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The Contribution of the Systems Sciences to the Humanities

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Abstract

This article presents the systems sciences as a field of inquiry and discusses the way in which it has evolved in relation to the humanities. Following a brief historical overview and assessment of the systems sciences by considering their origins and foundations in general system thinking, the review highlights the key players and the major trends in the field, and leads to a consideration of the ways in which it complements and contrasts the methods of human-related studies generally pursued in the humanities. It discusses the potential for the systems sciences to enrich descriptive, instructional, and explanatory orientations of contemporary *Geisteswissenschaften* through the inclusion of normative considerations.

The normative component of the systems sciences is considered within an evolutionary framework that presents holism as a methodology for understanding the dynamics of complex "real-world" (ontological) systems and suggests action imperatives for their viable and sustainable design over time. Through the tools metaphor, modeling and simulation, interactive design and other praxes, systems scientists investigate the goals and ends of systems and their interactions within environments shared with, and provided for, one another. In this way social systems in general, and human activity systems in particular, can be described in function of their degree of purposefulness in terms of the role of human values in concrete circumstances.

Through the tools of systems analysis and design, systems science represents the world of symbols, values, social entities, and cultures as embedded in an embracing order of hierarchies that bridges the gap between C.P. Snow's "Two Cultures" of the sciences and the humanities. The use of modeling in systems sciences provides the language of design and the means by which creativity is applied in the course of inventing, making, assessing, and implementing the designs. In this way it lends to the humanities the capability to deal with increasing systemic complexities, rapid societal

changes, and design decisions that affect the sustainable evolution of human societies within the wider context of their life support systems.

Key Words: systems science, humanities, human values, societal evolution, design.

Introduction

The contribution of the systems sciences to the humanities is of critical importance in view of the changing nature of human relations at the dawn of the 21st century. Conceptual frameworks for interpreting the meaning and significance of social change run the gamut of deconstructionist post-modern interpretation, ranging from predictive / empirical, to cultural / interpretative to critical / post-structural epistemological stances. In areas of human endeavor concerned with valuing and assessing human achievement, the result has been a multiplicity of possible interpretive frameworks and a concomitant fragmentation of disciplinary worldviews. While the sciences move toward theoretical syntheses through the construction of grand unified theories in physics and similar embracing theoretical frameworks in other realms of inquiry, the humanities manifest a countervailing trend toward relativistic positions on issues of societal evolution with a corresponding reticence for generally applicable normative viewpoints on designs for the human future.

The advantage of the systems sciences is their potential to provide a trans-disciplinary framework for a simultaneously critical and normative exploration of the relationships between and among human beings and their social, cultural, and natural environments. Studies of civilizational progress and organizational change rely more and more on the systems approach. Systems sciences do much to render the complex dynamics of human sociocultural and politico-economic change comprehensible. Observed phenomena in the natural and man-made universe do not come in neat disciplinary packages labeled scientific, humanistic, and transcendental: they invariably involve complex combinations of fields, and the multifaceted situations to which they give rise require an holistic approach for their solution. The systems sciences provide such an approach and can consequently be considered a field of inquiry rather than a collection of specific disciplines.

I. Origins and foundations of the systems sciences

Ludwig von Bertalanffy described the set of theories that together comprise the framework of systems thought in the following passage:

> The 19th and first half of the 20th century conceived of the *world as chaos.* Chaos was the oft-quoted blind play of atoms, which, in mechanistic and positivistic philosophy, appeared to represent ultimate reality, with life as an accidental product of physical processes, and mind as an epi-phenomenon. It was chaos when, in the current theory of evolution, the living world appeared as a product of chance, the outcome of random mutations and survival in the mill of natural selection. In the same sense, human personality, in the theories of behaviorism as well as of psychoanalysis, was considered a chance product of nature and nurture, of a mixture of genes and an accidental sequence of events from early childhood to maturity.
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> Now we are looking for another basic outlook on the world -- *the world as organization.* Such a conception -- if it can be substantiated -- would indeed change the basic categories upon which scientific thought rests, and profoundly influence practical attitudes.
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> This trend is marked by the emergence of a bundle of new disciplines such as cybernetics, information theory, general system theory, theories of games, of decisions, of queuing and others; in practical applications, systems analysis, systems engineering, operations research, etc. They are different in basic assumptions, mathematical techniques and aims, and they are often unsatisfactory and sometimes contradictory. They agree, however, in being concerned, in one way or another, with "systems," "wholes" or "organizations;" and in their totality, they herald a new approach. (Quoted by Lilienfeld in *The Rise of Systems Theory* , 1978, pp. 7-8.)

Von Bertalanffy considered the principles of organization involved at various levels in the manifestation of natural systems. His first statements on the subject date from 1925-26, during the time when Alfred North Whitehead was creating a related 'philosophy of organism.' At about the same time, biologist Paul A. Weiss also began to develop a systemic approach based on the importance of finding "the conceptual integration that renders the map of knowledge not only more complete, but more consistently coherent" (quoted in Laszlo, *The Relevance of General Systems Theory* , 1972, pp. 159-160). More than others before their time, von Bertalanffy, Whitehead, and Weiss became aware of the potential to develop a general science of organized complexity. Of them, von Bertalanffy gave fullest formulation of a general theory of systems. He defined the aims of the theory as follows:

> (1) There is a general tendency toward integration in the various sciences, natural and social. (2) Such integration seems to be centered in a general theory of systems. (3) Such theory may be an important means for aiming at exact theory in the nonphysical fields of science. (4) Developing unifying principles running "vertically" through the universe of the individual sciences, this theory brings us nearer the goal of the unity of science. (5) This can lead to a much-needed integration in scientific education. (Ludwig von Bertalanffy, *General System Theory*, New York, 1968, p.38.)

Although von Bertalanffy first presented his idea of a 'General System Theory' in a philosophy seminar at the University of Chicago in 1937, it was only after World War II that his first publications appeared on this subject. By the 1960s systems thinking began to be recognized as a paradigmatic effort at scientific integration and theory formulation on the transdisciplinary plane. No such effort derived from the natural sciences had been previously attempted.

