Co-creation, the motor of natural evolution and social health [1]

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"All is number." Pythagoras

" …the universe is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures, without which it is humanly impossible to understand a single word of it."
Galileo Galilei.

"War is the Father and Peace is the Mother of all things." Heraclitus.[2]

"Matter at each level of complexity appears to consist of two interdependent nonidentical elements in dynamic interaction and in integral relationship to each other. It appears that an interaction, dynamic asymmetrical binary relationship is the fundamental module of order in the cosmos. (…) This may account for the trend toward increasingly complex relationships in all forms of matter and even the importance for close and harmonious relationships among human beings."
Jonas Salk, discoverer of the first safe and effective polio vaccine

"Wherever the art of medicine is loved, there is also a love of humanity"
Hippocrates

"Medicine is a social science, and politics is nothing but medicine on grand scale."
Rudolf Virchow, founder of cellular pathology and of social medicine.

Abstract

This work presents the thesis that natural creativity is the causal motor of evolution and history. Natural and human processes are biotic (life-like) and creative. They result from simple and well defined causes, rather than random changes, and create diversity, novelty, and complexity. These processes can be changed by modest additions of input such as human action. On this basis, this article develops a set of six hypotheses that sketch a theory of natural and human evolution. These principles are: (1) Causal action: action (energy and matter continually changing in space-time) is the fundamental constituent of reality. (2) Opposition is universal, bipolar and creative. (3) Triads of complementary entities co-create tridimensional matter, stable structures, and complex systems. (4) Natural creation: Creative mechanisms are key component of physical, biological and human processes. (5) Changes in quantity generate changes

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[2] The second part of this statement has been omitted since antiquity, but obviously Heraclitus, who always focused on opposites, must have meant to include both war and peace, father and mother.

in quality and complexity, and changes in complexity generate changes in quantity. (6) Processes are organized hierarchically according to their rate of energy flow, their mass and size (matter) and their complexity (information). These three hierarchies are related but different. Each hierarchical relation is bidirectional, one pole predominating in one respect and the other predominating in a different one (priority and supremacy).
These principles provide a method to promote social health.

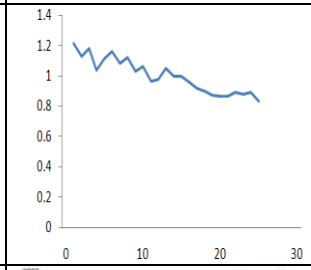
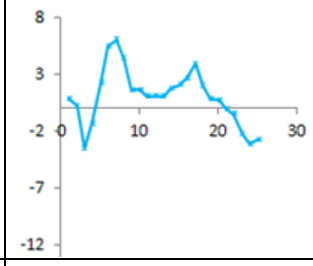
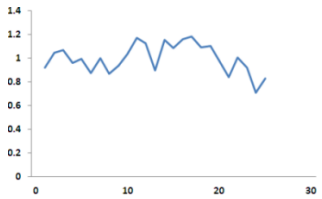
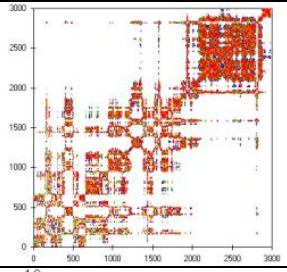
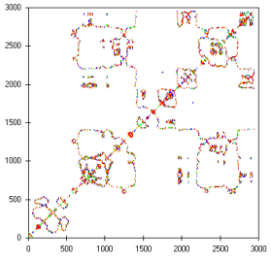
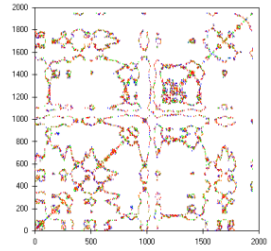
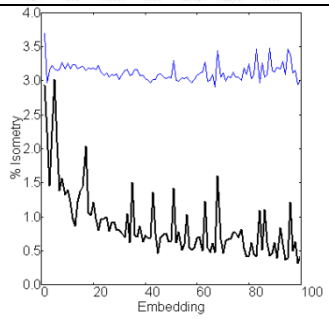
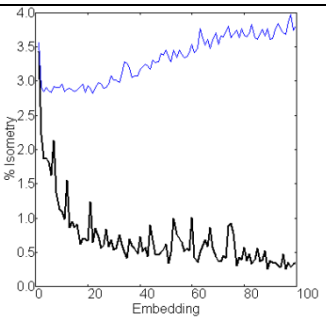
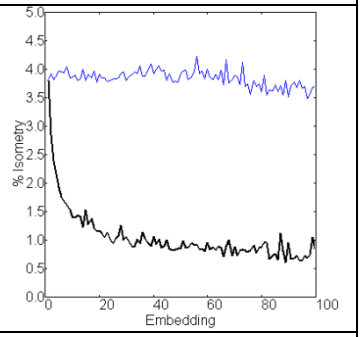
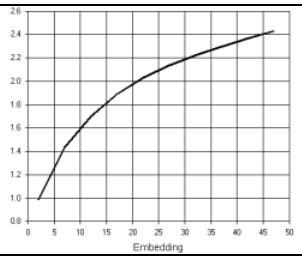
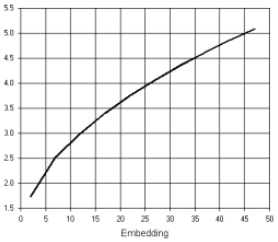
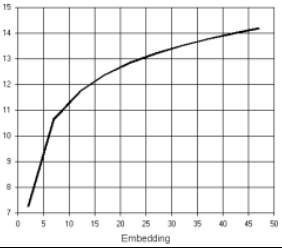
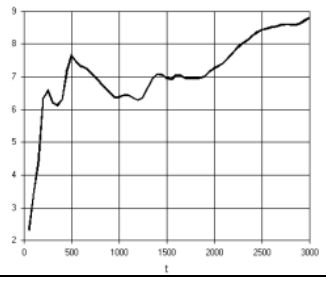
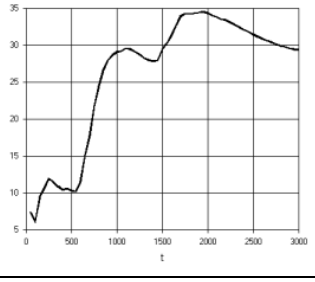
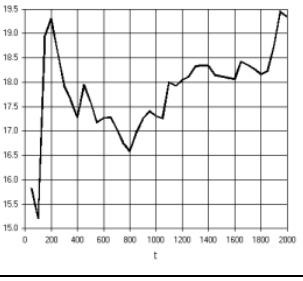
Introduction

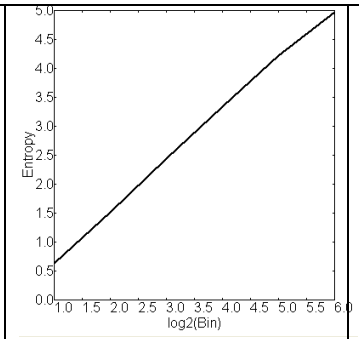
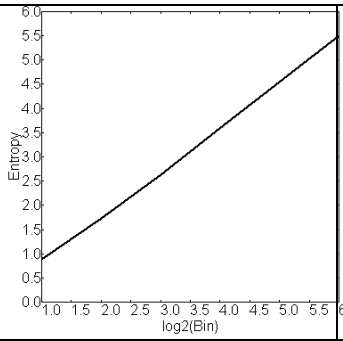
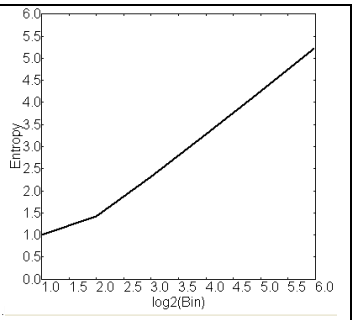
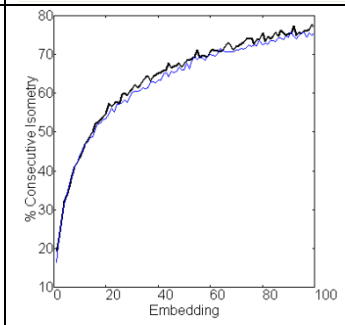
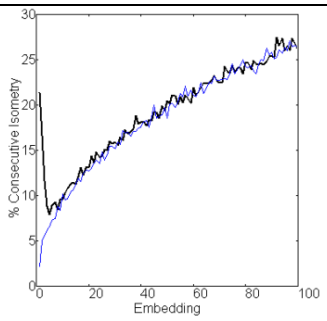
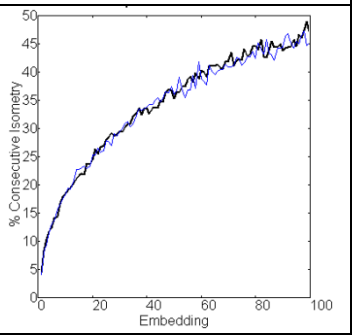
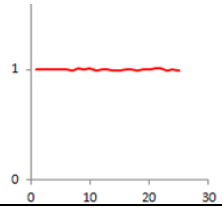
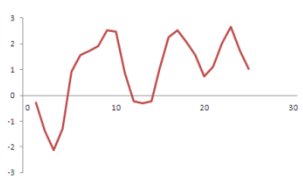
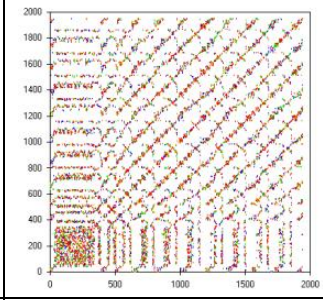
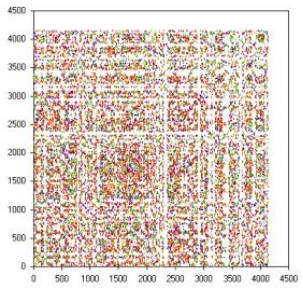
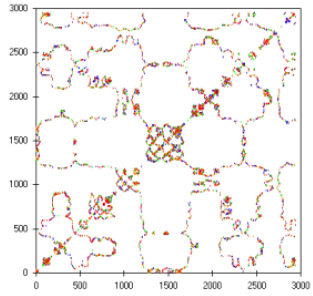
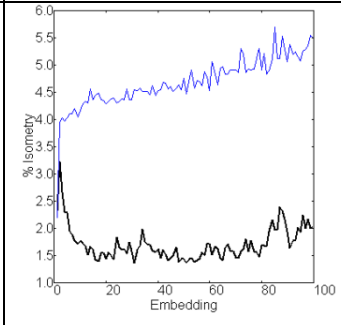
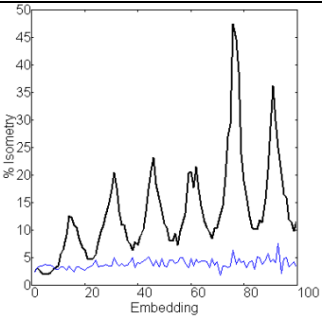
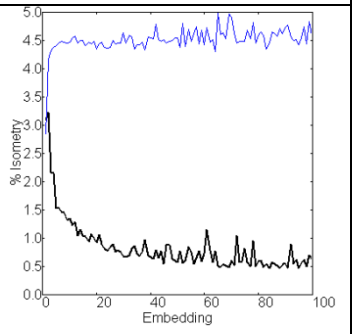
Creation is the generation of novelty, diversity and complexity. Creation, as used here, is the generation of information, not the creation of energy and matter that is excluded by the physical laws of conservation. A decrease in entropy is a sign of creativity, just as increasing entropy is a sign of decay.
Social health is an evolving concept that at present comprises ecological, public and personal health, peace, the end of poverty and abuse, medical care, education, personal freedom, and the pursuit of these goals by non-violent means. Health is defined as progress reflecting the therapeutic perspective of medicine rather than economic criteria.
Grounding social health on science is necessary because human action can only be effective when it fits reality. Mathematics and medicine, the oldest, most comprehensive and most practical sciences, are fundamental; social reality is wider than the narrower perspective of economics that dominates sociology from Adam Smith to Marx to current financial discourse. Conversely, applying general principles to human issues clarifies how our mental ideas influence how we think about scientific research.
The concept of natural creativity is formulated as a set of six principles[3] that describe the organization of natural processes and prescribe how human action and thinking can be rational and effective. While connecting to previous work, these six principles are here formulated anew.

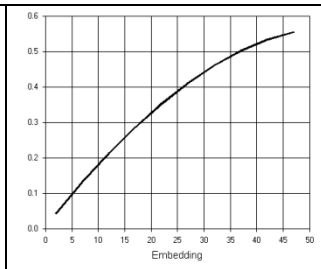
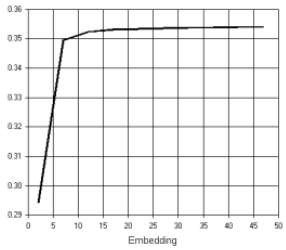
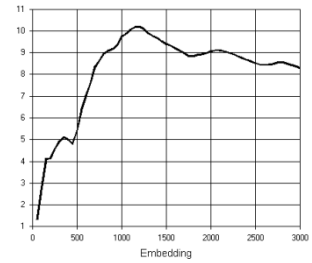
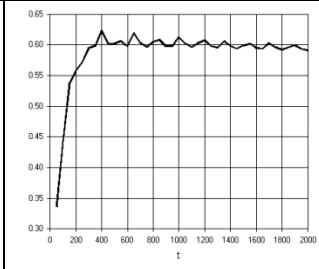
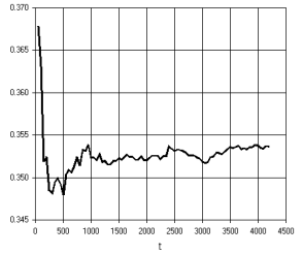
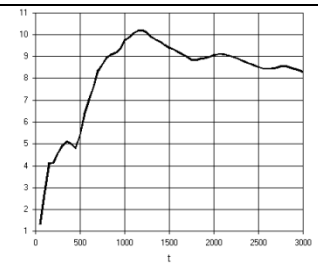
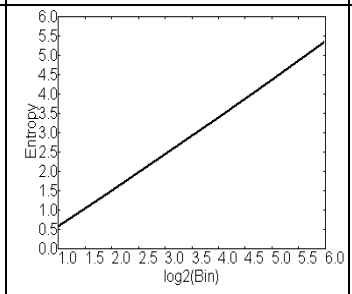
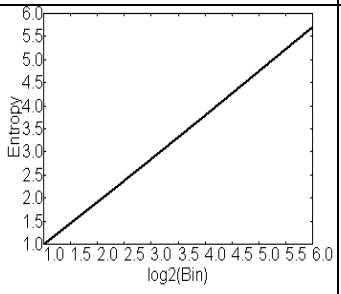
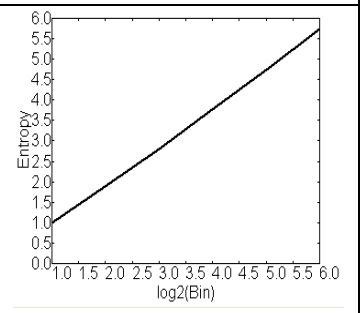
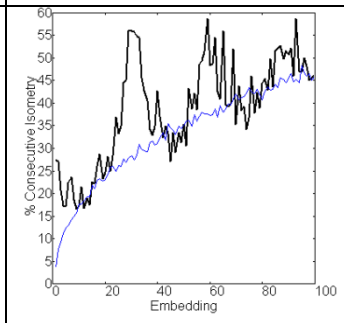
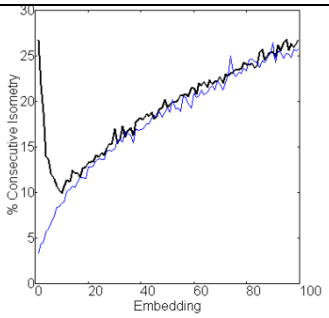
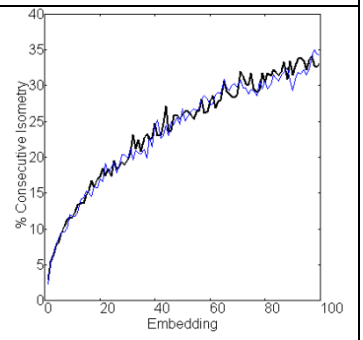
Methods

We developed methods to quantify temporal complexity (shifts from one morphological pattern to another), novelty (lower recurrence rate than randomized copies of the data), and diversification (increase in variance with longer sampling of the series or higher embedding). These methods are published in scientific journals [1-16] and have been applied to a wide variety of natural and human process as described later. They are illustrated in Figure 1, where the results obtained with heartbeat series are compared with paradigmatic examples of fractal series.

