Integration of Sources on “Self Organization” as a Systems Process in the SSP

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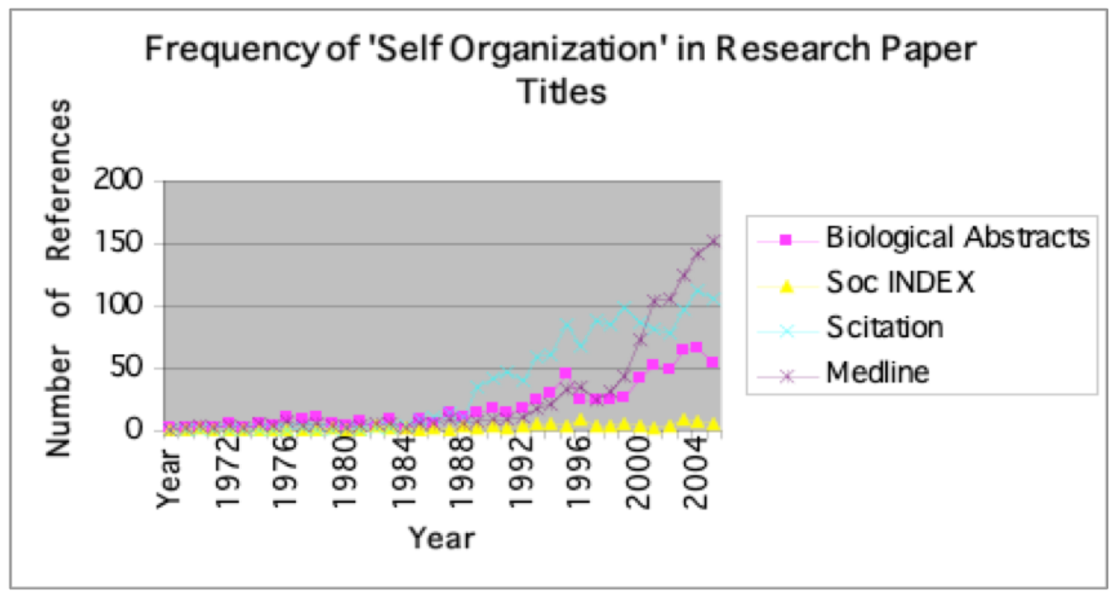
PURPOSE:

•Self-organization is ubiquitous in nature. Not only does it occur in non-living systems, such as lasers, magnets, and Bénard cells, but it is a defining feature of all living systems, from simple cells to organism collectives. Considering its immense breadth, research into the constitutive principles and dynamics of self-organization is of the utmost value to our general interest in understanding and shaping, to the degree possible, the world in which we live (11). The following graph illustrates the growing recognition of the importance of this inquiry.



WORKING DEFINITIONS:

•1.) “Self-organization is a process in which the internal organization of a system, normally an open system, increases in complexity without being guided or managed by an outside source. Self-organizing systems typically (though not always) display emergent properties.” – Wikipedia

• 2.) “Self-organization is a process where the organization (constraint, redundancy) of a system spontaneously increases, i.e. without this increase being controlled by the environment or an encompassing or otherwise external system.” – Principia Cybernetica Web

• 3.) “Conservative self-organization mainly creates order structures with low energy at low temperatures…Dissipative self-organization is the phase transition of irreversible structures far from thermal equilibrium.” Mainzer, K. “Thinking in Complexity” p4

TYPES AND TAXONOMIES:

Types of Equilibrium (Conservative) Self-Organization:

- Bose-Einstein Condensation
- Superconductivity
- Lasers
- Magnetization
- Crystallization

Types of Non-equilibrium (Dissipative) Self-Organization

- Bénard cell convection
- Self-similar expansion, percolation, and reaction-diffusion systems (Belousov-Zhabotinsky reaction, e.g.)
- Autocatalytic networks
- Protein folding
- Lipid bilayer formation
- Biological morphogenesis
- Biological coordination and locomotion
- Collective social behavior (such as flocking)
- Collective social structures (economies, e.g.)
- Stellar formation
- Galaxy formation

IDENTYFYING FEATURES AND FUNCTIONS:

• The following Identifiers describe the main characteristics of, and concepts either denoted or connoted by, self-organization, rather than mathematical formalizations, as are typically used in analysis or simulation. Accordingly, the ideas below, taken together, constitute a synoptic description appropriate to the general systems view of self-organization.

• New Pattern Formation: The *sine qua non* of self-organization is the formation of novel patterns conducive to the perpetuation of the emergent “functionstructures” (9) they instantiate. Such self-organizing systems are always dependent on certain boundary conditions for their perpetuation (12, 13), and these can be generically classified by the amount and type of energy throughput required to sustain the dynamics (3).