Boulding came into contact with the work of von Bertalanffy during the 1950s when he was conducting a seminar on the integration of the social sciences at the University of Michigan at Ann Arbor. In 1954, together with mathematician, Anatol Rapoport and physiologist Ralph Gerard, von Bertalanffy and Boulding came together at the Palo Alto Center for Advanced Study in the Behavioral Sciences. There it soon became clear that, although approaching the subject from different directions, their thoughts showed remarkable convergence.

The transdisciplinary endeavor of the systems approach was not restricted to the hard sciences but began to spread to the humanities as well. A 1953 letter from economist Kenneth Boulding addressed to von Bertalanffy summarizes the situation:

> I seem to have come to much the same conclusion as you have reached, though approaching it from the direction of economics and the social sciences rather than from biology -- that there is a body of what I have been calling "general empirical theory," or "general system theory" in your excellent terminology, which is of wide applicability in many different disciplines. I am sure there are many people all over the world who have come to essentially the same position that we have, but we are so widely scattered and do not know each other, so difficult is it to cross the boundaries of the disciplines (von Bertalanffy, *General System Theory*, 1968, p. 14.)

General system theory, like other innovative frameworks of thought, passed through phases of ridicule and neglect. It has benefited, however, from the parallel emergence and rise to eminence of cybernetics and information theory, and their widespread applications to originally quite distant fields. Though it grew out of organismic biology, general system theory soon branched into most of the humanities. Its recent applications include areas of social work, mental health, and the political and behavioral sciences. The rise and spread of system theory has been aided by societal pressures on science calling for the development of theories capable of interdisciplinary application.

The various conceptual frameworks of the systems approach and related areas have much to offer for the construction of an holistic methodology for humanistic inquiry. As Ilya Prigogine noted, "the basis for any natural law describing the evolution of social systems must be the physical laws governing open systems, i.e., systems embedded in their environment with which they exchange matter and energy." (Ilya Prigogine, et. al., "Long term trends in the evolution of complexity," in *Goals in a Global Community: The original background papers for Goals for Mankind*. Vol. 1: Studies on the Conceptual Foundations, New York, 1977, p. 2.) Without reducing the study of society to physics, the systems sciences promise to offer a powerful conceptual approach for grasping the interrelation of humans, societies, and nature.

The rational basis for the natural laws governing the evolution of social systems can best be illustrated through comparisons with analogous processes in the life sciences. For instance, if societal evolution is an example of a process following general evolutionary principles, then the information encoded in culture plays a role comparable to the information in DNA: it guides the replication of societal structures much the way DNA informs the replication of biological structures and provides an operational context for individual action. Extending the role of culture beyond individuals to societies may permit the application of systems-scientific theories of dissipative structures in nature to the evolution of human societal systems. Systemic processes obeying natural laws in the cultural sphere can be grasped through analogies with laws in the biological realm.

II. Systems sciences as a general field of inquiry

In regard to applications in the humanities, systems sciences can model complex interpersonal, intergroup, and human / nature interactions without reducing their subject matter to the level of individual agents. They capitalize on the emergence of parallelisms in different disciplinary interpretations of reality and consequently lay the foundation for a general theory of complexity *per se.*

Methodologically, it is important to set apart a theoretical system and an empirical system. The former is a complex of concepts, suppositions, and propositions having both logical integration and empirical reference, while the latter is a set of phenomena in the observable world that is amenable to description and analysis by means of a theoretical system.

Systems sciences defy classification as constituting either an epistemology or an ontology. Rather, they are reminiscent of the Greek notion of *gnosiology* concerned with the holistic and integrative exploration of phenomena and events. There are aspects of the systems approach that are ontological and aspects that are epistemological, and aspects that are at once both and should not be circumscribed to either.

Definition of system. The concept of "system" serves to identify those manifestations of natural phenomena and process that satisfy certain general conditions. In the broadest conception, the term connotes a complex of interacting components together with the relationships among them that permit the identification of a boundary-maintaining entity or process. As will be reviewed in a subsequent section of this article, on the origins and foundation of the systems sciences, more specific denotations have been offered since the early formulations of a general system theory in the first half of the twentieth century. For the purposes of this article, we give a definition based on Russell Ackoff's suggestion that a system is a set of two or more interrelated elements with the following properties:

1. Each element has an effect on the functioning of the whole.
2. Each element is affected by at least one other element in the system.
3. All possible subgroups of elements also have the first two properties.
(*Cf.* R.L. Ackoff, *Creating the Corporate Future.* New York: John Wiley & Sons, 1981, pp. 15-16.)

By substituting the concept of "element" for that of "component," it is possible to arrive at a definition that pertains to systems of any kind, whether formal (e.g., mathematics and language), existential (e.g., 'real-world'), or affective (e.g., aesthetic, emotional, and imaginative). In each case, a whole made up of interdependent components in interaction is identified as the system. In the most basic definition a system is *a group of interacting components that conserves some identifiable set of relations* *with the sum of the components plus their relations (i.e., the system itself) conserving some identifiable set of relations to other entities (including other systems).*

This definition is general but not meaninglessly so: it specifies a limited set of entities in the real world. If any set of events in the physical universe is to conserve an identifiable set of internal relations it must be capable of at least temporarily withstanding the statistical outcome of disorganization predicted by the second law of thermodynamics. That law states that "entropy always increases in any closed system not in equilibrium, and remains constant for a system which is in equilibrium." (*The Fontana Dictionary of Modern Thought*, Alan Bullock and Oliver Stallybrass (eds.), London: Fontana / Collins, 1977, p. 634.) Systems will dissipate energy unless they are purposively maintained by an outside agency; thus there must be organizing forces or relations present which permit the conservation of its structure (and function). Internal relations in an entity not possessing such characteristics tend to degrade until a state of thermodynamic equilibrium is reached.