[3] Principles, from the Latin term for beginning, are starting points; they are general scientific "laws." Scientific laws are hypotheses to be explored, not fundamental and definitive facts. A set of related principles is a theory. Here I avoid the terms "hypothesis" and "theory" because in popular speech, likely to be used by many in the social field, they carry the implication of speculative and uncertain, when in fact they are far more firmly established than those usually claimed as facts.

Figure 1. Methods to detect causal creativity.			
	Heartbeat Intervals	**Bios (g = 5)**	**Pink Noise**
Non-stationarity[a]			
Recurrence plot: temporal complexity[b]			
Novelty[c]			
Local Diversification[d]			
Global diversification[e]			

Entropy[f]			
Pattern in series of differences between consecutive terms[g]			
	Rössler Chaos	**Logistic Chaos (g = 4.3)**	**Brown Noise**
Non-stationarity[a]			
Recurrence plot: temporal complexity[b]			
Novelty[c]			

Local diversification[d]			
Global diversification[e]			
Entropy[f]			
Pattern in series of differences between consecutive terms[f]			

a. Changes in time series: mean by epochs.
b. Changes in pattern of the time series.
c. Greater recurrence in shuffled copy of the data than in the time series.
d. Increase in S.D. of the series by increasing embedding.
e. Increase in S.D. of the series by increasing length of the sample.
f. Entropy as a function of the number of bins used to calculate it
g. Pattern in series of differences between consecutive terms as shown by the number of consecutive isometries.

Temporal complexity, novelty, and diversification are evident in random walks and a newly identified pattern, Bios, and they are absent in stationary periodic and chaotic series. We thus interpreted non-

stationarity, temporal complexity, novelty, diversification and relatively low entropy as evidence for creativity (Table 1).

Table 1. Characteristics expected in creative processes and observations made in various types of processes.

	Random	**Steady state**	**Periodic**	**Chaotic**	**Biotic (empirical or mathematical)**
Repetition [a]	Frequently low	All	One half or less than maximal	Less than periodic	Less than chaotic
Point to point change	yes	no	yes	yes	yes
Statistical stationarity	yes	yes	yes	yes	**Non-stationarity**
Pattern (form)	Erratic	Convergence to steady state	Convergence to periodic attractor	Convergence to chaotic attractor	Erratic
Pattern stationarity	yes	yes	yes	yes	**Temporal complexity** [b]
Diversity		None	stable	stable	Monotonic increase (**diversification)**[c]
Diversification	Baseline	No	No	No	Yes
Recurrence	Baseline	Maximal	High, higher than randomized copy	Less than periodic, higher than randomized copy	Less than randomized copy (**novelty**)[d]
Entropy	Near maximal	Minimal	Much less than maximal	Maximal	**Relative decrease** (less than maximal)[e]

a. H. Sabelli, M. Patel, and V. K. Venkatachalapathy. Action and Information: Repetition, Rise and Fall. *Journal of Applied System Studies* 5 (3), 67-77, 2004.

b. Sabelli, H and A. Abouzeid. Definition and Empirical Characterization of Creative Processes. *Nonlinear dynamics, Psychology and the Life Sciences.* 7(1): 35-47, 2003.

c. A. Sugerman and H. Sabelli. Novelty, Diversification And Nonrandom Complexity Define Creative Processes. *Kybernetes* 32: 829-836, 2003

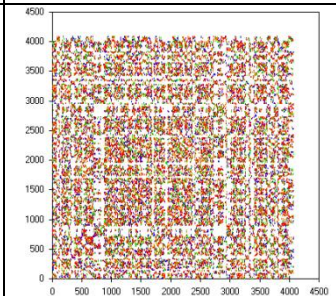
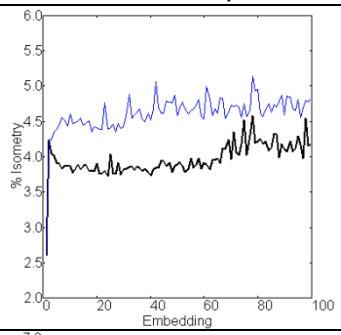
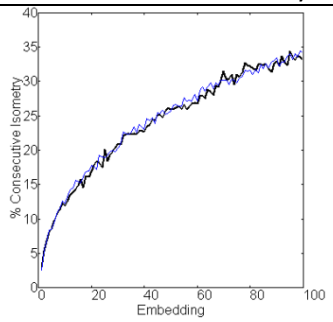
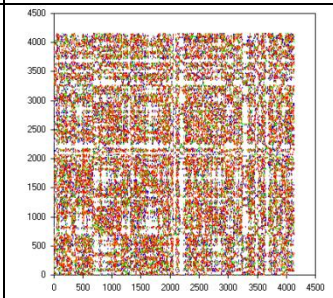
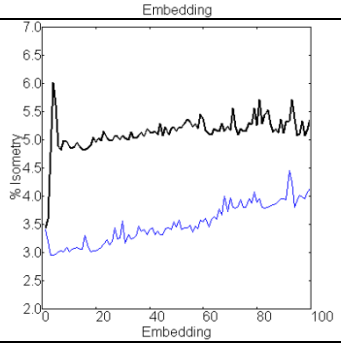
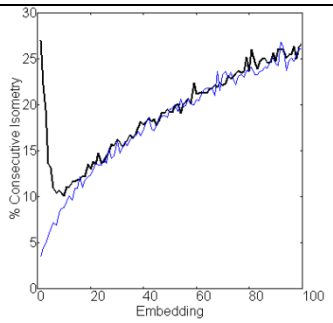
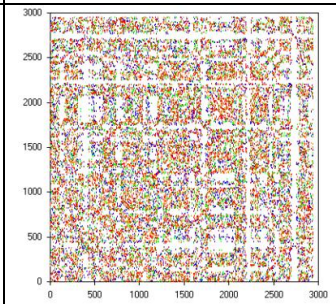
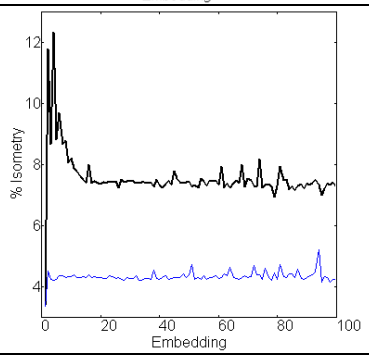
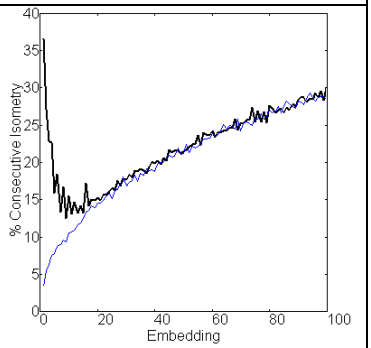
d. Sabelli, H. (2001). Novelty, a Measure of Creative Organization in Natural and Mathematical Time Series. *Nonlinear Dynamics, Psychology, and Life Sciences.* 5: 89-113. 2001.

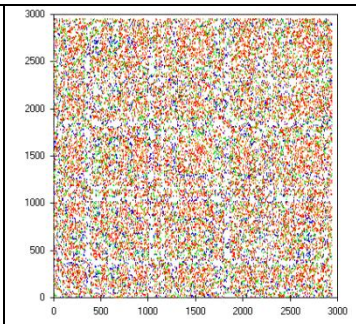
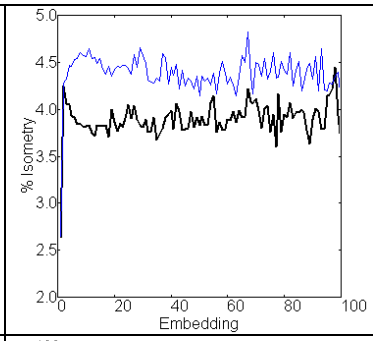
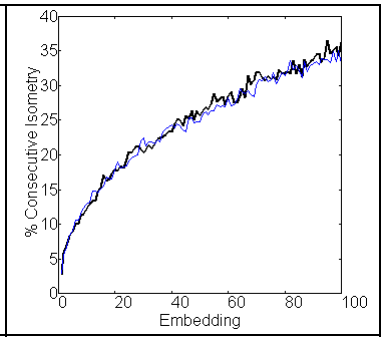
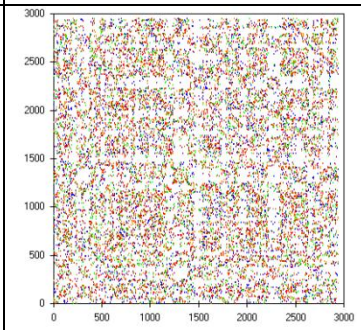
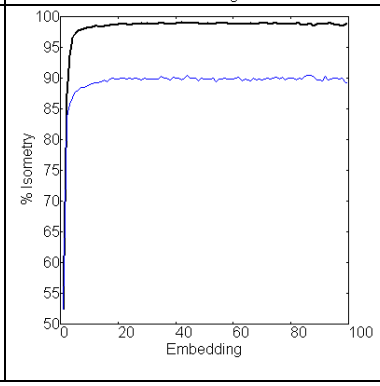
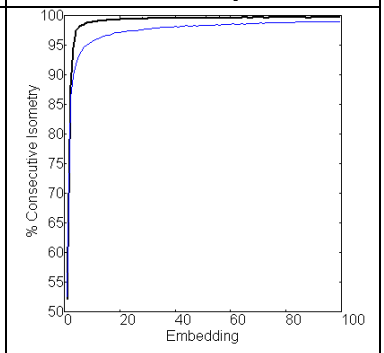
e. Sabelli, H. Biothermodynamics. *Open Cybernetics and Systemics Journal* (accepted for publication).

Temporal complexity, the change from one pattern to another, characterizes creative patterns, while stationarity is characteristic of stable organization. Increasing diversity with a sample of longer duration of the (global diversification) or higher embedding (local diversification) is expected in creative processes. Likewise creative processes can be expected to have less recurrence (repetition of vector of consecutive terms) than randomized copies (novelty).

We developed a simple way to differentiate causally generated (chaos, bios) from randomly generated series by examining the pattern of the series of differences between consecutive terms which displays pattern in the first case and is of course random in the latter (Figure 2). This method can be applied to the analysis of empirical series while standard methods [17, 18] purported to differentiate causal from random series are only applicable to mathematical series and hence irrelevant to empirical research; in any case, we already know whether or not we have generated a mathematical series deterministically or randomly.

Figure 2. A simple method to distinguish causal (Chaos, Bios) from randomly generated series

	Recurrence	Isometry	Consecutive Isometry
Random			
Chaos logistic			
Chaos process equation g 4.3			

Random walk			
Bios process equation g 4.7			
The series of differences between consecutive terms has structure as shown by a higher rate of isometry and consecutive isometry in Chaos and Bios (black line) than in their randomized copies (blue line). In contrast there is no significant difference in the case of random series and random walks.			

Results

Using the methods described above, we found that heartbeat series display non-stationarity, temporal complexity, novelty, diversification and relatively low entropy. These features are also observed in random walks, but heartbeat series differed from them in that their pattern is generated causally, as demonstrated by the existence of pattern of the time series of differences between consecutive heartbeats. We thus identified the pattern of heartbeats as a new pattern characterized by non-random causality and creativity, that we called **Bios** [19] (meaning life).

The **Bios pattern can be generated by a simple recursion involving coexisting opposites** formulated by Louis Kauffman [20], a cybernetic enactment of dialectic interaction [21]. This **bipolar feedback** process that generates Bios patterns was initially modeled using trigonometric functions as in the process equation

$$A(t+1) = A(t) + g * \sin(A(t))$$

where the gain g represents the amplitude or energy of the feedback, and the diversifying equation

$$A(t+1) = A(t) + \sin(j*A(t))$$

where the parameter j represents frequency. Bios is also generated by the addition of sine waves; this enlarges the range of Bios because sine wave patterns are widespread in nature.

