

THE SYSTEMS SCIENCES IN SERVICE OF HUMANITY

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Summary

This article presents the systems sciences as a field of inquiry and discusses the way in which it has evolved in relation to both the theoretical and the practical concerns of human welfare.

It begins with a brief overview and assessment of the systems sciences by considering their origins and foundations in general systems thinking. The review leads to a consideration of the ways in which it complements and contrasts disciplinary methods of human-related studies. 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 of 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. In this sphere of the systems sciences there is a meeting place of pure and humanistic science, as the former becomes the ground for the latter. The systems sciences draw on the insights gained in both the social and the natural sciences, while both these sciences use the products and results of systems-scientific analysis and design.

Through the tools of systems thinking 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 human sciences 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.

1. Introduction



The role of the systems sciences in service of human welfare, and their contribution to both theoretical and practical issues of human survival in partnership with Earth, are of critical relevance to the changing nature of human relations at the dawn of the twenty-first 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 natural 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 social sciences and 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 future of humanity.

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 human-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 integrative and 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.

2. Transformations in Society



Contemporary changes in society run deep and fast. In the last decade of the twentieth century a crucial juncture in societal evolution was reached. Societies that are growing out of the nationally based industrial systems created at the dawn of the first industrial revolution are now heading toward the interconnected and information-based global socio-economic system emerging under the impact of new technologies and new economic, social, and ecological relations. Both the ontology and the epistemology of social change require strong conceptual lenses with which to focus conceptual interpretation and effective action. The systems sciences offer such a bifocal vision.

2.1. The Subject of Societal Transformation

At the beginning of the third millennium classical assumptions concerning the nature of social and political reality have collapsed. The current system is no longer an arena for the struggle of capitalism and communism led by two superpowers; it is a more complex system with more actors and elements. The USSR has disappeared, and the US is preoccupied with economic problems at home. Japan has emerged into prominence, and the "tiger economies" of Asia are following suit. Europe has become a major economic power, with its East-West economic area of over 380 million people. Issues of environmental degradation have moved from marginal intellectual and youth groups to the center stage of international politics and global business, as some parts of the world—the 130-plus countries that make up 75% of the human race—sink rapidly into further poverty and underdevelopment.

A basic feature of the current transformation is the growing presence of information. The importance of knowledge, know-how, data, and the elaboration of data has grown exponentially in all sectors and segments of society. In the past, human communities have been shaped mainly by the information processed in individual brains; this was the case in raising children, in creating businesses, in setting up local or national governments, in organizing churches or armies, and in founding schools or theaters. But in the course of the twentieth century the information processed in human brains has been more and more supplemented by information processed in technical systems.

In the last decade of the twentieth-century, the advanced societies of the world became thoroughly "informatized". Now they are now longer just social, socioeconomic, and sociocultural entities; they are also information-processing systems. Individuals are reaching out to electronic networks, data banks, and mainframe computers; personal computers are interconnected through a variety of networks. Thousands of complex operations are programmed into mainframe computers as algorithms, and in artificial intelligence as sophisticated heuristics. Cognitive processes are transferred to computers. The processing systems are deeply embedded in the structures of society and interact with them in countless ways.

Along with cognitive processes also *control* is transferred to computers, with the result that information processing systems acquire a high degree of autonomy. International banks and financial institutions, for example, have almost completely delegated their financial routines to computer programs interfacing with globe-circling communication networks. The information standard has replaced the gold standard as the basis for international finance; information has become the crucial factor in channeling flows of capital. Money moves almost instantly around the globe in answer to the latest information (or misinformation).

Information processing systems are integrated in manufacturing (CIM), in design (CAD), and in inventory control (JIT management). They perform essential functions for the military (early warning and remote sensing systems), in telecommunications (communication satellites), in ground and air transportation (automatic rail switching systems, auto-pilots and instrument landing systems), and in such complex operations as balancing the atomic chain reactions of nuclear power stations. The systems have become well-nigh indispensable. They can neither be substituted by human brains (it is estimated that, in Germany alone, it would take seven million persons to carry out the computational workload of the automated banking system), nor can they be "switched off" without inducing dramatic consequences that range from stock market chaos to nuclear melt-down.

The systems are steadily climbing the ladder of human skills. Earlier devices replaced mainly lower-level skills, such as addition and subtraction, and the simpler forms of man-machine communication. With the advent of CIM and CAD, computers moved into slots that were previously the preserve of human technicians. And now sophisticated programs such as Automatic Theorem Proving (ATP) in mathematics and the automatic gene sequencers of the Human Genome Project encroach on the skills of scientific specialists.