Natural systems. An entity that does not degrade its structure to thermodynamic equilibrium but maintains it through the utilization of the energies available in its environment is a product of the slow but vast processes of evolution in nature. It has emerged in the course of time, maintains itself in the face of perturbations, and is capable of reorganizing itself to cope with changing conditions in its environment. Such an entity is a *natural system.*

Natural systems contrast with entities which obey the statistical predictions of entropy production dictated by the second law of thermodynamics. These types of entities are not products of sustained evolution in nature but are accidental agglomerations of natural entities, or else human artifacts. However, almost all the things we can identify as 'the furniture of the earth' are natural systems, or components of natural systems, or aggregates formed by natural systems. Stable atoms are natural systems, and so are molecules, cells, multicellular organisms, ecologies and societies. Complex socio-cultural systems, and indeed the global system itself, form natural (rather than artificial) systems. This is important, for certain general propositions are true of natural systems, regardless of their size, origin, and degree of complexity, which may not be true of artificial systems. These propositions are true in virtue of the fact that in a universe governed by uniform laws certain sets of relationships are required to conserve and enhance order over time. Much can be understood of the system's basic properties by assessing its behavior in reference to the imperatives of natural system dynamics.

Reduction to dynamics. The principal heuristic innovation of the systems approach is what may be called 'reduction to dynamics' as contrasted with 'reduction to components', as practiced in the methodologies of classical science. Phenomena in the observed world are usually too complex to be understood by modeling all their parts and interactions; some form of simplification is necessary. Traditionally, scientists have simplified natural complexity by viewing individual items of observation in isolation from the complex set of relations that connect them with their environment, and ultimately with the rest of the world. They have isolated the object of their investigations, interested mainly in delimited inductive chains that could be readily mapped as linear — and perhaps circular — causality (that is, A affecting B, and B affecting C and possibly also A).

The heuristic of 'reduction to components' has led to the accumulation of vast storehouses of information about specific entities and the interactions among them. It enabled scientists to know how one molecule, cell or organ reacts to a particular kind of energy or stimulant, and how one body reacts to a particular kind of force. The practical benefits have been many: medicines could be prescribed and bridges built based on such knowledge. But this type of knowledge proved deficient in one important respect: it did not disclose how complex things behave when exposed to a complex set of influences. Yet almost every real-world system contains a large number of components and is exposed to a large number of external forces and events. In consequence, another heuristic became necessary, capable of simplifying unmanageably complex phenomena by reduction to *dynamics* instead of to *components*.

Emergent properties and synergy. Structurally, a system is a divisible whole, but functionally it is an indivisible unity with emergent properties. An emergent property is marked by the appearance of novel characteristics exhibited on the level of the whole ensemble, but not by the components in isolation.

There are two important aspects of emergent properties: first, they are lost when the system breaks down to its components — the property of life, for example, does not inhere in organs once they are removed from the body. Second, when a component is removed from the whole, that component itself will lose its emergent properties — a hand, severed from the body, cannot write, nor can a severed eye see.

The notion of emergent properties leads to the concept of synergy, suggesting that, as we say in everyday language, the system is more than the sum of its parts. For example, the hydrogen atom, the simplest of the chemical elements, has a typical valence as an integral system made up of a proton and a neutron in the nucleus and an electron in the lowest energy shell around it, together with short-lived exchange particles and forces. The chemical valence of the entire structure is not present in the proton, the neutron, the electron, or any exchange particle taken in isolation; it is an emergent property of the whole ensemble and a result of the synergistic relationship among its parts. Consequently a reduction of the hydrogen atom to the level of its component elementary particles amounts to a simplification that eliminates some of the essential properties of the atom; in that regard it throws out the baby with the bath water.

A similar observation applies at the opposite extreme of the scale of complexity in nature. The human brain, the most complex system of matter known to science, consists of some ten thousand million neurons, with up to a hundred billion connections among them. The emergent properties of the full cerebral system include patterns of sensation, emotion, thought and volition familiar from introspective experience, as well as the complex homeostatic regulations performed by the autonomic nervous system. None of these characteristics and functions can be found in individual neurons, and in some cases reduction even to neural nets has proven impossible — as in the case of learned behavior and memory, which seem distributed throughout entire brain regions rather than being performed by individual nets or encoded in specific RNA sequences or engrams.

General theory. The definition of certain varieties of entities and events in the world as 'system' has made for the mid-century emergence of a *general* theory of systems. Prior to that time a specialized way of seeing things held almost exclusive sway in modern science. According to the specialized perspective, the world and all that it contains is an assembly of small and distinct parts, fit largely for analysis and study in isolation. This fragmented way of approaching empirical phenomena is predicated on the belief that it is better to have specific and intimate knowledge of smaller and more well-defined items than general and abstract knowledge of larger and less well-defined ones. As a result, instead of focusing on the interacting and integrated ensemble — the "system" — attention is drawn to the parts regardless of their position within the ensemble.

By contrast, the systems approach attempts to view the world in terms of irreducibly integrated systems. It focuses attention on the whole, as well as on the complex interrelationships among its constituent parts. This way of seeing is not an alternative, but a complement, to the specialized way. It is more all-embracing and comprehensive, incorporating the specialized perspective as one aspect of a general conception.

The specialized approach has created an orientation toward decision making that is currently in vogue in many parts of the world. It is based on individualism, competition, training for a specific profession, and indoctrination into a specific culture. On the other hand, the general systems approach encourages the development of a global, more unitary consciousness, team work, collaboration, learning for life, and exposure to the universal storehouse of accumulated knowledge and wisdom.

III. Current breadth and diversity in the systems sciences

Although the systems sciences themselves aim toward general theory and hence do not constitute a discipline, specific branches, such as cybernetics, can be thought of as disciplinary sub-areas of the general systems theory field. As Kenneth Boulding pointed out, general system theory (and systems sciences in general) "aims to provide a framework or structure on which to hang the flesh and blood of particular disciplines and particular subject matters in an orderly and coherent corpus of knowledge" (Boulding, 1956, p. 10).