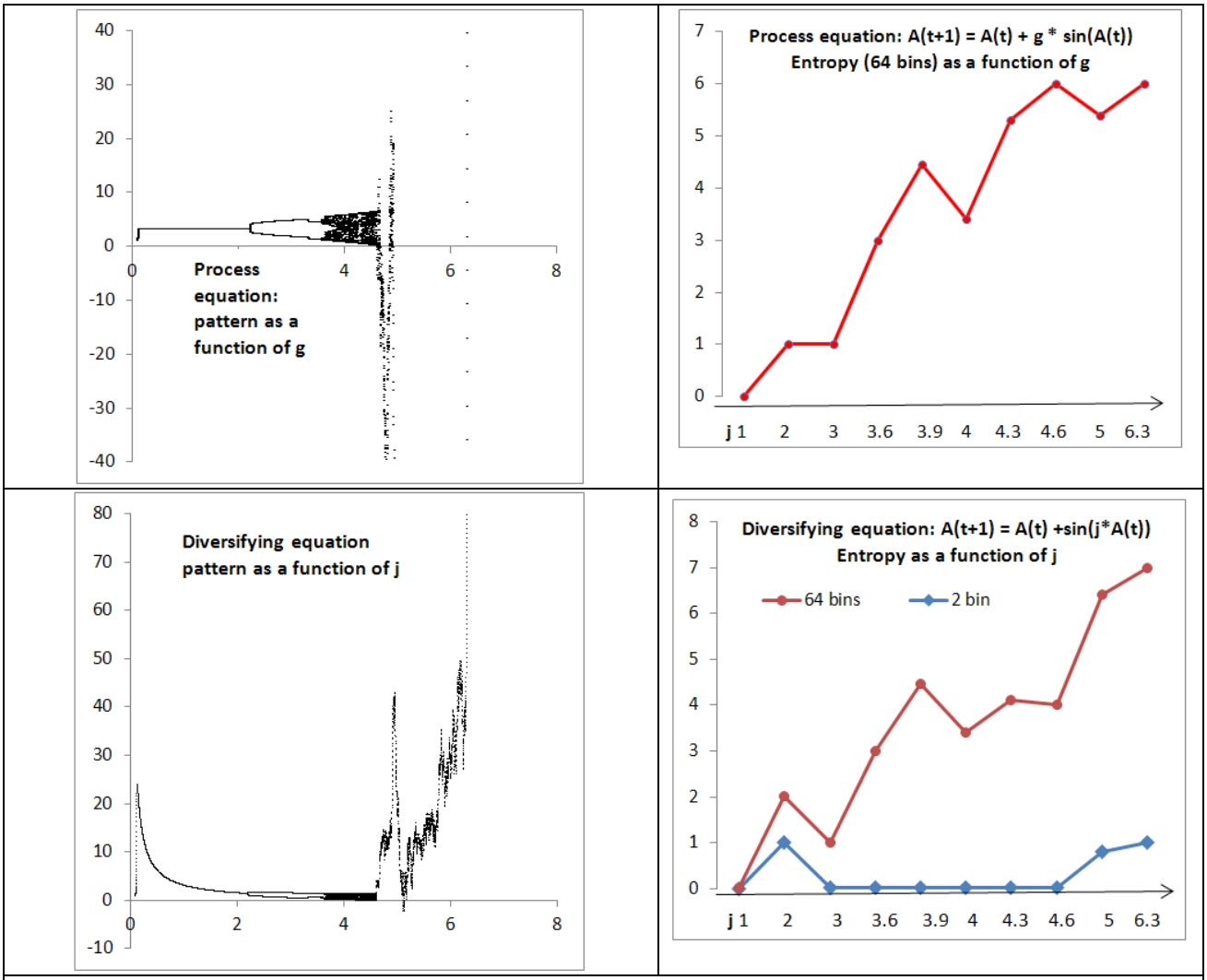
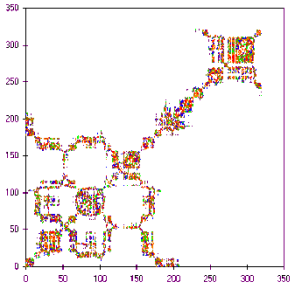
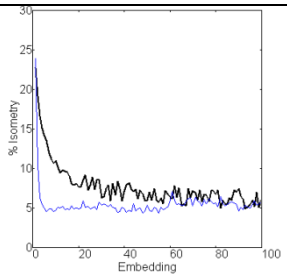
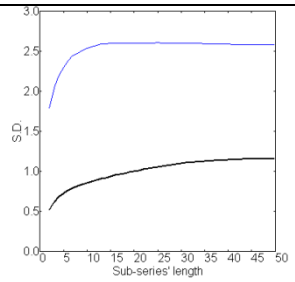
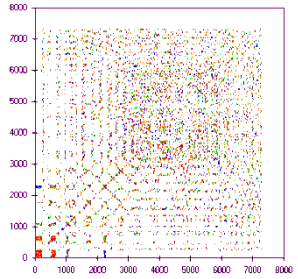
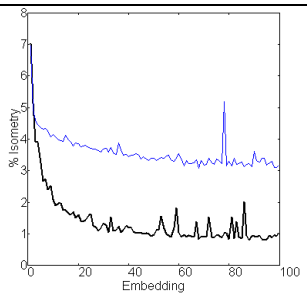
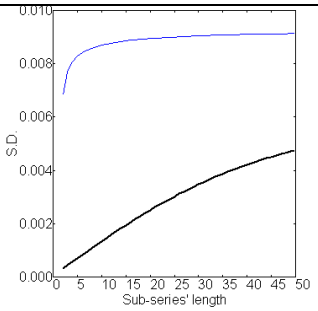
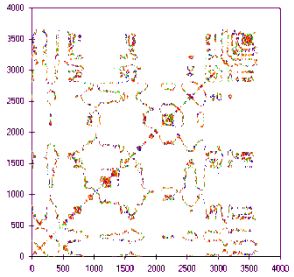
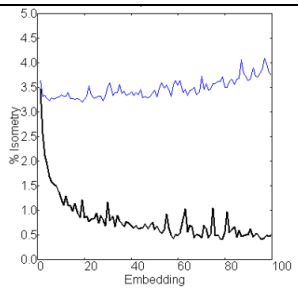
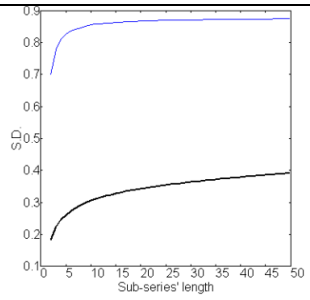
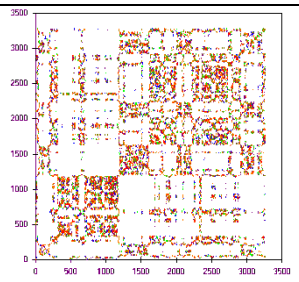
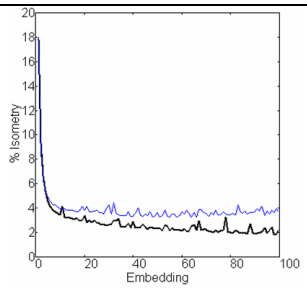
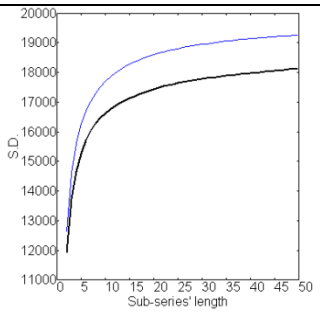
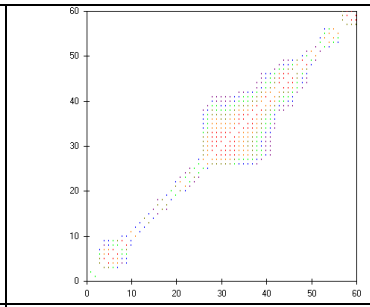
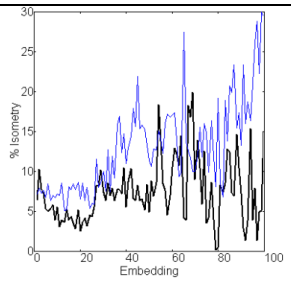
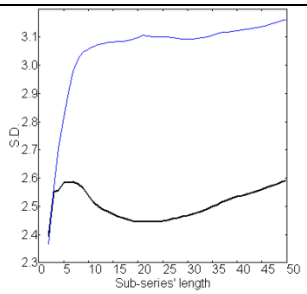
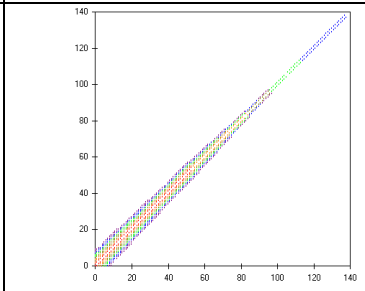
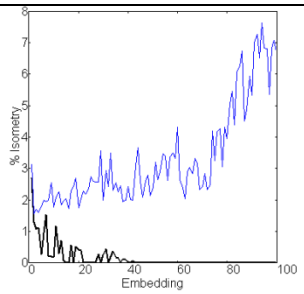
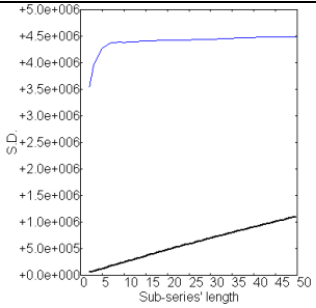
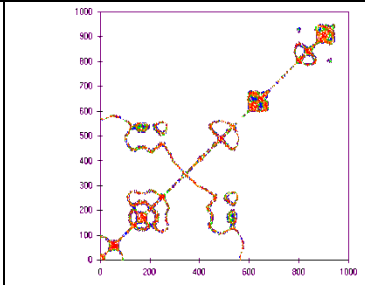
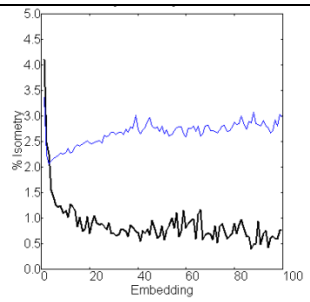
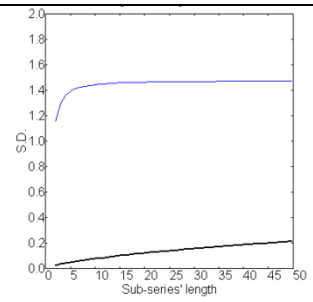
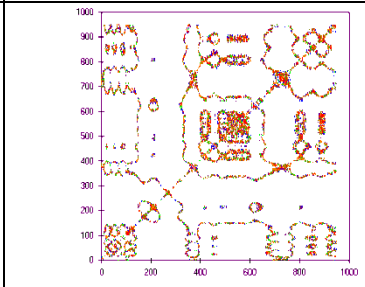
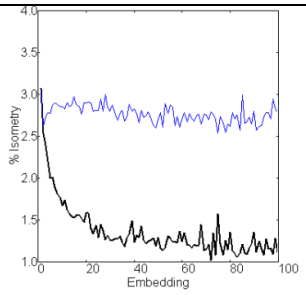
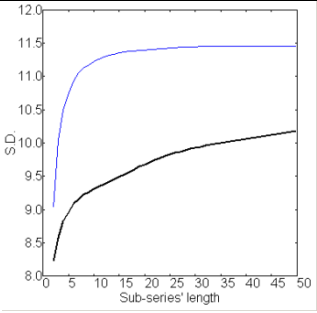


Figure 3: Variations in statistical entropy with pattern in the process equation and the diversifying equation. Statistical entropy attains its possible maximum during the leap at g = 2 * π. Note that in the process equation entropy is lower during Bios than during stationary chaos while in the diversifying equation entropy is higher during Bios than during stationary chaos.

Using the methods developed to study cardiac rhythms, we found that many physical, biological and human processes also are creative [22-24]. Bios is demonstrable in fundamental physical processes such as quantum [25, 26] and cosmological processes [27, 28], in the prime number series [29, 30], in animal and human population dynamics [31, 32], in economic processes [10, 26, 33-35], in social processes such as production and unemployment [36], and in music [37, 38]. Examples are presented in figure 4. These results are the empirical bases that led to the concept of causal creativity.

Figure 4. Empirical evidence for creativity in natural and human processes.			
Series	**Recurrence**	**Isometry plot**	**Local Diversification**
Expansion of the universe[a]			
Schroedinger's equation[b]			
Temperature: air temperature[c]			
Gravitational waves[d]			

Animal Population: Salmon[e]			
Human Population: Chile (1820-2008)[f]			
Economics: bond yield[g]			
Music: Bach's *Fantasia*[h]			

[a] Sabelli, H and L. Kovacevic, 2006.
[b] Sabelli and Lazar Kovacevic, 2003.
[c] Sabelli et al., 2004.
[d] Sabelli, 2010
[e] Lawandow, A. and H. Sabelli, this issue.
[f] Sabelli, and Kovacevic, 2008.
[g] Sabelli, H and L. Kovacevic. Economic Bios. *Kybernetes* (accepted for publication)
[h] Sabelli, Lawandow, and Kopra, 2010

These experiments simply illustrate the creativity of natural and human processes. Actually the mere observation of the wonderful diversity of the world we inhabit displays everywhere increasing organization beyond repetitive order. Physical evolution (Friedman, Lemaitre, Hubble), biological evolution (Lamarck, Darwin) and human history are seamless.

Principles

Causal creativity is formulated as a set of six principles that integrate and transform basic ideas in evolutionary theory and process philosophy. Thus, the concepts of coexisting opposites, quantum duality and evolution by competition and struggle and subsequent synthesis are unified and converted into the notion of co-creation of bipolar (synergic and conflictual) opposites that generate cascades of bifurcations.

1. Causal action: action (energy and matter continually changing in space-time) is the fundamental constituent of reality. [36]

Everything that exists is physical, that is to say material and energetic. (Information and hence complexity, is encoded by either energy or matter.) There is no separate substance or new forces in chemical, biological, or mental processes. Changes in psychological energy are embodied in metabolic changes in the Central Nervous System. The demonstration that psychological processes and illnesses actually are physical processes, and modifiable by drugs, is perhaps the most important philosophical discovery of the twentieth century.

Energy and matter are neither created nor destroyed but they can be convert into each other (Einstein's famous equation $E = m c^2$) and both are in continuous change. Matter is composed of rapidly moving energetic changes, and large concentrations of matter such as stars continuously emit energy. Energy always flows along asymmetry gradients.

Just as inertia, not rest, is natural in mechanical movement (Galileo), the change of energy in time and space (action), not energy, matter, or ideas, is the simplest component of all material, energetic, and mental processes. To postulate energy rather than action as fundamental, and then explore how to account for time (perhaps by an increase in entropy) is the product of a static view derived from ancient conservative ideologies at variance with empirical evidence.

Action captures the process conception of the universe advanced in Antiquity by Heraclitus and central to evolution. (However, describing action as "stationary" conceals change, which is its essence). But action goes further. All actions produce change, but not all changes are actions. Action is self-propelled change.

The concept of action derives from physics, but it is also central to biology, economics and psychology. Action is defined in physics as the change of energy in spacetime. Time increases, energy is conserved, transmitted in spacetime, which includes the unidirectionality of time. Hence actions cause change. Conversely, since energy is not created, there is no additional energy to generate a random event without a preexisting cause. Causality is indeed observed at every other level of organization, except, it is claimed, in quantum processes.[4]

[4] The conservation of energy, together with the continuity of action in time, indicates that random events are impossible. All processes are causal sequences of actions in time and space. The only possible way in which a random, non-causal event could exist would be an instantaneous, discontinuous change from one state to another of the same energy, and this appears to be the case for the emission of an electron in quantum processes. Thus, the Copenhagen interpretation of quantum mechanics postulates indeterminism. This cavalier dismissal of causality is

Time increases unidirectionally, and space expands in three dimensions, establishing fundamental and universal asymmetries in the universe that manifest at all levels of organization (Pasteur's cosmic asymmetry).[5] Asymmetry implies change; symmetries are also fundamental but never are separate from asymmetry. Thus actions always have a linear component, even when they display many properties that we now describe as "non-linear".