The effects of informatization are felt beyond the industry itself: the sectoral distribution of the entire workforce is slanted toward the information area. Employment patterns have been shifting not only from agriculture toward industry, but even within industry from raw-material and energy-intensive branches toward information-intensive ones. In the US, for example, the largest single workforce in 1860 was still in agriculture; the information sector comprised but a modest 5 percent. Between 1906 and 1960 it was the industrial workforce that became dominant, peaking in 1946 with 40 percent of the total employment. In the 1950s, however, the proportion of the workforce in traditional industry began to decline, falling to 25% by the 1970s. At the same time the segment of the work force employed in the information sector began a rapid rise, reaching to about 50 percent of the total employment figure by the late 1980s. The primary and secondary information sectors taken together now account for more than 50% of the US GNP.

A new nervous system is created in society. This system is exosomatic: it operates outside the human organism and thus is not limited by the size of the cranium. It has almost infinite growth potential, with its internal bounds given only by the minimum size beyond which there is noise or cross-talk among electrons and the maximum quantity of data held by a chip. Even these limits are expandable through optical processors and holographic data storage. It is calculated that a one-inch square hologram has nearly 100 million resolvable spots available for recording. This allows some 10 000 light sources to be linked up with 10 000 light sensors, a recording magnitude well beyond the absolute physical capacity of chips. Moreover holograms, the same as chips, can be superposed to act as three-dimensional storage-media rather than as two-dimensional surfaces. In principle, a hologram the size of a cube of sugar could store the entire contents of the US Library of Congress, being capable of handling all the possible interconnections of one million optical elements—some one trillion connections.

Also the external bounds of the system are vastly expandable. Microprocessors can be associated not only with high-capacity storage media but also in communication networks of growing extension and density. The potential capacity of a global telecommunication system such as that promised through ISDN is mind-boggling. To appreciate its dimensions, we should compare it with messages transmitted by humans. A literate individual who speaks and writes a relatively large number of words each day produces in his or her lifetime a total "message unit" of approximately 650 million words. An integrated worldwide telecommunication system operating at 100 gigabits per second and relying on six space satellites could transmit one year's total human message unit in about a month—that is, it could carry all the words spoken and written during a period of 365 days by six billion people in 30 days flat.

Another benchmark of the current transformation of society is the progressive globalization of its structures and institutions, in the public as well as in the private sector. Globalization is closely related to informatization. The exponentially growing networks of information and communication made possible the creation of international and transnational networks and associations, and many of these structures evolved into concrete business, governmental, or non-governmental organizations. The world's global flows of

information have already given birth to tens of thousands of international and intergovernmental bodies and thousands of globe-girdling business enterprises. Business enterprises and information networks were the first to reach global dimensions. Unlike governments, they were not hampered by constitutional and pragmatic ties to national constituencies and interests.

2.2. The Interpretation of Societal Transformation

Society, a dynamic but relatively simple suprabiological system, evolves in a fuzzy and generally disordered manner—so much so that students of history often question whether there is *any* pattern underlying the sequence of historical facts and events. History, as the positivists claim, seems to be "one darn thing after another". The hypothesis that the laws governing the evolution of natural systems also govern the development of human societies is contrary to a humanistic tradition in the social sciences, but it is not intrinsically unreasonable. These laws do not prescribe the course of evolutionary development but merely set the rules of the game—the limits and the possibilities that the players themselves exploit. The ground rules for biological evolution have been set by evolution in the cosmos. For sociocultural evolution the rules have been set by biological evolution, and first and foremost by the evolution of the brain and mind of *Homo Sapiens*.

The evolutionary thesis does not mean that human societies are biologically determined. It means only that societies are evolving systems emerging and persisting within the multiple-level structure of other systems in the biosphere. Societies follow the rules set by the general laws that govern the evolution of such systems within the limits and possibilities created by human beings, their values, beliefs, habits, and mores. But societies follow these rules on their own, typically societal, level—and not on the biological level of their members.