Qualitative aspects. The methodology of the systems approach involves an intuitive element in applying systems ideas, going beyond the methodology prescribed by the strictly analytical procedures of the classical sciences. Methodology itself is different from technique because it is not something which, if applied correctly, will inevitably lead to an answer. Procedures which follow a step by step path and lead to an end-result are known as algorithms. The systems approach may also involve non-algorithmic procedures — known as heuristics — which in many cases prove to be sufficiently powerful to obtain satisfactory results.

Within the field of the humanities systems-oriented inquiries are not necessarily quantitative in execution. This is true especially in regard to the application of systemic theories to social phenomena. Such phenomena tend to resist quantitative modeling by posing basic difficulties already on the plane of system identification. In these and similar difficult cases, systems theory performs a qualitative heuristic function: it attempts to identify specific entities capable of being modeled as systems, and wider areas as their relevant environment. As Majid Tehranian remarked, the systems thinker's perception always incorporates an element of human intuition. (M. Tehranian, *Toward a Systemic Theory of National Development.* Tehran, Iran, 1974, p. 68.) Implicit here is the notion that an observer engaged in systems research will "give an account of the world, or part of it, in systems terms; his purpose in so doing; his definition of his system or systems; the principle which makes them coherent entities; the means and mechanisms by which they tend to maintain their integrity; their boundaries, inputs, outputs, and components; their structure." (Peter Checkland, *Systems thinking, systems practice*, New York, 1981, p. 103.)

Systems and environments. In systems theory the term 'environment' is defined as the set of all objects a change in whose attributes effects the system as well as those objects whose attributes are changed by the behavior of the system. (A.D. Hall and R.E. Fagen, "Definition of system," *General Systems* , Yearbook of the Society for General Systems Research [SGSR -- now ISSS], 1956.) According to Ackoff, the environment of every social system contains three levels of purpose: "the purpose of the system, of its parts, and of the system of which it is a part, the suprasystem". (Ackoff, *op. cit.* p. 23)

This brings up the question, how systems thinkers formulate their perception of social reality in terms of what is a system, and what is an environment. Observers in the context of systems science have a clear conception of their mission as an integral part the social system with which they work. In performing a systems analysis of a problem or situation, they start from the problem, not from a preconceived model. Once the manifestation of the problem has been identified and described, they can proceed inward to the sub-systems and outward to the environment.

Method. The method proposed by systems theory is to model complex entities created by the multiple interaction of components by abstracting from certain details of structure and component, and concentrating on the dynamics that define the characteristic functions, properties, and relationships that are internal or external to the system. Such simplification — the above-noted 'reduction to dynamics' — is necessary throughout the range of systems inquiry from hydrogen atoms to human social structures. Atoms are composed of a handful of particles and forces, yet physicists find that their interactions require multidimensional spaces for adequate modeling. The human organism, on the other hand, is composed of some five octillion atoms, and the specific interconnections among them surpass any conceivable method or instrument of calculation. Even social systems are not simple; a detailed consideration of their interaction with natural and artificial systems involves a number of factors and variables that surpasses the capacity of any presently known heuristic system or calculating device.

When framed as a process of inquiry, these perspectives cannot be adequately presented by the familiar three-step process of the classical analytical sciences. Traditionally, the scientific method of analysis has involved:

1) the deconstruction of that which is to be explained;
2) the formulation of explanations that account for the behavior or properties of the components taken separately; and
3) the synthesis of these explanations into an aggregate understanding of the whole.

A four (rather than three) step approach of analysis/synthesis is needed to render possible the consideration of entities as diverse as atoms, organs and organ system, individuals, and societies through the common rubric of the systems sciences. The starting point is consideration of the embedding context that includes, and is to some extent defined by, the phenomenon under consideration. The second step involves description of what may be defined as 'sub-wholes within the embedding whole': identifiable discrete entities existing in their own right within the larger framework of the overall ensemble. Third, attention shifts to the specialized parts within the identifiable wholes, with emphasis on understanding the structures, their compositions and modes of operation, much as in the three-step process described above. The fourth and final step refocuses on the embedding context, integrating the perspective obtained at each of the preceding steps in an understanding of the overall phenomenon, including its internal and external context. Key to this understanding is the emphasis on function as well as structure, on relationships and bonds in addition to the elements and components to which they pertain, so that the resulting understanding of the entity or process under consideration is expressed in terms of its roles and functions within the embedding whole.

IV. Recent trends in the application of systems sciences to the humanities

A range of approaches. An exploration of the development of the systems sciences can be traced over a range of intellectual activity and practical endeavor. A number of distinctions have to be made. If we begin with the entire field of endeavor known as the systems sciences, the first distinction is between the development of systems ideas *per se* (as in cybernetics, for example) and the application of systems ideas within an existing discipline (as in the application of systems concepts to an engineering study program). This results in two broad areas of systems inquiry.

In the branch concerned with work in the systemic fields themselves, we can distinguish between the purely theoretical development of systems ideas and their interrelationships, and work aiming to develop systems ideas in the design of real-world systems. General system theory in the strict sense is an example of the former, while the development of systems engineering methodology is an example of the latter. There are others examples as well, leading to a three-fold distinction: *hard* systems approaches (such as are employed in systems engineering), *soft* systems approaches (used to tackle ill-structured problems), and mixed systems approaches — such as those employed in operations research — used as an aid to decision-making.

The classification of systems into *hard* and *soft* represents an effort to draw attention both to the degree of knowledge about a system, and about the system's aims or purposes. Checkland developed this classification to represent two ends of a continuum. Hard systems are more easy to define and have more clear-cut aims or purposes. They are typically the subject matter of engineers concerned with real-world problem-solving: mechanisms, machines, aircraft, and power plants are examples. Simplicity of purpose and clarity of boundary, however, do not necessarily mean ease of design, operation, or maintenance: hard systems, as we know, can indeed be highly complex. At the other extreme are *soft* systems, characterized by human beings as their principal components. Such systems are difficult to define; they do not have clear-cut and agreed aims or purposes. At the level of a multiperson organization there are frequently different and conflicting aims operating simultaneously. And the aims, even if agreed upon, may change over time.