In space, actions display three levels that we observe in the solar system as described by Copernicus: a central and dense material core with high energy content (the sun), a surrounding range of lower material density (the planetary system), and an unlimited range of low energy communication with no energetic interactions that extends to all galaxies in space and to the big bang in time. Atoms and "social atoms" (the interpersonal world of a person) show the same organization.

There are units of action at all levels (e.g. cardiac contractions, economic transactions, individual lives, and, from another perspective, atoms, cells, organisms, and galaxies). In particular, for all entities x, $x \geq h$, Planck's quantum of action. A process is a sequence of actions. Thus both physical and human processes can and must be analyzed numerically. As Pythagoras proclaimed, *"All is number."*

The fact that for all x, $x \geq h$ implies that there can be no absolute rest, and no absolute void. Even the vacuum state[6] is not an absolutely empty space but contains fleeting electromagnetic waves and particles that pop into and out of existence. Cosmic space is filled with "dark energy".

Matter gives shape to spacetime both by "curving" it, as detected by the trajectory of inertial movements near a mass, and by creating negative space just as architecture and sculpture do; a classic example of negative space or shapes is the brain-teaser where depending on how you conceive it, you see either a vase or two faces. The vacuum is continuous but perforated by the existence of matter. It is like Swiss cheese, continuous and discontinuous. It has no center and perhaps no boundaries. In contrast, matter has multiple centers and clear boundaries.

The concept of action is central in human processes. Taking action as fundamental is cogent from the perspective of biology and medicine, as life is a process of change and patient care requires continual action. It is also rational from the perspective of economics, as prosperity stems from production and

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surprising. The rate of decay of an atom is fixed and hence determined; only the emission of each electron appears random. Also, the emission of an electron by a radioactive atom may appear to occur randomly (atom → atom + emitted electron), but the reverse process (atom + emitted electron → atom) never occurs. Thus causality results from the conservation of matter, the transmission of action, and the asymmetry of time Many scientists prefer to account for apparent randomness by our ignorance of the facts. The surprise at the lack of evidence for causality in quantum processes is a consequence of the claim that quantum mechanics as first formulated was "complete", when in fact many phenomena and particles were discovered later on (e.g. neutrons in 1932, quarks in the 1960s).

[5] Having discovered the asymmetric of organic molecules, Pasteur concluded that it must result from a universal, fundamental asymmetry.

[6] The vacuum is the quantum state with the lowest possible energy, which has measurable effects; in the laboratory, it may be detected as the Casimir effect (two uncharged metallic plates in a vacuum, placed a few micrometers apart, without any external electromagnetic field, affect the virtual photons which constitute the field, and generate a net force[—either an attraction or a repulsion depending on the specific arrangement of the two plates). In physical cosmology, the energy of the vacuum state appears as the cosmological constant. The energy of a cubic centimeter of empty space has been calculated to be one trillionth of erg. The vacuum state thus is a process in constant flux. The early atomists (Democritus, Aristarchus and Archimedes) regarded matter and void as the two constituents of the universe, but Aristotle and his followers regarded the vacuum as impossible, so matter could not be atomic. The Italian mathematician and physicist Evangelista Torricelli (1608-1647) was the first to create a sustained vacuum. In our times, the existence of large areas of the universe free from matter has been established. As matter clumps into stars, galaxies, and clusters due to the attractive force of gravity, there are places in the universe where matter groups and places where space is devoid of any matter. Some of these holes are a billion light-years across.

work, not from material wealth, gold, stocks or unused land. The consumption of free energy, the depletion of energy and matter, pollution, and waste determine the actual benefit and cost of production. Civilization is basically an energetic phenomenon. Modern technology has dramatically increased the human use of energy. Also psychological processes are flows of energy: in fact the density of energy flow in the human brain (150,000 ergs sec^{-1} g^{-1}) is much higher in human brain than in the body, the planet, or even the sun (2 ergs sec^{-1} g^{-1}). Notably, the free energy flow density increases with complexity. Psychological energy also circulates between individuals; emotions, for instance, are shared, thereby creating collective moods and public opinion.

Physical and mental processes are actions, and hence equally important.

Taking action as a fundamental principle has obvious social and personal implications. Nothing is passive. Things do not "happen": either we or others do them. What we do, as well as what we don't do, are actions. We always act, even when perceive ourselves as passive or when we choose not to act.[7] The implications of agency are the importance of gaining the initiative, and of maintaining effort (energy) in time (perseverance).

Actions create human minds. Acting "as if" changes the spirit, pointed out leading psychologist Alfred Adler. It is thus essential to consider actions first; whatever fails to address actions is meaningless. Roads are made by walking. Synapses are made by thinking. Social movements are made by social action.

Action is a central concept in sociology,[8] psychodrama and sociatry [39]. Based on the closed system's model of nineteenth century thermodynamics, Freud assumed that psychic energy is constant. Energy could only be displaced, so symptoms of increased or decreased energy could not reflect actual changes in energy. For the same reason, love and self-love compete with each other, as one can grow only at the expense of the other. We now know that energy can increase or decrease in open systems such as biological organisms. Depression is a shortage of psychological action (energy flow), and mania is an overabundance [40, 41].[9]

2. **Opposition is universal, bipolar and creative.** [42]

[7] The tragic annihilation of the Spanish Republic and the ensuing bloody dictatorship were created not only by the Spanish military, the Church hierarchy, the German Nazis and the Italian fascists, but it was also co-created by the complicity of English and French "non-intervention". In fact the British secret services had furtively helped Franco to escape from prison and join the army in Morocco.

[8] Kurt Lewin coined the term "action research" in 1944. He described action research as "a comparative research on the conditions and effects of various forms of social action and research leading to social action" that uses "a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action".

[9] Affective disorders illustrate the conjoint variation of energy and time as feelings of low energy combine with slowness and even retardation of thinking and behavior in depression, while feelings of increased energy accompany acceleration in mania. Diminished interest, attention, concentration and pleasure, fatigue, lower self-love and self-esteem, reduced affection and sexuality, helplessness, retardation, indicate a lowering of psychological energy in depression, whereas the increased goal-directed activity, excessive involvement in pleasurable activities, increased sexuality, decreased need for sleep, talkativeness, flight of ideas, distractibility, inflated self-esteem that define mania point to an excess of psychological activity. Corresponding to the interpersonal dimension of psychological energy, affective illnesses are dysfunctions of interpersonal affection and love, not only of personal mood and energy. In depression there is not only a reduction in mood and self-esteem, but also a reduction in affection, sexuality and solidarity. In mania there is increased affection, sexuality, and solidarity. There is something wrong in disregarding interpersonal affect and defining depression as a mood disorder. Love and self-love are both increased in mania and reduced in depression.

Opposition is universal: electrical charge, acid and base, biological sexes, complementary DNA bases, supply and demand, abundance and scarcity, cooperation and conflict, true and false. Unipolar actions coexist with their opposites (e.g. mechanical action and reaction; inertial movement includes both gravitational attraction and the expansion of the universe).

Actions as well as entities are paired with complementary opposites –synergic, conflictual or both. Newton's law of action and reaction establishes that the mutual action of two bodies are always equal and opposite. There are opposing actions (convergence and divergence), opposite forces (attraction and repulsion), and opposite objects (proton and electron) and organisms (women and men). Material entities are paired with their complementary opposites. At the simplest quantum level, there are two pairs of orthogonal pairs of conjugated opposites (energy and time, position and momentum). Two values are required to encode information. We walk with two legs, see with two eyes, and think with two hemispheres. Social roles often are naturally paired: parent and child, woman and man, manager and employee, teacher and student, doctor and patient. Likewise concepts are often paired (tall and short, content and form, quantity and quality). Gender, classes and many other human processes and organizations show coexisting opposites.

Just as action in time is unidirectional, i.e. unipolar, the coexistence of positive and negative opposites represents bipolarity. All entities are bipolar, i.e. they contain opposites. Waves are bipolar (e.g. bidimensional electromagnetic waves). Tripolar and tridimensional structures include opposites (e.g. color and anti-color of quarks).

Biological evolution involves predation and competition (Darwin) but also mutual aid as discovered by the evolutionary biologist and anarchist Prince Kropotkin [43], symbiosis and endosymbiosis [44].

Opposition is not simply complementary. Complementarity often is static. The differentiation[10] into opposites is a simple and fundamental creative process. Opposites are the result and the cause of branching (e.g. bifurcations) such as differentiation of cells, species, and classes. Differentiation is a universal phenomenon: rivers divide into branches in deltas, species differentiate, classes multiply. Cascades of differentiations, such as the branching of trees or neurons and repeated cell division, are important in biology and are modeled by cascades of bifurcations as generated by the logistic map [45, 46].[11] Cascades of bifurcations can multiply the number of periodicities or generate chaos [47, 48]. [12]

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[10] The biological term differentiation is used here to refer to what is often called a bifurcation because the term bifurcation is used not only to refer to the actual splitting of one entity into two but also to a change from one state to another, including the splitting of one line into two that switch back and forth periodically or chaotically.

[11] The logistic map was described by Mitchell Feigenbaum. A logistic function is a common sigmoid curve, given its name in 1844 Pierre Verhulst who studied it in relation to population growth, after he had read Malthus' *An Essay on the Principle of Population*. As discussed in a companion paper, the logistic equation does not model population growth in nature, except perhaps in closed systems such as a Petri dish. The logistic map A(t+1) = r * A(t) * (1-A(t)), where A(t) is a number between zero and one that represents the population at year t, *r* is a positive number, that represents a combined rate for reproduction and death. It is an archetypal example of how complex, chaotic behavior can arise from very simple non-linear dynamical equations. The map was popularized in a seminal 1976 paper by the biologist Robert May.

[12] James A. Yorke coined of the term "chaos" as used today. "Chaos" originally meant disorder but in chaos theory it means an apparently erratic pattern that is sensitive to initial conditions, topologically mixing (the system will evolve over time so that any given region or open set of its phase space will eventually overlap with any other given region), and contains dense periodic orbits (every point in the space is approached arbitrarily closely by periodic orbits). Some dynamical systems are chaotic only in a subset of phase space. Chaotic behavior takes place on an attractor. Henri Poincaré. Chaos was subsequently studied by mathematicians (J. Hadamard, G. D. Birkhoff, A. N. Kolmogorov, M. L. Cartwright, J. E. Littlewood, S. Smale) but chaos theory became formalized only in the last half of the 20th

The differentiation of opposites precedes and is more effective than the union of opposites as a creative process, in contrast to the motions of dialectic synthesis or system formation.
The differentiation process is important in social processes. Ethnic groups and classes differentiate and multiply, reducing class differences. This is at variance with the hoped for absorption of classes and of ethnic differences. Opposites also converge (multiple sources of a river, formation of larger states) so the pattern is a lattice.
Cascades of differentiations are a major process for casual creation. Opposites co-create each other through mutual feedback, and their interaction also creates new entities.
Opposites may connect more or less permanently, but they rarely are engulfed into a synthesis or annul each other as inverses do in mathematical groups.
Opposites alternate and rotate, generating helical, spiral forms and more complex forms. Rotation is evident in cosmology and circulation is central to physiology. Opposites also co-create complex patterns, a concept applicable to personal, social, and intellectual endeavors.
The standard logic taught to students and used in computation involves a static view in which opposites are mutually exclusive. Likewise, traditional ideologies and religions often portray their beliefs as excluding all others, thereby promoting discrimination, antagonism and conflict.
The coexistence of opposites has been established from Greek and Chinese antiquity to quantum physics, electrodynamics, biology and psychology. Logic should be based on the logic of nature, not on arbitrary principles such as the mutual exclusion of opposites (Aristotle-Boole's logic).[13] If the concept of coexisting opposites is incorporated into our thinking, it is likely to promote scientific progress and social tolerance and peace. The coexistence of opposites can be conceived in terms of the bipolarity of waves rather than as conflict as it has been described from Heraclitus to Darwin and Marx. Wave theories (Descartes, Maxwell, Schrödinger), which are central to physics, may provide a scientific foundation for a harmonic dialectics.
Oppositions include both cooperation and struggle. Correspondingly, when confronted with conflict, it is advisable to seek a third option by opposing both opposites, while being conciliatory as necessary to prevent destruction.

3. Triads of complementary entities co-create tridimensional matter, stable structures, and complex systems. [37, 49]

Space is tridimensional and spacetime is shaped by matter which curves it establishing the path for inertial movement.
Matter is stable, qualitatively different from energy, even if they can convert into each other.

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century, with the widespread use of electronic computers. In 1960, Benoît Mandelbrot found recurring patterns at every scale in data on cotton prices and in 1967, and he published "How long is the coast of Britain?" showing that a coastline's length varies with the scale of the measuring instrument, resembling itself at all scales. In 1961, Edward Lorenz [48], using a simple digital computer to run a weather simulation, found that the predictions were widely different resulting from the very small initial value and developed a chaotic attractor as a model. No actual empirical data was tested. Observations of chaotic behavior in nature have been reported for changes in weather, the dynamics of satellites in the solar system, the time evolution of the magnetic field of celestial bodies, population growth in ecology, the dynamics of the action potentials in neurons, and molecular vibrations, but they have not been proven, because there are no methods to demonstrate chaos in empirical data.

[13] "It is impossible for the same thing at the same time to belong and not belong to the same thing in the same respect; and whatever other distinctions we might add to meet dialectical objections. This then is the most certain of all principle". (Aristotle)

The nucleation of 3 quarks by the strong nuclear force forms protons and neutrons, the basic components of matter.

Many relatively stable human organizations such as families (mother, father and child), and government (executive, legislative and judicial) are structured as triads.

The strong and the weak nuclear forces are tripolar, displaying an organization analogous (and perhaps homologous) to the visual colors. In humans, a triadic organization of three primary factors (and three secondary opposites) capable of combining in multiple ways observed for visual colors. Each primary color has a complementary opposite equal to the sum of the other two primaries, and this set of colors can combine in various ways to create a limitless number of new colors, including complex browns that include all three primaries. This combinatorial power, not just the existence of three values, is creative.

Emotions and other complex phenomena also show a chromatic organization, suggesting that perhaps all of them are expression of a universal triadic principle already evident in the tridimensionality of space.

Threeness appears necessary for symmetric and stable form. As tripolarity generates stability against change, the tripolar nucleation of quarks may also account in some way for mass, which also is a resistance to change,[14] and that is currently attributed to a hypothetical Higgs particle (postulated by quantum chromodynamics but not been empirically found as yet).

Reality involves three aspects: structure (matter), process (energy and work), and communication (information). They are organized in tridimensional space as in the Copernican model: a material core, a range of energetic interactions, and a wider field of communication.