• Spontaneous but Nucleated: As exemplified by Bénard cell dynamics, where convection cells spontaneously organize in a honey-comb manner once the heat differential in the liquid crosses a threshold (4,8,12), self-organization occurs spontaneously once thresholds are crossed and does so in a nucleated manner that reflects its internal organization (13).

• Bottom-up Driven: Self-organization requires an internally driven or directed process of aggregation (4, 6, 13). Although the critical energetic input may be external, without internal constraints on the flow of this energy, the increasing complexification implicit in self-organization can not happen.

• Decentralized: In far-from equilibrium self-organizing functionstructures, bottom-up origination produces decentralized control dynamics (2,4,7,8).

• Large Numbers of Coupled Individuals: Systems capable of self-organization involve large numbers of interdependent agents or variables, whose nonlinear (bottom-up) interactions produce emergent dynamics over time (5,6,7).

• Networks: Self-organizing systems are increasingly dependent upon network functionstructures as they grow in size, and they intrinsically create network structures (2,6,7).

• Simple Rules: Simple rules have been shown, through self-organizing dynamics, to create complex behaviors; thus, self-organization implies the generation of complex dynamics from simple (bottom-up) elements and interactions (5,6,7,8).

• Positive Feedback Amplifications: The generative aspects of self-organization – growth of all kinds – depend upon positive feedback cycles that amplify specific epigenetic and perturbation-contingent system activities. These physical, chemical and biochemical amplification cascades create emergent structures and functions, which, in turn, beget new possibilities for growth (4,5,6,7,8,10,12,13).

• Recursions: Self-organizing systems are self-referential in material, energetic and informational dimensions. Their self-referentiality is both implied by the basic denotation of ‘self’-organizing and by the force flows constituting them (1,4,6,10,13).

• Coupled Negative Feedback: In self-organizing systems, coupled negative feedback is indispensable for various homeostatic mechanisms that allow systems to maintain self-identity in the face of various perturbations (4,5,6,7,8,12,13).

• Dissipation: Aside from the most basic self-organizing systems (like ferromagnetism, Bénard cells, etc.), most self-organizing systems (all living organisms, e.g.) are dissipative in the sense that they depend upon energy from the environment, which they use and then expel (dissipate), to maintain their self-identity and organization. Without this energy input, dissipative systems themselves are unable to resist the dissolution inherent in the Second Law of Thermodynamics (3,4,8,12).

• Stigmergy of Information: Stigmergy is a method of communication in emergent systems in which the individual parts of the system communicate with one another by modifying their local environment. All types of self-organization occur in the context of multiple agents influencing a ground that, in turn, influences the contingent development of those agents, and so on.

•Using these ID Features taken together, students of general systems should be able to identify new examples of self-organizing system they have not encountered before, and distinguish these from related systems processes.

DISCINYMS AND DISCRIMINATIONS:

• The following terms, although used in disparate contexts, share semantic ‘family resemblance’ with self-organization. Such semantic similarities intimate deeper isomorphies, ultimately suggesting the processes may be identical, but having distinct names to reflect distinct modes and methods of inquiry.

• Origins: The coming into being of a functionstructure/event. Such origination implies self-organization in all cases in which externally-derived efficient causality cannot explain functionstructural growth.

• Emergence: The coming into being of a novel pattern, growth, or level of a system. Emergence implies that analysis appropriate to subordinate levels is incapable of capturing all relevant dynamics at the new ‘higher’ level. Emergence is a sine qua non of self-organization.

• Autopoiesis: Literally, ‘self-creation.’ Autopoietic processes involve the utilization of energy to *produce* the components which, in turn, continue to maintain the organized bounded structure that gives rise to these components (15). In this sense, autopoietic systems are self-organizing systems, by definition.

• Self-assembly: Self-assembly is defined as a reversible process in which pre-existing parts or disordered components of a preexisting system form structures of patterns. The key difference with ‘self-organization’ is that non-equilibrium self-organization is not reversible; otherwise, the processes are isomorphic. Hence, for equilibrium conditions, self-organization and self-assembly are discinyms.

LINKAGE PROPOSITIONS:

- Self-assembly is a subclass of self-organization: the class of reversible processes.
- Autopoiesis is a subclass of self-organization: the class of complex dissipative processes constituting living systems.
- Self-organization implies emergence: new forms or levels must emerge for a process to be self-organizing.
- Self-organization reduces required energy flows (14).
- Self-organization is a partial cause of systems development (14).
- Positive feedback loops are a partial cause of self-organization (14).
- Self-organization results in energy savings for the system (14).
- Self-organization results in less energy dissipation (14).
- Self-organization is a partial cause of synergy (14).
- Negative entropy is a result of self-organization (14).
- Self-organization requires flows and binding interactions (14).
- Self-organization is a source of new potential spaces (14).

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