Chapter 1

A Research Program: A Science of Creative Processes

Abstract: Our research program is to develop a science of creative processes through (1) the study of empirical processes, (2) the development of new methods to identify creative phenomena, (3) the formulation of mathematical models and abstract theory, and (4) the development and application of creative approaches to clinical issues.

Creation is spontaneous and ongoing in natural and human processes, yet there is no science of creation. There are no general hypotheses regarding creative phenomena and no mathematical methods to demonstrate and distinguish creative phenomena from randomly-generated noise.

Creative processes are attributed to random accidents because current scientific concepts cannot account for the generation of novelty and complexity. According to current views in quantum mechanics and evolutionary theory, the foundations of matter and the origin of life and its evolution are aleatory phenomena. Mechanical determinism cannot account for the origin and evolution of the universe, nor the creation of life, so random fluctuations and accidental contingency are offered as explanations.

A science of creation is necessary to replace the determinism, indeterminism and supernaturalism that dominate current discourse. Most scientists recognize these conceptions as ideologies rather than scientific theories, but still they use random, probabilistic, and stochastic models that are, in last instance, indeterministic; “deterministic noise” is an oxymoron. Predominant scientific worldviews regard processes as either deterministic or probabilistic and attribute innovation to random change. The assumptions these theories are predicated upon thus fail to provide guidelines to identify and measure creative phenomena, and in fact hinder the development of methods to analyze creative features in time series. No incentives and no guidelines to study creative processes can be derived from probabilistic views that regard innovations as aleatory events, or from mechanistic viewpoints that imply determinism without creativity. A major obstacle to the development of methods for the detection and measurement of creative phenomena is a lack of theory. Underlying the lack of theory is a lack of motivation stemming from the notion that natural processes are either determined or aleatory.

A theory of creative processes is necessary for scientific purposes because fundamental natural and human processes are creative. Our research goal is to define, measure, and account for creative processes as natural and spontaneous.

Creation has been accounted for in two ways.[1] Within a traditional frame of mind, many attribute physical reality, life and mind to specific supernatural acts of creation. Within a mechanistic frame of mind, creativity has been attributed to random events. In both cases, evolution moves from complex to simple: from supernatural to physical in one case and from infinitely complex randomness to relatively simpler physical, biological and human processes. In contrast, the scientific view regards creation as evolution from the simple to the complex.

In this view, creation is conceived as the product of simple forms of order (causation), physical laws. Natural science regards the universe as organized by a small set of simple forms. Through their interaction, they may generate nature, life and mind. Simple processes can produce complex behaviors.[2] Thus, mathematical form generates physical reality,

---

[1] A note on terminology: I use the terms "creativity" and "creation" more or less interchangeably with "creative process", meaning the production of novelty and complexity; I do not limit the meaning of creativity to artistic, scientific or personal creativity. I use the term creation, so full of connotations, to refer to nature. "Creative process" sounds more scientific but it may misleadingly imply that I am referring to some special type of process when in fact I mean to say that most natural processes are spontaneously and continually creating. Speaking of creative processes makes no sense unless what is said also applies to creation and creativity.

[2] May, R. M. (1976). Simple mathematical models with very complicated dynamics. *Nature* 261: 459-467; Metropolis, N., Stein, M., & Stein, P. (1973). J. Comb. Theor. 15A: 25; Berlekamp, E., Conway, J., & Guy, R. (1982). *Winning Ways for Your Mathematical Plays, Vol. 2*. New York: Academic Press; Wolfram, S. (2002). *A New Kind of Science*. Winnipeg: Wolfram Media.

physical processes generate biological organisms, and life generates human mind and beyond. Chemical syntheses illustrate that many causal processes spontaneously generate novelty and complexity. Language exemplifies how simple, nonrandom processes generate diversity, novelty and complexity in a nonrandom creative fashion. In a similar manner, the information contained in physical patterns and structures may be creative.

The notion that complexity can be generated by simple processes dates from antiquity; it is implicit in biological evolutionary theories, and it has been given new scientific foundations with the work of Prigogine,[3] May,[4] Mandelbrot,[5] Thom,[6] Lorenz,[7] Feigenbaum,[8] Smale,[9] Sarkovskii,[10] Ueda,[11] the Abrahams,[12] Wolfram,[13] and many others. Fractal geometry and chaos theory represent fundamental advances in understanding how complexity arises spontaneously from simple organization. However, chaos research has focused on bounded attractors, which, being stable, cannot account for creative phenomena. Here we identify bios and biotic feedback as further steps towards a science of creative processes. In the ever-shifting focus of nonlinear dynamics, from catastrophe to chaos to complexity, creative processes seem the next logical step.