Critical systems thinking. Recent work in the area of soft systems thinking has led to the development of what has become called emancipatory systems thinking. It has a branch that leads to critical systems thinking and adopts an epistemological stance toward systems that leaves aside ontological considerations. Such thinking advocates the critical and complementary use of various systems approaches. Although this is one of the most recent branches of systems inquiry, there are already indications of offshoots sprouting in the direction of multimodal systems thinking. These offshoots seek to break the bounds of the autonomous rationality that is still implicit in critical systems thinking and to develop a more normative conception of reality.

Critical systems thinking is a robust recent trend in humanistically oriented systems work. Spearheaded by M.C. Jackson, Robert Flood, and Werner Ulrich, this approach manages to accommodate the knowledge-constitutive interests of Jürgen Habermas and the interpretive analytical orientations of Henri Foucault through a meta-methodology involving constant critical reflection. The meta-methodology serves as the basis for the generation of a new methodology that critically applies various systems approaches to problem solving. In doing so, critical systems thinking pursues five areas of commitment:

1) critical awareness,
2) social awareness,
3) complementarism at the methodology level,
4) complementarism at the theory level, and
5) human emancipation.

Through critical awareness, a person is enabled to analyze the assumptions, strengths, and weaknesses of the theoretical underpinnings of the systems methods and techniques brought to bear both at a particular level of the system under consideration, and at the level of the system as a whole. Social awareness brings into play the societal or organizational climate that influences the acceptability of a given systems approach at a particular time. Complementarism of methodology addresses the use of different sub-methodologies for the attainment of particular tasks. Theory-complementarism advocates respect for different theories while seeking to address constitutive interests. Finally, the notion of human emancipation seeks to raise the quality of life and work for the persons involved in a systems intervention.

Total systems intervention. A specific and highly promising sub-area of critical systems thinking is the total systems intervention (TSI) approach. As a meta-methodology, TSI departs from the assumption that all problem solving methods are complementary. The requirement for each problem situation is a combination of the best methods for each aspect of the problem. The selection of a 'package' of complementary methods is accomplished by the problem solver (the person faced with the problem situation) with the aid of certain operational procedures. These procedures surface through three modalities of TSI: the critical review mode, the problem-solving mode, and the critical reflection mode. (*Cf.* Robert Flood, "An Improved Version of the Process of Total Systems Intervention (TSI)" in *Systems Practice,* 8:3.)

Multimodal systems thinking, as put forward by J.D.R. de Raadt, is informed by a perspective that places human reason as part of a supra-subjective and supra-arbitrary normative order of reality. This normative order is taken to precede reason and rationality, and to determine the status of reason and the boundaries and limitations of science. Complete control is viewed as an illusion in real-world systems interventions. This sub-branch of critical systems thinking swings the pendulum back toward ontological considerations.

Even though critical systems thinking holds much promise for the humanities, it is bounded by the overriding rationality that serves as an all-embracing framework for its approach to reality, and has a tendency to place heavy emphasis on the purely epistemological aspect of systems theory construction.

Systems design. The design of open social systems is a relatively new mode of inquiry. It emerged recently as a manifestation of open systems thinking and corresponding soft-systems approaches. As a disciplined inquiry, it serves to enable evolutionary systems designers to align the systems they create with the dynamics of civilizational change and the patterns of sustainable environmental development. Its early pioneers include Simons (1969), Jones (1970), Churchman (1971), Jantsch (1975 and 1980), and Warfield (1976). The watershed year of this approach was 1981, marked by the contributions of Ackoff (1981), Checkland (1981,) and Nadler (1981), followed by Agyris (1982), Ulrich (1983), Cross (1984), and Banathy (1984 and 1995).

The systems design approach seeks to understand a situation as a system of interconnected, interdependent, and interacting problems. Likewise, the solutions it seeks to create emerge from a vision of the entity taken as a whole. Such an orientation permits the design of the future through an informed understanding of the dynamics that govern evolutionary systems. It implies that we take responsibility for the creation of our future in co-evolutionary interdependence with our social and physical environment. This is based on the belief that we can shape our future on the one hand through the power of understanding the characteristics and requirements of the environment, and on the other through our aspirations and expectations.

Systems design is participatory by its very nature: significant social change can be brought about only if those who are most likely to be affected by it participate in soliciting it, and choose how it is to be implemented. Since in societal systems human beings are the critical factor, change must necessarily both emanate from and incorporate them. Systems design advocates *anticipatory democracy*, where people actively apply their skills to the analysis and design of socially and ecologically sustainable systems by becoming active participants in shaping their future. Groups of people engaged in purposeful systems design form an evolutionary learning community, and such communities make for the emergence of a culture of evolutionary design.

Systems theorist Bela Banathy characterized systems design in the following terms:

> Science focuses on the study of the natural world. It seeks to describe what exists. Focusing on problem finding, it studies and describes problems in its various domains. The humanities focus on understanding and discussing the human experience. In design, we focus on finding solutions and creating things and systems of value that do not yet exist.
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> The methods of science include controlled experiments, classification, pattern recognition, analysis, and deduction. In the humanities we apply analogy, metaphor, criticism, and (e)valuation. In design we devise alternatives, form patterns, synthesize, use conjecture, and model solutions.
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> Science values objectivity, rationality, and neutrality. It has concern for the truth. The humanities value subjectivity, imagination, and commitment. They have a concern for justice. Design values practicality, ingenuity, creativity, and empathy. It has concerns for goodness of fit and for the impact of design on future generations. (Banathy, *Designing Social Systems in a Changing World* , (1996), p. 42)

General evolution theory. An action-oriented systems approach to the development of human and natural systems has emerged from the study of evolutionary processes in nature and society. It is known as General Evolutionary Systems Theory (or general evolution theory for short). The evolutionary trend in the universe constitutes a 'cosmic process' that manifests itself through particular events and sequences of events that are not limited to the domain of biological phenomenon but extend to include all aspects of change in complex open dynamic systems with a throughput of information and energy. Evolution relates to the formation of stars from atoms, of *Homo Sapiens* from the anthropoid apes, as well as to the formation of complex societies from rudimentary social systems.