Information itself is triadic: there always is not only ignorance and uncertainty but also misinformation. Just as opposition consists of two oppositely directed asymmetries, structure is asymmetry in three dimensions.

The interaction of three or more agents is crucial to creativity, as illustrated by the ability of three kinds of quarks to create matter, three primary colors to generate all colors, and period three to imply infinite periodicities in a specific order (Sarkovskii's theorem), which is stated as "period three implies chaos" [50].

Table 2 presents these common, standard, generic aspects of observed in many processes, simple and complex. The asymmetric flow of energy in time, the opposition between forces, and the transformation of matter are three universal aspects of all reality, from atoms to minds.

Table 2. Three generic forms at multiple levels of organization

Level of organization	**Generic forms**		
	Action (energy)	Opposition (information)	Structure (matter)
Mathematics	Lattice theory	Group theory and algebra	Topology
Number and physical embodiment	Oneness and unidirectionality of action	Bipolarity of entities and co-creation of opposites	Tripolar and tridimensional structures
Physical	Quantum of action, work	Symmetries	Matter
Biological	Growth, reproduction	Gene pairs, sexes	Organisms
Social	Work, play	Generations, sexes, classes	Institutions
Psychological	Behavior	Emotions, ideas	Brain

[14] Inertia is defined as a property of mass that describes its resistance to a change of its uniform state of motion.

Lattices, the algebra of groups and topology correspond roughly to action, creative opposition and the evolution of material structures from simple to complex.

Lattices [51] are sets with an order relation defined as asymmetric and transitive. This corresponds to sequential order, characteristic of processes (i.e. sequences of actions). Infinite lattices offer an appropriate model for processes as a growing network with unions for all pairings, but no final greatest element.

Algebra studies the rules of operations and relations, and the constructions and concepts arising from them. The notion of group which is fundamental in nature (bipolar opposition, orthogonal pairs of opposites, the infinite pairing of opposites in the circular form of waves as in the electromagnetic force that forms atoms and carries information) is also fundamental in mathematics because every element is part of a duality and every two elements combine to form a third element that is in the group. Thus groups embody triplicity as well as opposition. Group theory (Euler, Gauss, Galois) captures only some aspects of opposition [52]. It may be it is more appropriate to model opposition by grupoids in which elements combine forming new elements, every element has an opposite (and/or every class of elements have an opposite class of elements), and the union of opposites generates a bipolar element different and more complex than the neutral identity.

Topology (Euler, Cantor, Poincaré) describing geometric-like forms, allowing deformation and change, and including triadicity (e.g. the three color encoding of knots), abstracts the essential properties of material structure [53]. Topology provides an exact definition of continuity which is regarded as defining topology, but continuity exists only in association with discontinuity. Thus form, rather than continuity, seems as the core concept of topology.

These are triads of coexisting and persisting entities, as contrasted to the dialectic triad thesis-antithesis-synthesis.

Triads are also important in human processes, such as the three basic cognitive structures described by Piaget [54, 55]. Emotions involve the neural network and neurohormones who mediate them, their social behavior and display, and the subjective feeling (e.g. acetylcholine, fight and anger). For Cannon [56], conflict leads to fight or flight. This dichotomy is modeled as a catastrophe [57]: when a subject experiences both anger and fear simultaneously, these opposites do not cancel each other (as in quantitative theories of opposition), but rather one emotion predominates. The subject either fights or flees. Actually, mammals confronted with conflict may also display submission, which normally terminates the aggressive behavior of the other, avoiding intra-species killing, and generating social hierarchies. Conflict poses a trifurcation: fight, flight or surrender [45]. This example has a practical implication: when you perceive two, consider the possible third.

Fight, flight or surrender may be mutually exclusive behaviors, but often they alternate, intertwine, and replace each other, according to circumstances. Their subjective components—anger/rage, fear/anxiety, and defeat/depression—coexist, consciously or unconsciously, because conflict is their common trigger. The conflict theory of affect [45, 58] postulates that rage, anxiety, and depression are pathological manifestations of these three innate responses to conflict, brought about by external conflicts, and/or triggered by dysfunctions in the metabolism of the neurohormones that mediate these emotional behaviors—in this case, the manifested hostile and depressive behaviors can create interpersonal conflict.

Triads are prominent in artistic archetypes such as Imhotep's immortal pyramid. Triadic images of Divinity are present in almost all cultures. Triadicity is also eminent in mathematics. The historical "mother structures" of mathematics are arithmetic, geometry and logic. The Bourbaki School identified lattice theory, algebra and topology, three relatively autonomous developments [59, 60] as the abstract "mother structures" of modern mathematics. Piaget related the Bourbaki mother structures of mathematics to fundamental cognitive structures developed in childhood, namely three forms of thinking that are parallel to lattice, group and topology in mathematics.

We related the Bourbaki structures to the three dimensions of the human body illustrated in figure …, and of the Central Nervous System [36], and to the evolution of physical forces [28].
Oppositions include both cooperation and struggle. Correspondingly, when confronted with conflict, it is advisable to seek a third option by opposing both opposites, while being conciliatory as necessary to prevent destruction.
While dialectic thinking focuses on the interaction of opposites in creativity, stressing triadicity may be psychotherapeutic. Black and white thinking fosters fanaticism and social conflict, as well as neurosis and depression [58, 61, 62], while thinking in color, or at least in shades of gray, has been shown clinically to be is therapeutic.

4. Natural creation: Creative mechanisms are key component of physical, biological and human processes. [36]

Physical, biological and human processes include mechanisms that generate novelty (decreased repetition), diversity (increase variance) and complexity, as well as mechanisms that generate repetition, uniformity, and simplicity. By way of contrast, equilibration and periodicities are stable, maximally repetitive, simple and determined. Random processes represent a baseline of stationarity (as contrasted to diversification and uniformization), repetition (as contrasted to novelty and increased repetitions) and organization (as contrasted to complexity and simplicity).
Even simpler physical processes can undo what was typical before and create new outcomes. Healing after a wound, brain plasticity after a lesion, and personal resilience after a loss illustrate the human importance of creativity.
Creation is natural in the cosmos (from Big Bang to galaxies), planetary life (from unicellular organisms to humans), history (from Stone Age to modern society) and in each person (from egg to adult and elder).
From simple and few materials, arise many new, diverse and complex outcomes: four physical forces (gravitation, electromagnetic, strong and weak nuclear forces) generate the universe; genes produce body and its functions; a limited vocabulary generates new dialogues, and great literary creations; from a limited set of notes, there always is new music, dances, and songs. Bios is demonstrated in quantum processes as described by the Schrodinger's equation, cosmic gravitational waves presumably originating 1 trillionth of a second after the Big bang, to the expansion of the universe and current planetary processes. Creation is not a single event (Big Bang, revolution); it continues in our times.
While decay increase entropy, creation reduces it (Figure 3) [63]. Figure 5 shows that entropy is maximal in ordered, linearly increasing series than in random data, in other words, in order rather than disorder.

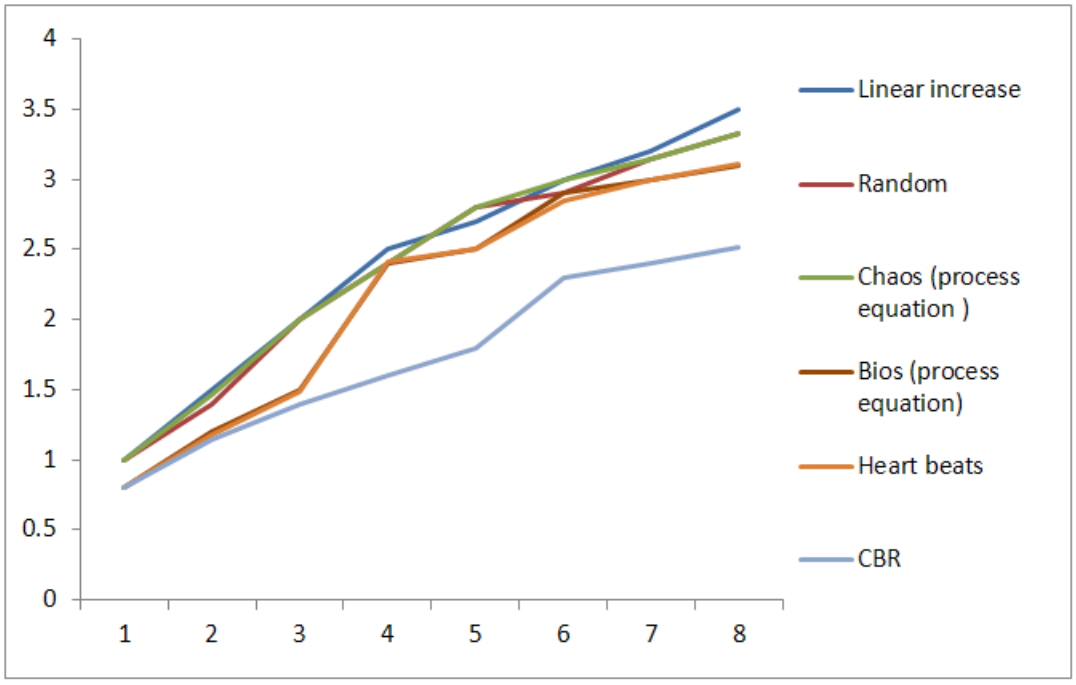


Figure 5: A comparison of the entropy measured with a number of bins shows that it is maximal for ordered series, less for random and chaos, and even lower for Bios and biotic series heartbeats.

Creation precedes and exceeds decay.

"Creative" is usually understood to be positive, However, whether physical or human, creative mechanisms can not only be truly constructive (i.e. truly creative) but they can be destructive or both. But creation by necessity precedes and surpasses decay, and likewise action must precede and surpass destruction. Evolution predominates over involutionary processes such as thermodynamic decay that increases uniformity and repetition and decreases complexity. In the classic thermodynamics, decay predominates globally and evolutionary episodes are local and fueled by the overall decay. While one may explain thermodynamic decay as a process of randomization, its directionality is determined.

Since creative processes can be destructive, it is thus cogent to separate the issues of creativity and progress. In fact, the notion of progress is not particularly connected with creativity. The assumption of progress has usually been associated with determinism at last since the nineteenth century, when scientific and social progress became the heart of the Western worldview. Deterministic progress became associated with the grandiose idea that the entire evolution of life, even of the universe, was directed to the emergence of us humans, just as their forefathers had regarded the entire Creation as a stage for their human existence. Paralleling the notion of a world created by God as a stage for human life, some physicists advance an anthropic principle [64, 65].[15]

But challenging the notion of determined progress does not imply that evolution is not progressive. The physical world that long preceded chemical and biological processes was obviously simpler. The history of life reveals a hierarchical structure in organisms, from virus-like entities to prokaryotic cells, eukaryotic

[15] The anthropic principle states that our location in time and space in the universe is necessarily privileged to the extent of being compatible with our existence as observers. The age and the fundamental physical constants of the universe are necessary to accommodate conscious life.

cells and multicellular individuals. Hierarchical structuring is only one aspect of the growth in complexity, but one also observes an increased number of different types of parts at a given level and of the number of interactions among them.

Creativity is causal but not determined; it is contingent on external interactions –contingent but not accidental.[16] While relatively stable regularities ("scientific laws") create and thereby determine the pathways that may be taken, the particular course of action actually taken depend on many circumstances (including our own actions in the sphere of human processes) and thus each time makes history.

Natural creativity is demonstrated by empirical evidence of physical, biological and human evolution (Figure 4). Creativity has been specifically recognized in the arts since the Renaissance, in science since the nineteenth century, and in social and personal life simultaneously with the development of sociological and psychological determinism in the 19th and 20th centuries.

Creativity was explained by supernatural intervention and it is now explained, among scientists, by random events (a passing meteorite, genetic mutations, economic events).

Creation actually is the natural consequence of action, opposition, and tridimensionality. Pairs, triads, and larger sets of processes interact and thereby co-create novelty, complexity and structure. The convergence of actions generates new processes. **Co-creation** thus is the motor of natural evolution and of human processes.[17] The bipolar feedback process that generates Bios patterns is a significant example of co-creation. The role of co-creation is highlighted in principles (2) and (3).

Oppositions are important motors of change in science, society, and thinking. Regarding social processes, we must consider the oppositions within and between natural categories of age, sex, class, race, and nationality, see Sociatry, this issue).

5. **Changes in quantity generate changes in quality and complexity, and changes in complexity generate changes in quantity.**

Because processes are composed of discrete actions and structures are made of particles, the universe is organized numerically. Numbers encode order, quantity, form and complexity, so changes in one of these aspects changes the others.

The form of numbers is revealed by complement plots (sine vs. cosine) of their multiples (figure 6).

[16] "Contingent" means dependent on events or conditions, but it also means dependent on something future, not yet known, and also used as happening by chance or without known cause. These meanings are confused, and "conditional" is often taken as evidence for accidental. Gould [66] has developed a conciliation of determinism and contingency that differs from the concept of creativity in that it explains contingency as the result of large, third order processes, that may be accidental (e.g. a collision with a giant meteorite).

[17] I seem to have coined the term co-creation, which is now also used in somewhat different meaning in business.