The hypothesis that natural processes are creative has been recently championed by Jantsch[14] and Prigogine,[15] among others. The bios model

---

[3] Prigogine, I. (1980). *From Being to Becoming. Time and Complexity in the Physical Sciences*. San Francisco: W. H. Freeman.
[4] May, R. M. (1976). Simple Mathematical Models with Very Complicated Dynamics. *Nature* 261, 459-467.
[5] Mandelbrot, B. B. (1977). *The Fractal Geometry of Nature*. New York: W. H. Freeman and Company.
[6] Thom, R. (1983). *Mathematical Models of Morphogenesis*. Chichester, West Sussex: Ellis Horwood.
[7] Lorenz, E. N. (1993). *The Essence of Chaos*. Seattle: University of Washington Press.
[8] Feigenbaum, M. J. (1983). Universal Behavior in Nonlinear Systems. *Physica* D: 16-39.
[9] Smale, S. (1967). Differential Dynamical Systems. *Bulletin of the American Mathematical Society* 73: 747-817.
[10] Sarkovskii, A. N. (1964). Coexistence of Cycles of a Continuous Map of a Line into Itself. *Ukrain. Mat. Z.* 16: 61-71 (in Russian).
[11] Ueda, Y. (1992). *The Road to Chaos*. Santa Cruz, CA: Aerial Press.
[12] Abraham, F. D., Abraham, R.A. and C.D. Shaw (1990). *A Visual Introduction to Dynamical Systems Theory for Psychology*. Santa Cruz, California: Aerial Press.
[13] Wolfram, S. (2002). *A New Kind of Science*. Winnipeg: Wolfram Media.
[14] Jantsch E. (1980). *The Self-Organizing Universe*. New York: Pergamon Press.
[15] Prigogine, I. (1980). *From Being to Becoming. Time and Complexity in the Physical Sciences*. San Francisco: W. H. Freeman.

is a logical continuation of ongoing developments, but it also represents a break with current "cutting edge" science. A science of creative processes stresses co-creation instead of catastrophe, bios instead of chaos, enantiodromia rather than entropy, flux rather than uncertainty, creative development rather than homeostasis or autopoiesis, symbiosis instead of biological competition, personalization[16] instead of market economics. The difference is evident even at the simple level of recording and analyzing data (Chapter 4).

To develop a science of creative processes, we construct methods to identify and measure creative phenomena. We formulate mathematical models to understand how creative phenomena can result from causal interactions. We consider biological processes as models for creativity in physical phenomena. We undertake critical psychological analysis of scientific ideology. We integrate dynamics and psychodynamics.

Our project is to formulate the ideas of the Greek naturalists in modern scientific terms to develop a science of creative processes. Salient characteristics of this process view are: (1) a focus on temporal change rather than on substance, composition, static structure, or self-maintaining organization; (2) the interpretation of process as self-propelled action, rather than as passive change or random events; (3) the investigation of interactions, relations, and context, as contrasted to the definition of boundaries to delimit systems and the formulation of criteria to differentiate classes; (4) the search for interacting opposites as contrasted to their separation as mutually exclusive classes; (5) the consideration of living processes as paradigmatic examples of physical processes; (6) a focus on creative process rather than mechanical determination or aleatory events; (7) attention to the creative or destructive implication of assumptions, conjectures, and methods.

A theory of creative processes also serves as a foundation for scientific and humane social and clinical interventions. According to predominant scientific worldviews, we either inhabit a giant mechanical clock or an accidental universe. In either case, our world is meaningless. Denying ongoing creation, positing a mechanical world determined by

---

[16] Sabelli, H. C. and Synnestvedt, J. (1991). *Personalization: A New Vision for the Millennium*. Chicago, IL: Society for the Advancement of Clinical Philosophy (SACP).

inexorable cause –a world without alternatives− discourages human action and can serve to justify the inhumane status quo. Attributing creativity to random chance or to supernatural intervention cannot foster or guide human creativity. Even worse, portraying nature as random encourages disregard for natural patterns, the consequences of which we experience as pollution, iatrogenic illness, and failed social experiments.[17] In our times there is vacuum of ideas promoting ethical progress –and an excess promotion of greed and conflict. Developing a science of creative processes serves two purposes: understanding nature and guiding constructive action.

1.1 Defining Creative Processes

The essential features of creative processes are (1) diversification, (2) complexification, (3) novelty, (4) episodic patterning, (5) autogenesis and (6) irreversibility. A creative process at first displays order and simple organization, and later includes both simple and complex components. While most authors equate **order and organization**, the two **need to be distinguished** in the study of creative processes. Order, as illustrated by linear cause and periodic waves, is simple, stable, rigid, and often primordial, while organization is complex, unstable, varying, and created by preexisting processes. Heartbeat interval series, the prototype of bios, exemplify the distinction and interrelation of order and organization. They display novelty, i.e. greater variability than random, as opposed to ordered series that are of course more repetitious than random (Section 4.6). Yet trigonometric analysis reveals a Mandala, simple archetypal order.