Human societies evolve through convergence to progressively higher organizational levels. When flows of people, information, energy, and goods intensify, they transcend the formal boundaries of the social system. Thus neighboring tribes and villages converge into ethnic communities or integrated states, these in turn become the colonies, provinces, states, cantons, or regions of larger empires and eventually of nation-states. Today, we are witnessing yet a further level of convergence and integration as nation-states are joining together in the creation of various regional and functional economic and political communities and blocs, in Europe as well as in North America and elsewhere in the world.

Through the notion of 'bifurcations' (nonlinear and often indeterminate transitions between system states), evolutionary systems theory refers to conditions that prevail when societies are destabilized in their particular time and place. They then either reorganize their structures to establish a new dynamic regime that can cope with the original perturbations, or disaggregate to their individually stable components. Bifurcations are revolutionary transformations in the development of society. The reins of power change hands, systems of law and order are overthrown, and new movements and ideas surface and gain momentum. When order is re-established, the chaos of transformation gives way to a new era of comparative stability.

Societal bifurcations can be smooth and continuous, explosive and catastrophic, or abrupt and entirely unforeseeable. However, they always describe the point at which a social system traverses a period of indeterminacy by exploring and selecting alternative responses to destabilizing perturbations.

The promise of general evolution theory is captured succinctly by Ervin Laszlo, Ignazio Masulli, Robert Artigiani, and Vilmos Csányi as follows:

> The description of the evolutionary trajectory of dynamical systems as irreversible, periodically chaotic, and strongly nonlinear fits certain features of the historical development of human societies. But the description of evolutionary processes, whether in nature or in history, has additional elements. These elements include such factors as the convergence of existing systems on progressively higher organizational levels, the increasingly efficient exploitation by systems of the sources of

> free energy in their environment, and the complexification of systems structure in states progressively further removed from thermodynamic equilibrium.
>
> General evolution theory, based on the integration of the relevant tents of general system theory, cybernetics, information and communication theory, chaos theory, dynamical systems theory, and nonequilibrium thermodynamics, can convey a sound understanding of the laws and dynamics that govern the evolution of complex systems in the various realms of investigation. ..... The basic notions of this new discipline can be developed to give an adequate account of the dynamical evolution of human societies as well. Such an account could furnish the basis of a system of knowledge better able to orient human beings and societies in their rapidly changing milieu. (E. Laszlo *et al.*, *The Evolution of Cognitive Maps* , (1993), pp. xvii and xix)

In relation to the humanities, general evolution theory provides a conceptual foundation for theories and tenets of evolutionary governance, evolutionary management, and evolutionary ethics. It suggests that human destiny can be placed in human hands, since it is possible to move toward conscious evolutionary strategies by which to guide the sustainable development of our societies. When this theory is combined with the emancipatory systems approach, a normative imperative emerges for the proactive design — or redesign — of the human future. It accents the empowerment of individuals and groups through the envisioning and subsequent creation of co-evolutionary pathways to desired future states of multiperson evolutionary systems.

Normative considerations. The increasing complexity and interrelatedness of societies highlight the need for a systems science that combines the humanities and the sciences in an holistic interpretation of current realities -- one that foments the robust design of desired (and desirable) futures as legitimate responses to global and individual needs. Conscious human guidance is an ongoing requisite since the ability of human societal systems to evolve, and even to survive, depends in a great measure on their ability to adapt to changing realities. A systemic orientation in the humanities is needed to maintain an holistic, critically self-reflective attitude that seeks to integrate individual satisfaction (including the physical, mental, and spiritual needs of human beings) with their societal and natural environments in consideration of dynamic developmental laws and processes.

However, given that they are culture-conditioned, societal systems are embedded in an even more mercurial environment than are biological systems. What the reality is that affects the existence of social institutions, political states, and economic systems depends not only on what the case is, but on what its members and its leadership believe that it is. Since reality is not an absolute given, systems scientists and humanists should not seek to design absolute solutions to contemporary challenges; solutions should take the form of flexible surveillance systems that help decision-takers select humanistic and sustainable responses to the issues they confront.

V. A desirable partnership: the systems sciences and the humanities

The above insights have led to the development of an orientation in the systems sciences that may overcome the gap between the "two cultures" of the sciences and the humanities. In mid-twentieth century, C.P. Snow contended that a widening gulf was separating the humanities from the sciences; he saw the humanities and the sciences as conflictual intellectual stances disjoined by misunderstanding and misbelief. "I believe the intellectual life of the whole of western society" he wrote, "is increasingly being split into two polar groups ... at one pole we have the literary intellectuals, ... at the other scientists, and as the most representative, the physical scientists" (*The Two Cultures and a Second Look,* 1969, pp. 3-4). This is a problem when systems scientists face the challenge of transferring general models from the sciences into the area of the humanities. The series of debates over *soft* versus *hard* systems ideas and thinking since the 1960s and '70s testified to this struggle.

A decade after Snow presented his original discourse on the two cultures, he reflected on the possibility of a third culture coming into existence as a bridge between them. "It is probably too early to speak of a third culture already in existence. But I am now convinced that this is coming. When it comes, some of the difficulties of communication will at last be softened: for such a culture has, just to do its job, to be on speaking terms with the scientific one. Then, as I said, the focus of this argument will be shifted, in a direction which will be more profitable to us all." (*ibid,* p. 70-71.)