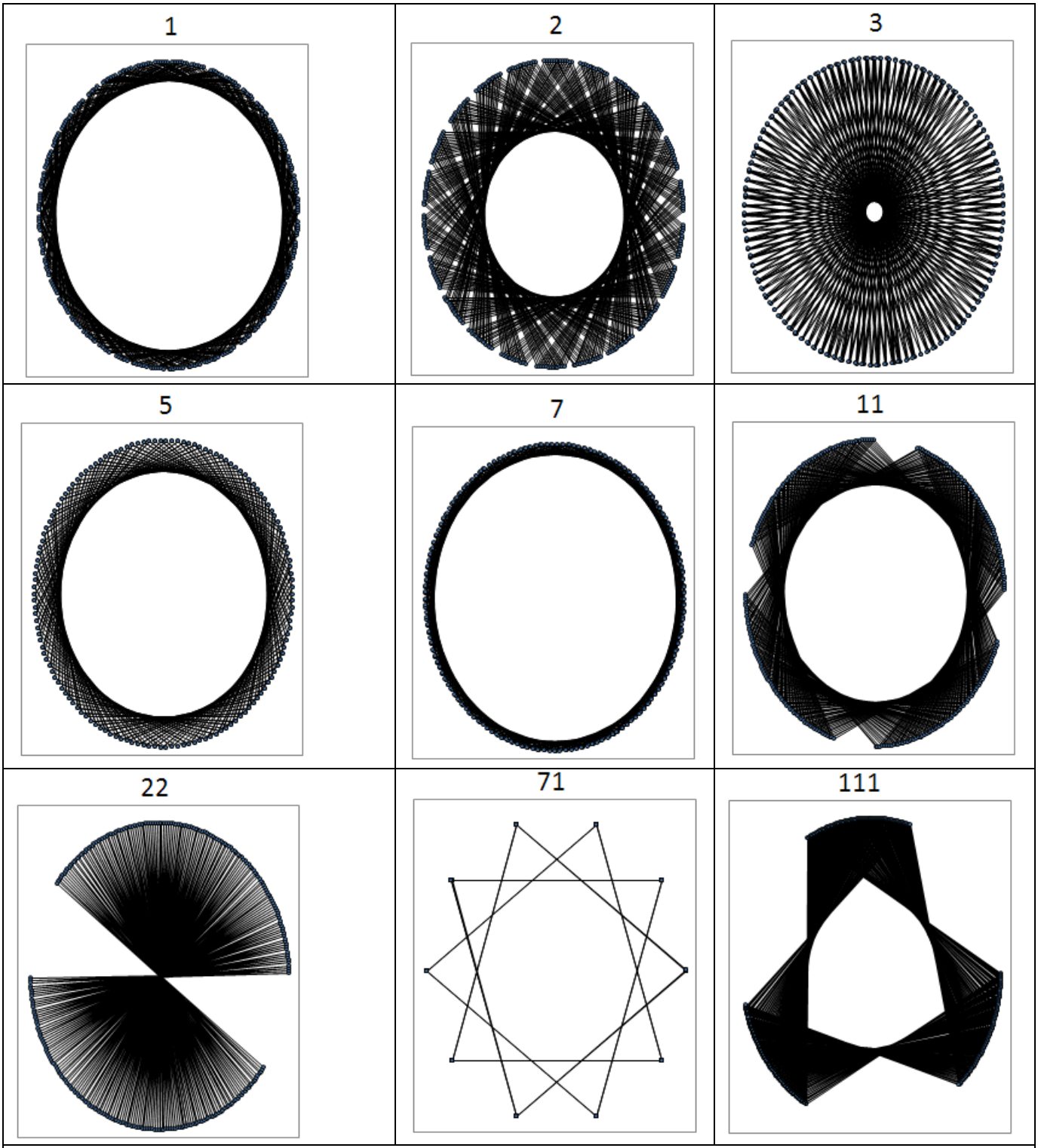


Figure 6 : The formal aspect of a number as detected in complement plot of the series of its multiples.

Changes in quantity generate changes in quality [67] and in complexity (this article): Changes in temperature change the state of substances, lengthening the number of atoms in a molecular chain changes their chemical properties, the nucleation of uranium beyond a critical mass produces an explosion. Maximal entropy occurs in quantitative "leaps" from one quantity to another, not in processes of disordering and decay.

Hegel's law of quantity and quality applies to the changes from material core to energetic fields to informational range (figure 7).

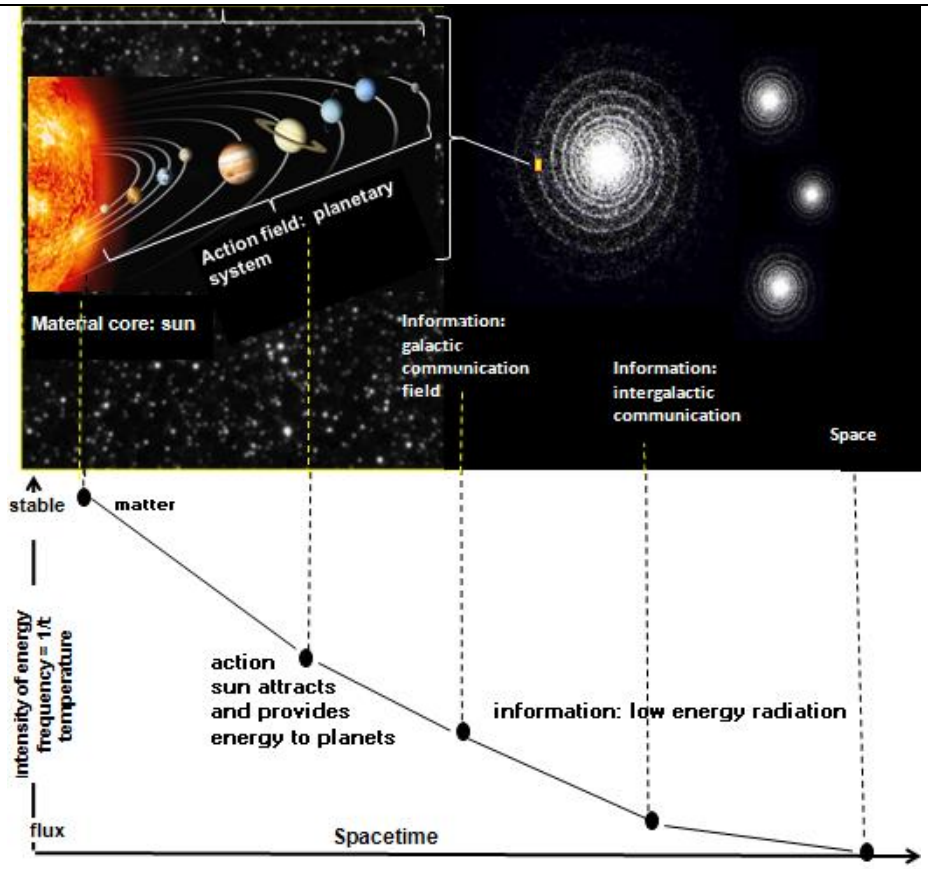


Figure 7: The law of quantity and quality applies to the changes from material core to energetic fields to informational range. The change in quality from matter to interactions to communication results from changes in the density of energy.

Quantitative changes in age, population and wealth underlie changes in quality in social and personal processes. The economic and political domination of the Europeans created an explosion in their number, from 18% of the world's population in 1500 to 36% in the 1900s. In contrast, there is now concern that the lower rate of reproduction of Europeans is decreasing its population relative to Asian and African immigrants in Europe itself.

Increases in population can either split simple social units (a change in quantity) or increase their complexity (e.g. formation of clans and moieties) [68].

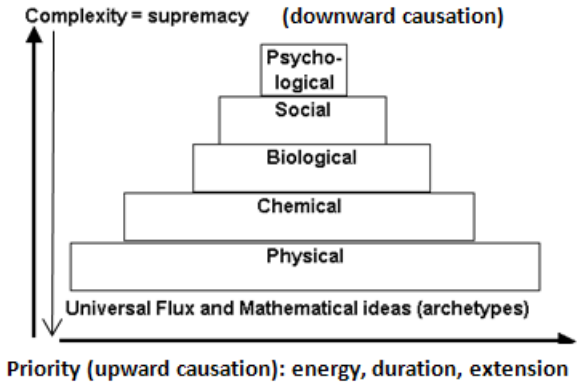
The occurrence of leaps should not be regarded as necessary for social progress. Revolution is not the same as transformation. Reform is both less difficult and more radical than revolution. Revolutions may not transform their society, and transformations do not require revolution.

Changes in quality generate changes in quantity (Engels). Conversely, changes in complexity generate quantitative changes in physical, social and economic processes (this article). The attachment of neutrons into atomic nuclei expands their mean lifetime of less than 15 minutes when free to prolonged stability when bound inside of a nucleus; conversely, protons, which are stable in empty space, may transform into neutrons when bound inside of a nucleus.
The Industrial revolution of 18th and 19th century generated unprecedented growth in average income and population; qualitative progress in medical and public health have engendered a great increase in world population in the twentieth century; changes in the mode of production have produced global warming; the ongoing computer revolution is expanding social, industrial, commercial, and production. One may take advantage of the fact that changes in quality generate changes in quantity to control global warming and population growth.

6. **Processes are organized hierarchically according to their rate of energy flow, their mass and size (matter) and their complexity (information). These three hierarchies are related but different. Each hierarchical relation is bidirectional, one pole predominating in one respect and the other predominating in a different one (priority and supremacy).** [58, 61]

The physical and the human world are organized in levels. As energy and matter are different, the corresponding hierarchies also are different and both contribute to levels of informational complexity. From the perspective of energy flow, the hierarchy of complexity evolves from simple and universal processes (quantum and cosmic processes, which were identical in the primordial atom) to progressively more localized and complex levels. Simpler and larger processes create complex local complexity. In contrast, from the systems perspective that describes hierarchies of matter, complexity arises from the combination of simpler parts, so atoms are the simplest level and the universe is the most complex. The systems model splits physical processes at into opposite extremes. These two views have opposite implications for medical, psychological and social action. According to the priority and supremacy principle, social processes precede and create individual processes, while in the systems view individual processes precede and create social processes. According to the priority and supremacy principle, social processes precede and create individual processes, while in the systems view individual processes precede and create social processes. Thus the priority and supremacy principle prescribes a bio-socio-psychological approach in medicine and in sociology, while the systems approach prescribes a bio-psycho-social approach.
The relation between levels of organization is bidirectional, one pole predominating in one respect and the other predominating in a different one, so simple and complex interact in a repetitive manner, a creative feedback similar to the interaction of other opposites. Bidirectional hierarchy describes the relation between levels of organization (physical priority and personal supremacy), as well as the relation between simple action (priority) and creative processes (supremacy).
The concept of priority and supremacy (Figure 8, left) was introduced by Sabelli and Carlson-Sabelli to integrate the many aspects of clinical work [61]. It leads to a bio-socio-psychological strategy. The concept of priority and supremacy is modeled on the hierarchical organization of the Central Nervous System. The Systems Theory of levels of organization (Figure 1, right) leads instead to a bio-psycho-social strategy. Systems Theory splits the physical level into atomic and cosmic while the process view recognizes that quantum and cosmic processes are intimately related. The size of systems does not correctly portray complexity, which is greater for cells and organisms than for either atoms or galaxies.

Levels of organization
according to the complexity of processes



Levels of organization
according to the extension of systems

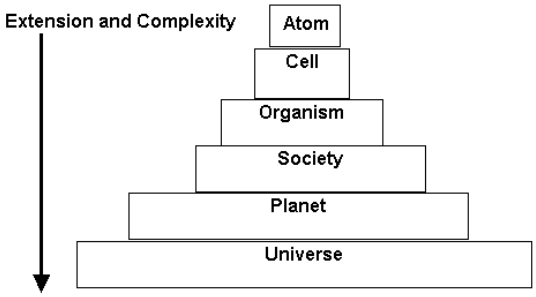


Figure 8: Two views of levels of organization. Left: Bios theory: bidirectional hierarchy from the simplest and most extensive to the most complex and less extended (priority) and from the extensive to the most complex to the simplest (supremacy). Right: Systems theory: hierarchy from smallest to largest. Both hierarchies are operative.

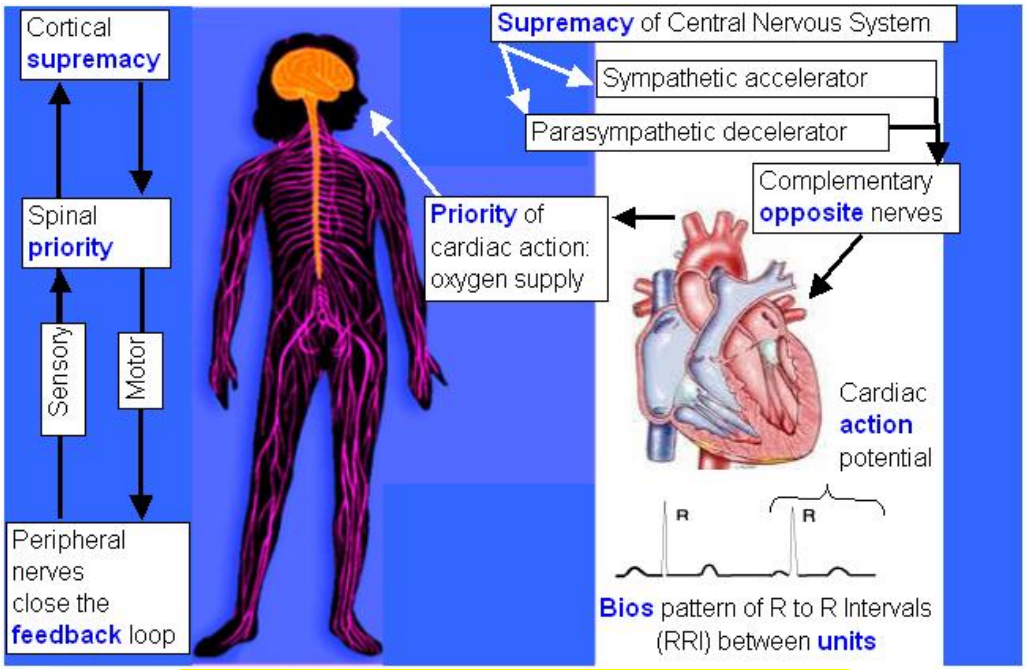


Figure 9: A biological example of priority and supremacy

The priority and supremacy process is a feedback that generates change (figures 9 and 10) and may actually be a fundamental mechanism in evolution.

