions and conflicts go against active workers' participation. The reality of a mutual, bidirectional process of *hierarchical feedback* also applies to organizational hierarchies. Those on the bottom provide the power of those on top, and lend them authority. The weaker are collectively more powerful than the powerful. Innovations are naturally developed by those who work directly in production, so rational and creative management foster their active participation. Unfortunately class divisions and conflicts go against it. Overall changes in the hierarchical relation between generations, sexes, classes and races during the last century lend credence to the notion that fundamental social innovations are beginning to undermine the structures of oppression built by centuries of patriarchy, slavery, and exploitation but there has been a return to exploitative practices in the last twenty years. There is a contradiction between bottom-up ideal democracy and the top-down governance of corporations. Often, innovations are imposed within organizations or in the market in a top-down fashion. Because of its property of emerging from iterations of oppositonal factors, bios can model the kinds of hierarchical feedback needed for innovation in organizations and societies.

Innovating computation

Illustrating these concepts, let me discuss how I see them operating in our current development of an idea that we expect to lead to a significant innovation in computation. We are exploring the development of new logic for computation that matches the logic of quantum physics and thereby will also adapt our humanly-conceived computer logic to the actual logic of nature (Sabelli and Thomas, 2008) and will allow the full use of quantum processes for computation. Regarding innovation, this logic may serve to foster creative thinking and management.

The "general purpose" digital computer is constructed with electrical circuits as the logical gates that represent Boolean logic functions corresponding to a mechanical, static, non-evolutionary world view in which opposites exclude each other as they do in the case of abstract

mathematical objects (principle of no contradiction).The current approach to quantum computation likewise forces a static logic in which opposites exclude each other on quantum devices. In contrast, quantum processes involve actions (rather than static states) and the universal superposition of opposite states (e.g. spins). The superposition of quantum opposites may allow us to generate complex logical functions beyond those of Boolean logic. The logical connection between this view and quantum logical gates is Bios Theory, and the demonstration of bios in quantum processes (Sabelli and Kovacevic, 2006; Thomas et al, 2006). The project of such a quantum computer is discussed in a current publication (Sabelli and Thomas, 2008), here, however, I shall focus on the process of developing the proposed innovations.

Our project for a future quantum computer is also based on process philosophies going back at least as far as Heraclitus rather than static structures or immaterial ideas. Following the rediscovery of Heraclitus texts, this concept was named dialectics by Hegel and made famous by Marx and its followers, although other versions of dialectics were also developed. Our first step was to combine the process viewpoint of dialectics with a mathematical formulation as it had been done for standard logic (Sabelli, 1984). I also revised dialectic theory by incorporating mathematical, physical, biological and psychological perspectives which led us to the concept of Bios and creative processes (Sabelli, 2005). The next step in the process of developing a new logic for computation required collaboration with the physicist Gerald Thomas who, for his part, brought the concept of decision gates, in this manner we sketched a new logic that we called biotic because it focuses on creativity and its generation by the interaction of opposites.

Table 3 compares the Biotic Logic with Boolean and dialectic logics. Classic logic as well as dialectics is formulated verbally; mathematization is necessary for computation. Boolean logic resorts to set theory. The scientific description of natural processes requires employing lattices, groups and topology, the three pillars of mathematics (Bourbaki, 1948). Also physics itself provides concepts that can be incorporated into logic. For instance, to go beyond the static perspective of Boolean logic, so contradictory to all we know about the world we inhabit, and adopt a evolutionary perspective, we resort to the concept of action, so the static identity A=A is replaced by a recursive process in which A(t+1) is a function of A(t). This embodies the dynamic approach of dialectic logic but formulates it in terms of modern physics. Likewise opposition is formulated in term of group inverse, so opposites imply each other (e.g. action and reaction; particles and anti particles; sexes); group theory is of course central to modern physics.

Table 3 Biotic, Boolean and Dialectic logic

Logic	**Biotic**	**Boolean**	**Dialectic**
Identity	Recursion A(t+1) = f(A(t)). Physical action, the integral of temporal change in energy	Static A = A, valid for mathematical entities and for static structures	Dynamic, as evident in sociology and psychology
Implication	Mutual implication of opposites. Particles and anti-particles, action and reaction, sexes.	If-then deduction. False implies truth.	Proof by refutation of the opposite.
Opposition	Electrodynamics. Paired opposites that are similar, synergic and antagonistic. 2^N bifurcations.	Mutual exclusion of opposites. Differences stressed. Black or white thinking.	Contradiction (Hegel) and conflict (Marx) are universal.

Implication and exclusion of opposites	Mutual implication of opposites. Exclusion of identical fermions (Pauli)	Mutual implication of complementary sets. Mutual exclusion of opposites in Logic.	Coexistence and separation stressed in different contexts.
Information	Information = difference between opposites	Separate information theory, probabilistic, using logical values 0 and 1	Separate information theory, developed along the same lines
Logical operations	Composition modeled by physical and chemical connections	And, Or	Dialectic synthesis, no formal model
Quantity and Quality	Quantitative factors in quality changes in biological and physical development, and in catastrophes, chaos, bios and leaps. Fractal self-similarity.	Separate categories.	Necessary and non-linear relation. Dialectic leaps.
Quality	Dimensions	Classes	Classes (e.g. socio-economic)
Simplicity and complexity	Priority of the simple and supremacy of the complex	Focus on simplicity; complex analyzed into simple components	Focus on single composition, material (Marx) or ideal (Hegel)
Logical properties included	Asymmetry (action) and symmetry (negation), non-commutativity, direct and indirect transitivity	Reflexive identity, asymmetric negation, directly transitive implication	Not formalized but implicit asymmetry and direct and indirect transitivity
Computation	Planning quantum computer with biotic logic	Digital computer, developing quantum computer with Boolean logic	No computer application
Human processes	Causal and creative development through synergy and conflict. Health initiatives: Sociatry (collective psycho-therapy); Bio-socio-psychological medicine.	Static models. Unchanging human nature. Competition leading to conflict (Malthus, standard economics, Social Darwinism, racism).	Conflictual models (Marxian class war, Freudian oedipal conflict)
Innovation processes	Causal and creative development by synergy and conflict (bipolar feedback)	Mechanical determinism. Innovation only by chance.	Innovation by synthesis. Frequent use of deterministic models.

We will welcome the work of others to transform these ideas into actual innovations in computer programming and design.

Summary and Conclusions

In summary, human as well as natural innovation occurs in the context of ongoing creative development, that is to say, evolution from simple to complex generated autodynamically in a causal manner, not through a process of unexplained and completely unpredictable emergence as result of random interactions. Creative innovations require not only spontaneity but also the conservation of previously acquired knowledge (Moreno, 1977).

We can create only insofar as we can co-create with others, so reversing roles with them and understanding their needs, wants, beliefs, and ways of thinking are essential. Preventive peace can succeed, while preventive war simply creates new enemies thereby guaranteeing our defeat.

To promote innovation we must recognize the ongoing flow, cut across it in a diagonal fashion, neither aligning ourselves with it (non-creative) not opposing it frontally (ineffective), and generating third options orthogonal to both of the current opposites, and further diversifying by spontaneous variations based on the material bases and the informational templates offered by the existing culture.

For practical purposes it is sensible to convey these theoretical concepts regarding creative innovation as simple rules of thumb, as templates to foster and select innovation. This is the focus of a companion article.

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