Creation is the autodynamic generation of complexity (autogenesis),[18] as contrasted to patterns generated by random changes. Creative processes differ from stochastic ones by their causal origin, shown by the presence of simple components of variation. Stochastic processes are generated by random events, independent from one other; random

---

[17] Berry, W. (1987). *Home Economics*. North Point Press: San Francisco.
[18] The term originates with Lamarck.

generators are more complex than the series they generate. The time series of stochastic processes have only complex components.

A creative process continually evolves, generating new, complex, and diverse forms (Table 1.1), as contrasted to self-organizing processes that form and maintain a single dissipative structure. Creative processes thus expand their phase space volume (Fig. 1.1). Mechanical processes are conservative, i.e. they maintain their pattern, phase space volume and dimensionality. Random processes are also conservative. Attractive processes converge to an attractor, which can be equilibrium (point attractor), a regular cycle (periodic attractor), or an aperiodic fluctuation (strange attractor, often called chaotic). Once the attractor is reached, chaotic processes maintain their phase space volume, dimensionality and pattern. These chaotic processes resemble random fluctuation: the more they change, the more they remain the same. Natural processes are fundamentally creative, although they include conservative and attractive components. Deterministic processes, whether mechanical or chaotic, do not generate diversity, novelty or complexity.

Table 1.1 Process Causation and Pattern

Phase Space evolution	Causation		
	Probabilistic (High dimensional randomness)	Deterministic (Low dimensional cause)	Natural
None (Conservative processes)	Uniform random	Mechanical	Electron orbitals
Contraction (Attractive processes)	Convergence to population mean by repetitive sampling	Point attractors Periodic attractors Chaotic attractors	Resting pendulum Moving pendulum Chemical oscillations
Expansion (Creative processes)	Statistical noise (Random walk, Levi flights)	Biotic Homeobiotic Parabiotic	Biotic galaxies Homeobiotic heartbeats Parabiotic economic series

An essential feature of creative processes is **diversification**. Evolution results in an immense diversity of inorganic structures and living organisms, and generates unique individuals –from snowflakes to human persons. Diversification can be quantified by measures of change in statistical variance with newly developed methods (Chapter 4). In a creative process, the patterns are not only new but also unique with respect to one other. As a result, variety increases with time.[19] As a rule, in noncreative processes, the variance, no matter how large, is stable. Other measures of innovation, such as the Lyapunov and the Hurst exponents, do not measure diversification or novelty.

Diversity and complexity are associated but are not identical. Speech continually generates new sentences from a limited supply of words and grammatical rules (diversification), but does not always generate complex meaning. A creative process is not always creating. Creation is a sine qua non for diversification, but in turn diversification promotes creation and reduces destruction. Consider for instance the greater security of a diversified stock portfolio. In the same manner, diversification generates organisms adapted to a wider range of environments, capable of new behaviors, resistant to predators or pathogens, and much more. Only in the short range does life aim at self-reproduction (autopoiesis); in the long run, life is promoted by diversification. Diversification probably also explains why sexual reproduction is predominant among complex organisms, an enigma that biology has yet to solve. Diversification is a general and essential advantage; if a pathogen can destroy an organism, it can also destroy its clones.[20]

Another essential feature of creative processes is **increasing complexity**. Complexity means the coexistence of a large number of different qualities or dimensions. Well-defined qualities, such as energy, electrical charge, or information, can be described by orthogonal axes or dimensions; in principle, other qualities may also be defined in the same

---

[19] Sabelli, H. and Abouzeid, A. (2003). Definition and Empirical Characterization of Creative Processes. *Nonlinear dynamics, Psychology and the Life Sciences* 7: 35-47; Patel, M. and Sabelli, H. (2003). Autocorrelation And Frequency Analysis Differentiate Cardiac And Economic Bios From 1/F Noise. *Kybernetes* 32: 692-702.

[20] Ridley, M. (2001). *The Cooperative Gene*. New York: Free Press.

fashion. A creative process generates new qualities or dimensions (dimensiogenesis). A creative process generates complexity in a non-random manner. Random disorder appears complex; in fact, random distributions have maximal algorithmic complexity. This goes against our intuitive understanding of complexity. We shall define arrangement as an empirical measure of **nonrandom complexity** (Chapter 4).

Even if we cannot witness this process of "complexification" because we only observe later stages of development, still we will be able to observe that a creative process shows both simple and complex components. The analysis of a creative process may reveal a simple **lower dimensional generator** embedded in a pattern of ever-growing complexity, absent in stochastic processes. **Coexistence of simple and complex components of variation** can be shown by embedding and wavelet plots and power spectrum. It is cogent to highlight the coexistence of <u>different</u> simple and complex components in creative processes, as many of them are fractal, meaning that the process shows the same degree of complexity at many different scales. Fractality occur in both creating and decaying processes.