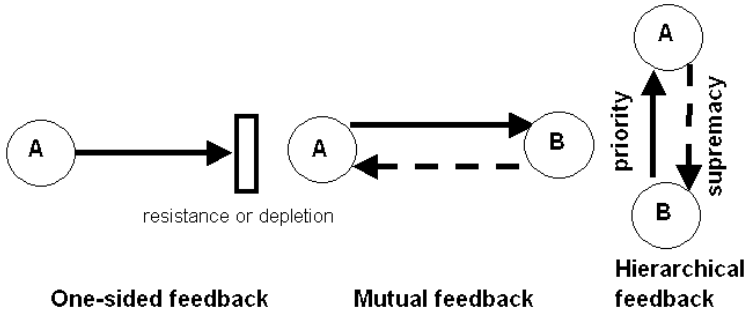
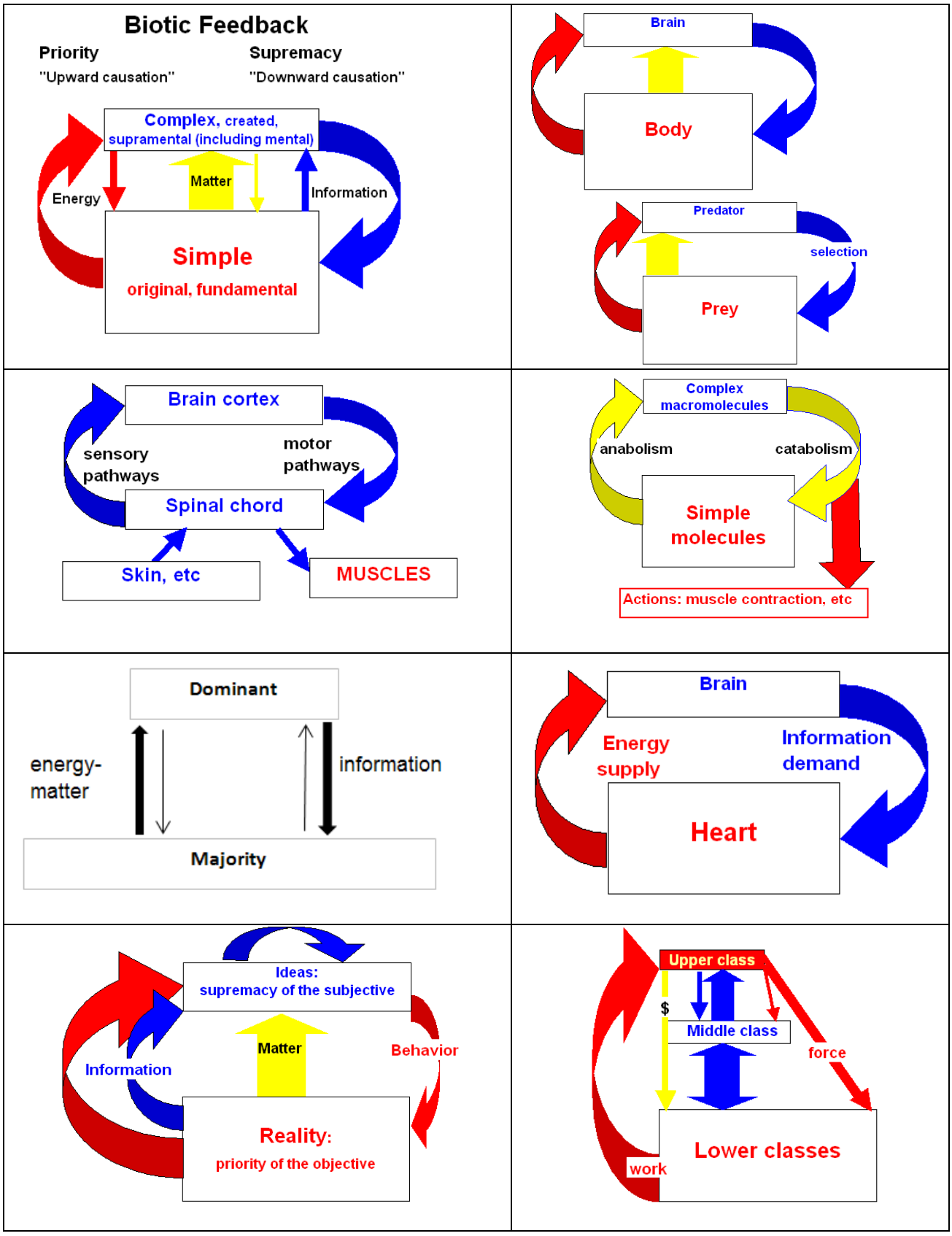


Figure 10: The priority/supremacy relation as a feedback process.


Biotic Feedback
Priority
"Upward causation"
Supremacy
"Downward causation"
Complex, created, supramental (including mental)
Matter
Energy
Information
Simple
original, fundamental
Brain
Body
Predator
selection
Prey
Brain cortex
sensory pathways
motor pathways
Spinal chord
Skin, etc
MUSCLES
Complex macromolecules
anabolism
catabolism
Simple molecules
Actions: muscle contraction, etc
Dominant
energy-matter
information
Majority
Brain
Energy supply
Information demand
Heart
Ideas: supremacy of the subjective
Matter
Information
Behavior
Reality:
priority of the objective
Upper class
$
Middle class
force
Lower classes
work

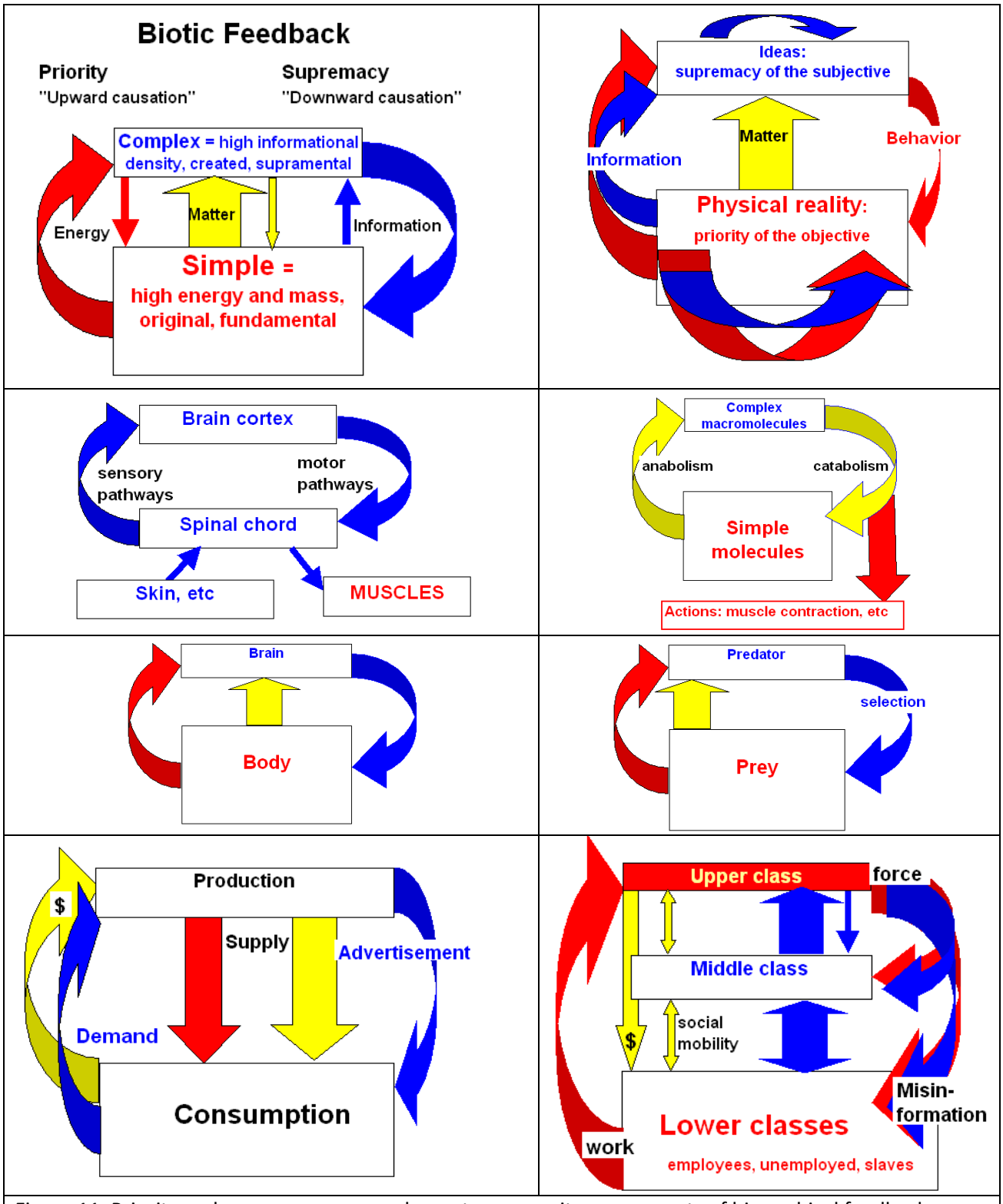


Figure 11: Priority and supremacy as complementary opposite components of hierarchical feedback.

The priority and supremacy bidirectional hierarchy applies to nature, society and logic. In processes, order involves temporal sequence and its complement, the hierarchy of complexity. In logic, the objective has priority but the subjective has supremacy. Scientifically, method has priority and ideas have supremacy over observation and experiment.

The Central Nervous System is organized in levels, from the simpler spinal cord that channels sensory and motor functions, to the cerebral cortex that has supremacy of control. The human cerebral cortex is the most complex system in the known universe. Correspondingly, the psychological and the personal level are the highest level of organization. A bio-socio-psychological integrative approach is likely to be the most effective clinically and socially.

Health issues have priority, and among them priority resides with infectious diseases –the struggle of viral and bacterial species against multicellular organisms. While chemotherapy has an enormous impact in our health and survival, perhaps vaccines (Pasteur, Salk) play an even more important role.

The supremacy of complexity generates quantitative growth, as illustrated by the enlargement of the nervous system at the cerebral cortex level, the expansion of dominant populations (e.g. the replacement of all other human species by the African Cro-Magnons, the growth of the European population from 18 % of the world's population in 1the 1500s to 36 % in the 1900s), and the development of the economy in dominant countries.

The priority and supremacy principle plays a fundamental role in social processes, as generations, sexes and classes relate in a hierarchical but bidirectional manner. Adults have supremacy, but children must have priority. Men, as many males in the mammalian world, have social supremacy, but women, as all mammalian females, have priority because of their fundamental role in reproduction, child rearing, and longer life span. Upper classes, by definition, have a degree of supremacy, but they depend on the production of the workers.

As result of the bidirectional exchanges between levels, economic forces are important regarding generational, sexual, racial, and national divisions, not only regarding socioeconomic classes. Conversely, cultural issues are important regarding socioeconomic classes. Feminism does not struggle against discrimination based on ideologies that regard women as inferior but against the lower income of women that result from the fact that much of woman's labor concerns reproduction (including child rearing) rather than production. Ageism is not discrimination against the old but the exclusion of the elderly from productive work.

Conversely, education, culture and religion are important regarding socioeconomic issues. The supremacy of the complex often is more powerful than the priority of simpler processes. Indeed, most persons would regard spiritual matters as the highest level of organization and also as the source of their beliefs. Religions thus have practical implications, and unfortunately they often promote unscientific ideas, authoritarian regimes, conflicts and war, as illustrated not only by Muslim theocracies but also by Western advanced countries. Religions need not support authoritarian systems (Moses, Jesus, Vatican II, liberation, feminist and ecological theology) nor are they necessarily unscientific. Teilhard [69] and Whitehead [70] have proposed process views of God.[18] I shall not pursue this matter here. This is an article about creation in nature and practical human enterprises, not a book about divine creation.

[18] I have explored this idea though the concept of an infinite attractor of evolution [36, 42]. I am not indifferent either the emotional meaning of spiritual ideas. Once I was inspired to write a play attempting to capture the image of Mary of Nazareth as a young woman who reached to co-create the divine. It was sweet experience to imagine Mary.

The bidirectionality of hierarchal relations render crucial to combine socialization and individuation, attending to the two complementary aspects of each person ("personalization") as an alternative to both collective (religion or socialism) and individualistic conceptions [71].

Discussion

These principles describe the organization of natural processes and thereby prescribe rational and effective human action and thinking. Logical thinking and rational behavior must capture what is true in reality. How could otherwise be rational and effective?

Specific social applications of these principles are explored in *Sociatry* and other companion articles in this issue. This article focuses on principles because concrete analyses and practical strategies can only be effective for relatively short periods of time. Social processes are unending. They create and recreate progress and deterioration. One cannot solve age, sex, class or ethnic conflicts once and forever. One cannot resolve current problems at once, nor prevent the occurrence of new ones. Growth and liberation, both social and individual, will continue to be tasks for each generation.

Not only is natural science necessary as a foundation for effective human action, but also examining the social implications of scientific ideas reveals how social ideologies influence our scientific ideas. Here again we encounter the bidirectional relation of opposites, in which objective reality has priority but subjective ideas have supremacy.

As a theory, causal creativity integrates and transforms dialectics [67, 72, 73], cybernetics [53, 74, 75], and systems theory [76, 77]. The concept of causal creativity is based on the work of many others, combining ideas regarded as unacceptable or "enemy" ideologies by many, thereby transcending the notion of conflict as a way of thinking.

The six principles outline a new theory of natural and human processes. This is the way in which they depart from established or current ideas:

Causal action implies change, which is not included in the static framework of Aristotelian or Boolean logic. It also implies non-random causation, at variance with random models in economics and physics, including quantum indeterminism.

The principle of co-creation of bipolar (synergic and conflictual) opposites that generate cascades of bifurcations contradicts the principle of no contradiction which is central to the logic currently used in computation. Bipolar co-creation integrates the notion of harmony implicit in many religious creeds and the conflict theories of biological (Darwin) and social (Marx) evolution and the concepts of mutual aid (Kropotkin), symbiosis and endosymbiosis (Margulis).

Triadic co-creation contrasts with the reduction of matter to energy, and with the formulation of logic as set theory, which is immaterial and simple, discounting as unnecessary to consider the three fundamental structures embedded in Bourbaki's structures and in neurobiology.

Natural creation transcends determinism and opposes the notion of thermodynamic decay which is at best a hypothesis opened to question rather than a universal law of nature. The "heat death of the universe" postulated by the prominent 19th century physicist Lord Kelvin, was based on the everyday observation that objects warm up when they gain energy, but this is not so for astronomical objects for which gravitation is the main form of energy. As a star loses energy by radiation, it becomes smaller and denser, and thereby hotter rather than cooler. As a consequence, temperature differences increase in the universe, instead of becoming more homogenous.

The quantity-quality-complexity principle contradicts the focus on quantity championed by positivism, drastically enlarges Hegel's law, and limits the significance of fractal scale-free organization.

The priority supremacy principle complements systems hierarchy in accounting for complexity, and challenges its applicability as a bio-socio-psychological approach in medicine and sociology. It also rejects

idealist as well as materialistic reductionism (such as the reduction of science to physics, psychology to biology, and sociology to economics).

The bipolar feedback models for the co-creation of opposites follows the notion that logic must be mathematical and incorporate many of the contributions of dialectics, but it departs radically from set theory and from dialectic materialism. The concept of natural creativity by the co-creation of opposites and triads is an alternative to several other encompassing worldviews including:

1. The static view that dominated late Antiquity and medical thinking, and still permeates stationary views.
2. The notion of global thermodynamic decay.
3. Determinism, physical, biological, social and psychological. It has been claimed that the evolution of the universe and life was somehow encoded in the distribution of particles in the early universe. The chance explanations of quantum phenomena, biological evolution, and economic processes (argued to replace God as an explanation for creative processes) and the denial of evolutionary progress as an appearance resulting from an increase in variance, which divest change of meaning, and deprives us from hope and of an active role in our future.

As simple levels of organization are <u>not</u> eliminated by the evolution of the more complex ones they generate, so the mean complexity of the system may not increase, its lower level will remain unchanged, and the only evident statistical effect of evolution may are an increase in variance. But this does not negate the development of a new and higher level of complexity.

The assumption of randomness has a negative effect on human behavior. While Shannon's Information Theory took the notion that "meaning is irrelevant" as its basic assumption, we must bring meaning as the Ariadne's thread to understand natural and human processes, and to deal with the massive amount of information that overwhelms us since it has become easier to generate and collect data than to understand it.