A more profitable direction may now be indicated by a partnership between the systems sciences and the humanities. In this context it is useful to recall what Anatol Rapoport wrote in the entry "Systems Analysis: General Systems Theory," in the 1968 edition of the *International Encyclopedia of the Social Sciences* (Vol. 15):

> ...the task of general systems theory is to find the most general conceptual framework in which a scientific theory or a technological problem can be

> placed without losing the essential features of the theory or the problem. The proponents of general systems theory see in it the focal point of resynthesis of knowledge. There was a time when the man of knowledge was a generalist rather than a specialist, that is, he embodied the knowledge of principles rather than skills. He was the philosopher and the sage, and his epistemological creed was most clearly stated by Plato, who believed that all real knowledge comes from within rather than from without, that is, from the contemplation of what *must* be rather than what seems to be. (p. 457)

The erstwhile future of systems thought is now the practice of the contemporary systems sciences. Systems design, based on evolutionary systems theory and drawing on emancipatory systems thinking, presents the humanistic manifestation of the systems sciences in its fullest expression. In the context of social systems, systems design is a rigorous future-creating discipline. People engage in design in order to devise a model of a system based on their vision of what *should* be. They seek a design that has a 'good fit' with the dynamics of their society, with their own expectations, and with the expectations of their milieu. The way of progressing beyond the dichotomy of C.P. Snow's two cultures may well lie in this direction.

Bibliography

Ackoff, R.L. (1981). *Creating the Corporate Future*. New York: Wiley.

----- (1976). "The Systems Revolution." *Long Range Planning.* 1-20.

Anderson, W.T. (1994). "The Moving Boundary: Art, Science, and the Construction of Reality." *World Futures,* 40:27-34.

Banathy, B.H. (1996). *Designing Social Systems in a Changing World.* New York: Plenum Press.

----- (1995). "Developing a Systems View of Education." *Educational Technology,* May-June, 53-57.

----- (1994). "Comprehensive Systems Design in Education." *Educational Technology,* July-August, 32-34.

----- (1993). "Is the Improvement of the Human Condition Our Field? Making Evolutionary Science Work for Human Betterment." *World Futures,* 38:17-31.

----- (1993). "From Evolutionary Consciousness to Guided Evolution." *World Futures,* 36:73-79.

----- (1992). "Designing Educational Systems: Creating Our Future in a Changing World." *Educational Technology,* November, 41-46.

----- (1991). "Cognitive Mapping of Educational Systems for Future Generations." *World Futures,* 31:5-17.

----- (1989). "The Design of Evolutionary Guidance Systems." *Systems Research,* 6(4):289-295.

Bateson, G. (1979). *Mind and Nature: A Necessary Unity.* New York: Ballentine.

Baum, J. (1981). "Science vs. Humanities: The Legacy of C.P. Snow." *Change,* March, 11-13.

Berman, M. (1982). *The Reenchantment of the World.* Ithaca: Cornell University Press.

Berry, T. (1988). *The Dream of the Earth.* San Francisco: Sierra Club Books.

von Bertalanffy, L. (1968). *General System Theory: Essays on its Foundation and Development,* rev. ed. New York: George Braziller.

----- (1950). "The Theory of Open Systems in Physics and Biology." *Science,* 111:23-29.

Boulding, K.E. (1956). "General Systems Theory -- the skeleton of science." *Management Science,* 2(3):197-208.

Brouwer, W. (1994). "The Image of the Physicist in Modern Drama (Part II)." *American Journal of Physics,* 62(3):234-240.

----- (188). "The Image of the Physicist in Modern Drama." *American Journal of Physics,* 56(7):611-617.

Bullock, Alan and Oliver Stallybrass, eds. (1977). *The Fontana Dictionary of Modern Thought.* London: Fontana / Collins.

Capra, F. (1982). *The Turning Point.* New York: Simon and Shuster.

Checkland, P. (1981). *Systems Thinking, Systems Practice.* New York: Wiley.

----- (1979). "The Shape of the Systems Movement." *Journal of Applied Systems Analysis.* 6, 129-135.

Cerroni-Long, E.L. (1994). "Evolution and Human Choices." *World Futures,* 40, 215-225.

Ceruti, M. (1993). *Constraints and Possibilities: The evolution of knowledge and the knowledge of evolution.* New York: Gordon & Breach.

Clarke, R. (1993). "Asimov's Laws of Robotics: Implications for information technology." *Computer.* December.

Colombo, U. (1994). "Science and Art." *World Futures,* 40, 1-5.

Davies, P. (1988). *The Cosmic Blueprint: new discoveries in nature's creative ability to order the universe.* New York: Touchstone.

Dorfles, G. (1994). "Conflict Between Art and Science." *World Futures,* 40, 83-86.

Edel, L. (1999). "The 'Two Cultures' and the Modern Imagination," in *Values and Value Theory in 20th century America.* Philadelphia: Temple University Press.

Feyerabend, P.K.(1994). "Art as a Product of Nature as a Work of Art." *World Futures,* 40, 87-100.

Flood, R.L. (1995). "An Improved Version of the Process of Total Systems Intervention (TSI)." *Systems Practice,* 8:3.

----- (1990). "Liberating Systems Theory: Toward critical systems theory." *Human Relations,* 43(1), 49-75.

----- and M.C. Jackson, eds. (1991a). *Critical Systems Thinking: Directed Readings.* Chichester: Wiley.

----- and M.C. Jackson (1991b). *Creative Problem Solving: Total Systems Intervention.* Chichester, Wiley.

Freeman, R.A. and W.A. Little (1980). "Physics 13: Teaching modern physics through science fiction." *American Journal of Physics.* 48(7):548-551.

Frye, N. (1981). "The Bridge of Language." *Science,* 212, 127-132.

Hall, A.D. and R.E. Fagen (1956). "Definition of System." *General Systems,* Yearbook of the Society for General Systems Research (SGSR - now ISSS).