Systems sciences perceive that there is pattern in history, as there is pattern in the evolution of order and complexity in all realms of nature. Even if the outcomes are never predetermined, it is not accidental that, given sufficient time, life should appear, and then society. It is logical, in terms of the dynamics of evolution, that on each level evolving systems should acquire greater complexity and retain more of the energy fluxes in which they are immersed. The emergence of mammals with endothermy is just as much in the logic of evolution as is the emergence of technological societies. One is a complex open *organic* system capable of storing and using increasing amounts of increasingly dense energies on the level of individual organisms and the other is a complex open *supraorganic* system with equivalent capabilities on the level of groups and populations of organisms.

The adoption of increasingly energy-intensive technologies with improved (though not necessarily optimal) efficiency sets forth the evolutionary trend toward growing dynamism and autonomy in nature. Just as organic species evolve toward the use of greater densities of a wider variety of free-energy sources in their environment, so human societies develop to access, store, and use in greater densities larger quantities of free energy through the ongoing improvement of their technologies. As a consequence societies, the same as natural systems, tend to grow larger in size, develop more intricate relations among their diverse components, and create more massive and flexible modes of interaction among them.

3. The Relevance of the Systems Sciences



The changes and transformations occurring in both science and society highlight the relevance of the systems sciences in the investigation of nature

and society.

The progress of the systems sciences has been contiguous to the development of the natural sciences throughout the last century. With the Einsteinian revolution at the turn of that century, physics moved beyond the mechanistic paradigm. Then, some two decades later, with the advent of quantum theory, the physical sciences abandoned the remaining vestiges of the classical paradigm. In the life sciences, the rise of population biology and ecosystem analysis prompted a dynamic approach focused on the emerging wholes of nature, rather than on linear interactions among their parts. In some fields of the natural sciences reductionism has been completely abandoned. In quantum field physics, for example, particles are now analyzed in terms of field interactions. The fields are viewed as constituting the particles, rather than the particles constituting the fields. The distinction is significant because a continuous field is not reducible to the particles that dot its continua, much as the behavior of a dynamical system is not reducible to the equations that define relations among its individual components.

Today, the natural sciences are reaching a critical threshold. Gone is the assurance that the fundamental features of the observable universe have been already discovered; the complacency typical of the late nineteenth century all but vanished in the twentieth. Anomalies are discovered in field after field, and interest in them is growing. As the twenty-first century begins, a deepening sense of unease at the centers of the science establishment is compensated by a growing openness and sense of excitement at its innovative edge. More and more societies and associations are created for the exploration of the anomalies encountered in scientific research, and these networks are growing in prestige and legitimacy.

Thanks to the combined effort of conceptual innovators in the systems sciences, and advances in computational hardware and software, sciences such as cybernetics, general system theory, nonequilibrium thermodynamics, nonlinear dynamics, general evolution theory, evolutionary systems design, and theories of self-organization and chaos have experienced rapid development. Leading-edge scientists from von Bertalanffy to Prigogine, and from Wiener to Ashby and Abraham, learned to decode the dynamics intrinsic to complex systems without needing to decompose them to linear interactions among their elements.

However, in some human and social science fields, investigators remained wedded to the Newtonian formulas. When social scientists endeavored to emulate the natural sciences, they did not readily discover a good substitute for classical mechanics. The social entities of interest to them were thought to be reducible—ultimately—to the behaviors, values, and intentions of individual humans. These factors were taken to be related by simple and direct chains of cause and effect, so that societal interrelations, no matter how complex, could be simplified for purposes of computation.

The preferred instrument for computing interrelations was the calculus. Assuredly, the calculus functions well in regard to systems that are integrable, with causal relations among the elements conceived as linear chains of cause and effect. But the assumption of linear chains of causality could not be maintained in regard to simultaneous interactions among nonlinear processes. When a number of nonlinear cycles interact, complex loops and feedbacks are produced, exhibiting features such as recursion and self-referentiality. While at the one extreme, the behavior of the system may be so simple as to be almost linear, at the other it may be so complex as to seem chaotic. The classical calculus, adapted to the former, encouraged the assumption that societal phenomena can be analyzed into simple and linear causal relations. Recent investigations benefiting from advances in computational technology have

shown the fallacy of this assumption. They have succeeded in penetrating progressively higher levels of organization, decoding dimensions of complexity that were previously thought to be chaotic. The latter, mapped by a variety of chaotic attractors, turned out to have irreducible characteristics of their own. These include a high level of input- and initial-condition dependence, fractal dimensions, and indeterminate—and thus intrinsically unpredictable—trajectories.