The core idea is that **natural and human processes are causal and creative, and therefore it is rational to exert our efforts to decide our future**. This is a new concept in science, where natural and social processes are described as determined by physical law or dependent on accidental change. Yet creativity is everywhere, from the origin of the universe and the development of life to our evolving human behavior, ideas, and social organization. The need to understand creativity has been clear since the earlier times in human history, as evident in the widespread occurrence and diversity of creation myths. In recent times, accidental and meaningless change is a less beautiful and imaginative myth but, as the empirical analysis of the data shows, no more scientific than earlier fables. The notion that economic changes are the product of random events provides no tools for action, and initiated the irresponsible policies led to the financial crisis that started in 2007 and for which there is no end in sight. The notion that social processes are determined likewise provides no tools, and underlies the mechanical pursuit of developmental paths pursued earlier. For instance, undeveloped countries must follow the course of development that occurred in Western societies. Likewise, and in the Marxist scheme, a society must develop from agriculture to capitalism industrialization to socialism. Processes are causal but not determined because something new is created, and furthermore, we can choose what we create.

This introduces a set of new principles that are scientific and humane. Their scientific foundations are primarily from medicine and mathematics, but they have also being tested in physics, economics, and psychology. Their humane character follows from normal human solidarity, and is made sharper by being grounded in clinical medicine and psychology.

In contrast, the current economic focus is neither scientific nor humanistic: it pollutes and depletes the planet and generates chronic wars and increasing poverty. Its scientific foundations are merely analyses of economic processes of finance controlled countries without reference to physics, ecology, biology and psychology, and the policies recommended pollute and deplete the planet, produce economic crises,

generate chronic wars, and increase poverty and hunger even in the richest countries. The oil fields that sustain our wealth are a great loss if destroyed, a problem to govern, impossible to annex, and of limited duration. Many of our crises are fostered by the thoughtless search for power and wealth which is described as the core of our cultural heritage.

Exploitation, war, and hunger are described as unavoidable realities, and justified as the inevitable consequences of economic laws, human nature, or even of God's will by those who benefit from them, and the public is indoctrinated in these views by the media they control (commercial, government, and religious education, information, news, and entertainment).

The crises we face are said to be the inevitable consequences of the laws of nature, random change, and chaotic unpredictability. But, **when confronted with unavoidable reality, we can always resort to improbable and unpredictable creativity**. Creativity is improbable but not rare. In fact, fundamental natural and human processes are creative. The specific changes they generate may be unpredictable but creativity itself is a fundamental component of natural and human processes, and it is propelled and guided by simple and predictable actions. We have to imagine what to do, to think how to do it and to do it ourselves.

In any case, how "inexorable" are the laws we confront? "Inevitable laws of nature" and "random accidental processes" are beliefs supported by current ideologies, not by scientific facts. Environmental depletion, global warming, increased poverty and inequality and decrease in global demand, scientific and medical progress and worsening of medical care, chronic war and terrorism, are not the accidental consequences of random processes or of chaotic unpredictability, but the straightforward predictable effects of causal, linear processes, resulting from human actions.

Unpredictable creativity is not the product of spontaneous improvisation or chance events that most often are repetitive. Action is necessary for creation, but most actions are not creative. Spontaneous, "chance" actions rarely are. Creation requires thinking. Original, improbable, unpredictable creativity requires us to think anew

Our own actions can thus be creative. Our future is not determined by inflexible laws of nature or of divinity, nor are we at the mercy of random, accidental variations. But if our actions are not determined, they may also be destructive. In the mist of our progress, our world is immersed in war, economic crisis, and ecological decay. Poverty is widespread and often severe to the point of starvation. The threat of nuclear holocaust has not ceased thanks to Muslim terrorists and political extremists elected in Western democracies. The pace of ecological decay is accelerating. A few years ago, we felt the responsibility of saving the environment for our grandchildren. We see now that we must save it for ourselves.

The USA continues to be involved in chronic wars and financial crises that sink us into economic decay. In 2010, there are 15 million jobless workers. Diseases once considered all but eradicated in the United States (many of them childhood illnesses) have re-emerged in the past several years according to the Centers for Disease Control and Prevention as result of the declining living standards for the working class.

Given the severity of our current ecological, economic, social and national problems, profound changes are needed. We need a fundamental change in our thinking. Economic, political, or ideological changes are not sufficient. Ecological, medical, and ethical issues must be considered. There is a moral crisis generated by the government condoning torture. In fact, we need a new, scientific and humane way to think about human processes. This is sociatry, a scientific, therapeutic and comprehensive approach to social issues developed by Moreno [39].

Faced with severe problems, only fundamental change is practical. Instead our leaders advise us to believe, to follow, to vote, to shop or to save, to act, to fight, to kill their enemies. Armed with ever more powerful weapons, we may indeed destroy humanity or perish in the process. The oil fields that sustain our wealth are a great loss if destroyed, a problem to govern, impossible to annex, and of limited duration. Our leaders play tough or conciliatory party politics. Afraid to attempt necessary change, our leaders have

squandered not only our wealth but also our hopes. There has been no difference in their plans to deal with chronic wars, economic crises, and ecological disasters. The mounting threat of nuclear war has become an issue for party politics.

Facing squarely the impending nuclear holocaust, Einstein called for a new manner of thinking as necessary to survive. To survive we need to think rationally and humanely. Fundamental change must start with the basic sciences, including both mathematics and medicine. Few will quarrel with mathematics as necessary. But medicine is not only the oldest profession (the medicine-priest shaman was the only specialized role, other than leader, in prehistoric groups) but also the oldest science (e.g. the empirical pharmacology of prehistoric shamans). The oldest scientific text is medical.[19] Modern science began with the work of a physician, Copernicus,[20] and the empirical method and the numerical-geometric approach were developed by two physicians, Harvey, who demonstrated the circulation of blood, and Descartes, a contemporary of Galileo who was the father of analytical geometry (the Cartesian coordinate system allows geometric shapes to be expressed in algebraic equations) and a pioneer physicist.[21] Descartes practiced medicine all his life, without charge, and Descartes' most important disciples, Leroy, La Mettrie, and Cabanis, were physicians.[22]

Besides this history, medicine provides a philosophy for scientific research and human action. Medicine is practical and concrete. It focuses on reality, matter,[23] and change, not on pure abstractions or spiritual beliefs. A focus on reality diverges from current strategies according to which implausible models are accepted if they fit numerically the data. A focus on reality diverges from current strategies according to which implausible models are accepted if they fit numerically the data.[24] Also, medicine fosters

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[19] The Edwin Smith papyrus, attributed to the Egyptian physician Imhotep (3000 B.C.E.-2950 B.C.E.). This text was used for over 1500 years to teach medicine. Imhotep also designed the first Egyptian pyramid, the oldest and most famous artistic archetype. He was also a statesman, a poet, and a philosopher who advised us "Eat, drink and be merry for tomorrow we shall die."

[20] Nicolaus Copernicus (1473 –1543) practiced medicine for much of his life. For Copernicus, astronomy was an avocation.

[21] Descartes formulated the *law of conservation of motion* (a precursor of the law of conservation of energy) that excluded random accidents or supernatural interventions in natural processes. To this general conservation law he adds two particular laws, first that everything maintains its own state until interfered with by an external cause (a principle directly opposed to the Aristotelian view that things in motion tend to come to rest) and second, that bodies tend to move in rectilinear paths, so bodies in circular motion tend to move in the direction of the tangent. These laws together constitute the first published statement of what Newton, who knew Descartes work, later called the law of inertia (Brackenridge, J. B. *The Key to Newton's Dynamics: The Kepler Problem and the Principia.* Berkeley: University of California Press, 1996). Descartes was also a forerunner of wave theories in physics (Maxwell, Schrödinger).

[22] While Descartes was still living, Leroy stated that Descartes had disguised his real opinions, transferred to the human soul the Cartesian construction of animals, and explained the soul as a mode of the body and ideas as mechanical movements. La Mettrie proposed the metaphor of the human being as machine, prefiguring twentieth century cybernetics. Cabanis metaphorically explained that the brain secreted thoughts just as the stomach digested food.

[23] Focusing on the treatment of illness, medical practice naturally led to scientific materialism. Hippocrates changed the course of Greek medicine with his certainty that disease was not caused by gods or spirits but it was the result of natural action. He is thus considered as one of founders of naturalism or materialism.

[24] Demanding that a model must also be physically meaningful may guide research further. For instance, Feynman's idea of a particle following all possible paths might be enhanced by considering that such portrait may represent the flow of a wave.

comprehensive and humanistic philosophy. This is a welcome departure from the focus on economic matters that is too restricted and devoid of humanistic dimensions.

A philosophy is not an addition to research. It informs how research must be conducted. As we discuss in (6), method has priority and ideas have supremacy over observation and experiment**.**

A new approach is needed. A new approach to our ecological and social problems is needed now. The cost of restoring our environment will only increase if we delayed even by a decade or two. The human cost of pursuing peace is small compared to the ever increasing economic and social cost of pursuing war. "**If not now, when?**" asked Rabbi Hillel (ca. 60 BC-ca. 10 AD), and added: "Do not separate thyself from the community." We should take the problems that affect our community and our world seriously.

We must take ideas seriously. A very limited number of empirical studies (that certainly must be enlarged) led us to consider causal creativity as central to physical and human evolution. This is a high claim, and many scientists would recoil from formulating such hypothesis as an unwarranted extrapolation. Further, the notion of causal creativity has implications regarding logic, psychology and social action. This is another high claim. Can we extrapolate from scientific experiments to life?

One must be prudent in proposing answers, but we cannot stop asking questions and posing hypotheses, particularly hypotheses based on empirical research. We should take scientific research seriously. We must explore the implications of empirical findings.

In contrast, scientific thinking has been dominated by an ideology, sometimes called positivism or empiricism, which as a principle refuses to consider the meaning of physical experiments, regarding that as "metaphysics". "Grand principles" are summarily and strongly rejected. This is, of course, a principle. Such positivism discourages rather than guide research.[25]

If we cannot learn from science, from what can be learn? From politicians, the media, commercial enterprises, or religious position of one denomination or another? Would you give up up-to-date medical care, contemporary methods of production, computers, or communication? **If not science, then what ideas should we take seriously?**

We should then attempt to develop a new and creative way of thinking about our reality based on what we learn from scientific studies. But, what qualifies you or me to attempt such a task?

We may answer "***If not us, then who?"*** as did the citizens of Ville Platte, when desperate Americans were escaping the hurricanes that destroyed New Orleans and devastated Texas and Florida in 2005, and the government sent no help. Local fishermen and hunters were among the first volunteers to take boats into New Orleans to rescue distressed residents from their flooded homes. Ville Platte, a poor Cajun and black Creole community of 11,000 in the heart of French-speaking southern Louisiana, with a median income less than half that of the rest of the nation, opened their doors and fed more than 5,000 of the displaced people they called "company," as the terms "refugee" and "evacuee" are impersonal and rude.

The 2005 tragedy was repeated in 2010 when the worst oil disaster in American history resulted from the offshore drilling that had been declared safe by the government a few days before. Not surprisingly, the government has not provided funds to its own agencies for a thorough investigation, still protects the

[25] The history of positivism does not recommend it as a scientific strategy. Comte regarded as a paradigmatic example of positivism the impossibility of the chemical analysis of stars, which has become a centerpiece of contemporary research. In the name of empiricism, Mach denied the existence of atoms and did not believe in relativity. Einstein had to fight to convince his generation of the existence of electrons, and eventually Mach's empiricism was dismissed from the minds of the majority of physicists, even after the Copenhagen interpretation of quantum mechanics briefly resurrected it. Also in the name of empiricism, Mach asserted that only sensations exist, reproducing the philosophical idealism of Bishop George Berkeley, dismissed by most thinkers as leading to the absurd notion that the only thing that exists is me (solipsism).

financial interests of the culprit, British Petroleum, and has not stopped future deep drillings. If not us, who will protect our shores?

As scientists and as clinicians, we have specific contributions to make. To construct a different world, we need a new worldview. Attempting such task may appear overambitious, but to whom could we entrust this task?

Should we consign this enterprise to corporations that in the pursuit of profits are destroying the environment and even consciously increase infant mortality by discouraging breastfeeding in Africa to sell their products? Should we entrust this task to those who pursue wealth, "progress" and "development" that often are more destructive than constructive as a religious mandate? Should we trust economists who focus on profit and disregard ecological and social consequences, and who in recent years devised programs of austerity that wiped out the economy of many countries including our own? Should we entrust this task to the Harvard law professors who endorsed torture or to its sociology professors who proclaimed a clash of Christian versus Islamic civilization, and asserted the need to exclude Mexicans from the USA? Should we entrust this task to the Marxist intellectuals who did not see the horrors of Stalinism and in to some extent created its ideology? Should we hand it over to Darwinian theorists who regard evolution as the result of conflict and survival of the fittest, providing a (false) rationale for racism and imperialism? Should we trust the press that swallowed and spread the myth of weapons of mass destruction in Iraq that led to war? Should we appeal to the Church that recently had to apologize for their support of bloody dictatorships and dirty wars in Latin America, or to other Christian leaders, whose fundamentalism supported state terrorism and torture? Both in the Christian and non-Christian worlds, religion is more often used to promote war and terrorism than to preach peace.

Likewise, political and economic philosophies have often been used to support war, tyranny, and gruesome torture. Capitalism fostered the development of individual freedom and electoral democracy, but is destroying the environment and now also its own financial bases and has promoted exploitation and war in Asia, Africa, and Latin America. Communism has for good reason collapsed in Russia and has been abandoned in China. European Socialism has promoted the welfare state but offered no real alternative: British socialists built Asian and African empires, French and German socialists fought each other in WWI in support of their employers, German socialism became National Socialism (Nazism), and Russian socialism became the communist dictatorial empire. Only in Latin America there is a serious attempt to recreate a new socialist view. Can there be an attempt to recreate American democracy?

America has a long democratic tradition. It is not simply capitalism as its champions and enemies portray her, but it is a living and evolving entity that is developing a sexually egalitarian and multiracial community even when the election of the first half Black president has not offered any new policies regarding peace, employment, medical care or the environment.

We need new ideas. We need to find new foundations. We need to foster the development of socially conscious science. If not us, then who?

This article is a call for action, but not for action without thinking. This is a call for thinking, for thinking for yourself, but not by yourself: rationality requires attending to the thinking of others, to learn from them, and sometimes to protect ourselves.

Conclusion

In summary, a set of hypotheses supported by limited but real data, and modifiable by future studies, can account for creative processes in nature and society. This article presents three important hypotheses, co-creation by pairs and triads of complementary opposites as a mechanism for causal creativity, and changes in quantity resulting from changes in complexity, which may be particularly significant regarding the control of population and global warming.

Natural and human processes are biotic (life-like): they are creative: they originate with simple and well defined causes (not random changes), and they generate novelty (initiative, spontaneity), diversity (of physical processes and structures as well as of age, sex, class, ethnicity, culture, and ideas), and complexity (scientific, psychological, ideological and personal). They are readily modifiable by small causes, such as human action. Our origin is determined. Our destiny is open.

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