Henle, R.J. (1960). "Science and the Humanities." *Thought*, 6, 513-536.

Holbrook, D (1977). *Education, Nihilism and Survival.* London: Sarton, Longman & Todd.

Holton, G. (1960). "Modern Science and the Intellectual Tradition." *Science,* 131, 1187-1193.

Huxley, J. (1953). *Evolution in Action.* New York: Harper.

Kouzminov, V. (1994). "Remarks on Art and Science." *World Futures,* 40, 115-117.

Kraft, Q.G. (1975). "Science and Poetics, Old and New." *College English,* 37, 167-175.

Krippner, S. (1991). "The Holistic Paradigm." *World Futures,* 30(3).

Libianca, D.A. and W.J. Reeves (1975). "An Interdisciplinary Approach to Science and Literature." *Journal of Chemical Education,* 52(1), 66-67.

Lilienfeld, R. (1978). *The Rise of Systems Theory: An Ideological Analysis.* New York: Wiley.

Laszlo, A. (1996). "Science and Socio-Ecological Responsibility Revisited." *Systems Research* (pending).

----- (1995). "Technology and Values: Interactive learning environments for the future generation." *Educational Technology,* 35(2):7-13.

----- (1994). "Toward a World Class University." In *Transferencia,* 7(28):14-15.

-----. (1992a). "A Cognitive Map of Cultural Change: Systemic Concepts of Energy and Culture," in *The International Systems Handbook*, Raphael Rodríguez Delgado (ed). Madrid: SESGE.

-----. (1992b). "Fostering Design Competencies: Empathizing With and Enhancing Individual and Collective Self-Development Capacities." Proceedings of the Sixth International Fuschl Conversation. Fuschl, Austria.

-----. (1992c). "Regional Development: A Review of the Issues." Internal document for the Center for Strategic Studies of ITESM. Monterrey, Mexico (manuscript).

Laszlo, E. (1995a). *Systems Theory at the End of the Millennium: Revolution in Science and Transformation in Society,* Presidential Address, International Society for the Systems Sciences, Louisville.

----- (1995b). *The Interconnected Universe: Conceptual foundations of a transdisciplinary unified theory.* Singapore: World Scientific.

----- (1994a). "The Alliance of Science and Art for Human Survival." *World Futures,* 30, 105-110.

----- (1994b). *The Choice: Evolution or Extinction? A thinking person's guide to global issues.* New York: Tarcher/Putnam.

----- and Ignazio Masulli with Robert Artigiani and Vilmos Csányi, eds. (1993). *The Evolution of Cognitive Maps: New Paradigms for the Twenty-First Century,* New York: Gordon & Breach.

----- (1992). *The Age of Bifurcation: Understanding the Changing World.* The World Futures General Evolution Studies Book Series, Vol. 3. New York: Gordon & Breach Science Publishers.

----- (1987). *Evolution: The Grand Synthesis.* Boston & London: Shambhala New Science Library.

----- (1975). "The Meaning and Significance of General System Theory." *Behavioral Science,* 20(1):9-24.

----- (1972a). *The Relevance of General Systems Theory: Papers presented to Ludwig von Bertalanffy on his seventieth birthday.* New York: George Braziller.

----- (1972b). *Introduction to Systems Philosophy: Toward a new paradigm of contemporary thought.* New York: Gordon & Breach Science Publishers.

Lawless, G.W. and J.R. Picci (1977). "Art versus Science." *Journal of Chemical Education,* 54(5):312-313.

Lizzani, C. (1994). "Art and Science: Distinction or Noncommunication?" *World Futures,* 40, 111-113.

Loye, D. (1990). "Moral Sensitivity and the Evolution of Higher Mind." *World Futures,* 30, 41-52.

Meyer, L.M. (1994). "Concerning the Sciences and the Arts -- AND the Humanities." *Critical Inquiry,* September.

Montuori, A. (1993). "Evolutionary Learning for a Post-Industrial Society: Knowledge, Creativity & Social Ecology." *World Futures,* 30, 181-202.

----- (1989). *Evolutionary Competence: Creating the Future.* Amsterdam: J.C. Gieben.

Mushakoji, K. (1994). "From Technocracy Back to Humanism." *World Futures,* 40, 75-81.

Prigogine, I. (1994). "Science, Reason and Passion." *World Futures,* August, 493-507.

----- (1989). "Science, Civilization and Democracy." *Futures,* 40, 35-43.

----- *et al.* (1977). "Long Term Trends in the Evolution of Complexity," in *Goals in a Global Community: The original background papers for Goals for Mankind,* Ervin Laszlo *et al.* (eds). Vol. 1: "Studies on the Conceptual Foundations." New York: Dutton.

Root-Bernstein, R.S. (1984). "The Creative Process as a Unifying Theme of Human Cultures." *DÆDALUS,* 113(3).

Ritchie, L.D. (1994). "Objectivity, Doubt, and the Two Cultures." *Journal of Communication,* 44(1):65-72.

Rapoport, A. (1968). "General System Theory," in *The International Encyclopedia of Social Sciences,* 15, 452-458. David L. Sills (ed). New York: Macmillan & The Free Press.

Sandelin, S. (1991). "Resistance to Dynamic World View." *World Futures,* 30, 211-219.

Smith, W.L. (1975). "Thermodynamics, Folk Culture and Poetry." *Journal of Chemical Education*, 52(2):97-98.

Strijbos, S. (1995). "How can Systems Thinking Help us in Bridging the Gap between Science and Wisdom?" *Systems Practice,* 18(4):August.

Snow. C.P. (1959). *The Two Cultures and the Scientific Revolution.* New York: Cambridge University Press.

----- (1969). *The Two Cultures and a Second Look.* New York: Cambridge University Press.

Tehranian, M. (1974). *Toward a Systemic Theory of National Development.* Tehran: IMI Press.

Ulrich, W. (1983). *Critical Heuristics of Social Planning: A new approach to practical philosophy*. Bern: Haupt.