Caveat: Extremely complex processes, such as art, may find their highest form in the creation of extremely simple forms. This issue is neglected in this book.

The third defining characteristic of creative processes is **novelty**. Organization is often regarded as the generation of order. But order is static repetition, while living organization is always changing and evolving. Stable order and creative organization are two opposite departures from the middle ground of random flux. Repetition, recurrence, and periodicity are the hallmarks of non-creative order. Creative processes are characterized by non-repetitive change. This is what we call novelty, for which we have developed a measurement based on the quantification of isometric recurrences. Creative processes generate innovation. The Lyapunov exponent, the Hurst exponent,[21] and novelty[22] quantify different types of innovation.

---

[21] Mandelbrot, B. B. (1977). *The Fractal Geometry of Nature*. New York: W. H. Freeman and Company.
[22] Sabelli, H. (2001). Novelty, a Measure of Creative Organization in Natural and Mathematical Time Series. *Nonlinear Dynamics, Psychology, and Life Sciences* 5: 89-113.

Innovation may be the result of chance, but in a creative process there is change beyond chance. Random and chaotic processes do not produce novelty. A creative process generates novelty faster than change would occur as the result of pure chance. For instance, biological variation occurs as a result of the recombination of genes in sexual reproduction much faster than it occurs as a result of mere random mutation. Also, mutations are mechanisms to promote diversity, not simply chance "errors" (see Chapter 13).

When a process generates new patterns, each pattern must have a limited lifetime by necessity, so the time series consists of a sequence of episodes separated by transitions. These time-limited patterns can be detected as clusters of recurrences that we call *complexes*. In contrast, the time series of noncreative processes have a uniform pattern, no matter how variable the individual terms. **Episodic patterns (complexes)** are a hallmark of creative processes. In contrast, the time series of noncreative processes must have a uniform pattern, no matter how variable the individual terms.

Spontaneity is central to creativity. Bread unavoidably molds, even in the refrigerator. Whether you interpret this as a sign of unavoidable decay towards entropy or the ease with which life emerges depends on your scientific ideology and your psychological frame of mind.

A creative process is **autodynamic**. Every change brings on the next one, so there is a correlation between steps **(**autocorrelation). If a process changes by chance (external agency), each change is independent of all previous ones. In autodynamic processes, there is a chain of connections, so changes at a given stage of development affect its subsequent course (partial autocorrelation).

Another characteristic of the nonrandom complexity observed in natural processes is **asymmetry**, which Pasteur postulated as fundamental.[23] The distribution of events in a creative process is asymmetric in contrast to the symmetric distribution of random distributions and most chaotic series. A creative process is, as all natural processes, asymmetric in time, that is to say, **irreversible**. A random process is, by definition, reversible. Even a randomizing process is in

[23] Haldane, J. B. S. (1960). Pasteur and Cosmic Asymmetry. *Nature* 185: 87.

principle reversible, although statistical mechanics dismisses this as unlikely. Irreversibility can be demonstrated in biotic series generated by mathematical recursions, but not in chaos, stochastic series or idealized mechanical models.

The complex patterns of creative processes are **aperiodic**, so they resemble random and chaotic series. Random processes, and many chaotic ones, show an equal distribution of fast and slow changes. In creative processes, slower (low frequency) changes are more prominent than fast frequency changes. This is **1/f pattern,** meaning that power is inversely proportional to the frequency. It can also be generated stochastically; for this reason, it is often called "1/f noise". But the occurrence of 1/f pattern in so many natural and mathematical process belies the notion that 1/f pattern is noise. Also, in biological processes, aperiodic patterns are often associated with **quasi- periodic patterns sensitive to input**. For instance, a short burst of light during the night can alter the circadian rhythm; similarly, periods within bios are highly sensitive to inputs (**bioperiodicity**).

Non-stationarity is often associated with creative processes; undoubtedly it is responsible for some of the properties that differentiate bios from chaos. As result of nonstationarity, creative biotic processes have a **global sensitivity to initial conditions** absent in chaotic attractors. Notably, creative processes also show limits to nonstationarity; for instance, cardiac biotic patterns are bounded. Living organisms have multiple mechanisms (including positive, negative and bipolar feedback loops) that maintain the internal state (homeostasis) and organization (autopoiesis).

What other features are characteristic of creative processes? Continuing to focus on the most creative process, life, points to their most fundamental characteristic: **limited life tenure**. Living processes show relatively stable and ordered organization that may appear similar to crystalline order, but crystals are stable organization is always transient. Creation is inseparable from decay. Birth is inseparable from death.

Creative processes are also destructive. It is inadequate to regard them as noise generated by random events, or as stable periodic, chaotic or homeostatic processes. Planetary processes do not display stability,