Systemic approaches, whether explicitly so identified or just implicitly employed, have become a mainstream methodology in the advanced branches of the natural sciences. They are most likely to gain increasing application and importance also in the social sciences. Notwithstanding pockets of conservatism and resistance, this expectation is justified by the fact that not only nature but also human society exhibits growing complexity. While the complexity of the former is increasing geometrically at most (due to ongoing evolution in both cosmos and in biosphere), the complexity of the latter is increasing exponentially. And, for decoding complexity, no viable alternative has presented itself in the social sciences or the humanities to the methods and models of the contemporary systems sciences. (See, [System Approaches](#).)

4. Systems Sciences as a Field of Inquiry



In regard to applications to issues of human relations, the 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 an integrated theory of complexity *per se*.

Methodologically, it is important to distinguish theoretical from empirical systems. 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 either epistemology or ontology. Rather, it is 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 therefore not be circumscribed to either.

4.1. 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 covered 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.

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 (mathematics and language), existential ("real-world"), or affective (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 (the system itself) conserving some identifiable set of relations to other entities (including other systems).*

The generality of this definition does not undermine its plausibility: 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." 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.

4.2. 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, because 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.

4.3. 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*.

4.4. Emergent Properties and Synergy

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 is broken down to its components—the property of life, for example, is not retained 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 bathwater. Indeed, water itself has emergent properties that cannot be found in its component parts: wetness is a principal characteristic of H₂O but it does not pertain to either Hydrogen or Oxygen atoms; it emerges through molecular association.

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.

While the concept of synergy specifies that the whole is more than the sum of its parts, this should not be taken to mean that a system is fundamentally indivisible. Structurally, a system is a divisible whole, but functionally it is an indivisible unity with emergent properties. As a functionally indivisible whole, a system loses both its emergent properties and the synergy of its components if taken apart. The same holds true for the components of a system if they are taken apart, as described above. Nevertheless, a system is structurally divisible into its component parts (the difficulty arises in attempting to reconstitute a viable system upon dissection). The fact of structural divisibility and functional indivisibility create the aforementioned condition of synergy. Here the whole is to be considered more than the sum of its parts yet equal to the sum of its parts plus their relationships. Hence the systems appreciation of the equation $1+1=3$, since two units plus their relationship (which is additive, in this case) equals a total of three components. Of course, this is not a mathematical statement that expresses a quantitative relation but rather a systemic expression of a qualitative relationship. The systems perspective permits appreciation of the variable nature of the relationships in any open dynamic system as a critical factor to be considered in its own right in determining the actual state of the system.

4.5. General Theory

The definition of certain varieties of entities and events in the world as "systems" has made for the mid-twentieth 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.

Nevertheless, a systems view is not to be equated with a naive holistic view. Holism, as descended from Jan Smuts who introduced the term in 1926, is a form of reductionism just as simplistic in its representation of complexity as is the process of "reduction to components" employed in the specialized approach of classical scientific analysis. As Edgar Morin points out, "Holism is a partial, one-dimensional, and simplifying vision of the whole. It reduces all

other system-related ideas to the idea of totality, whereas it should be a question of confluence. Holism thus arises from the paradigm of simplification (or reduction of the complex to a master-concept or master-category)". Holistic appreciation involves sympathetic, experiential, and intuitive understanding. Systems thinking also involves such ways of appreciating phenomena and events, but is not limited to them. The systems sciences are considered scientific precisely because they *also* draw on more disciplined forms of inquiry that involve observation, identification, description, experimental investigation, and theoretical explanation of phenomena and events. Additionally, while holism employs a synthetic function (useful for identification of a system's operational role) and classical science employs an analytical function (useful for identification of a system's structural components) systems science employs *both* an analytical and a synthetic function, thereby offering a means for insight into both structural and functional aspects of complexity. (See, [General Systems Theory](#).)

5. The Breadth and Diversity of the Systems Sciences



Although the systems sciences do not themselves constitute a discipline, specific branches such as cybernetics can be thought of as disciplinary sub-areas of systems inquiry. As Kenneth Boulding points out, general system theory (and systems science 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."

5.1. 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. A methodology is different from a 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 both specific entities capable of being modeled as systems, and wider areas as their relevant environment. As Majid Tehranian has remarked, the systems thinker's perception always incorporates an element of human intuition. 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".

5.2. Systems and Environments

In systems theory the term "environment" is defined as the set of all objects a change in whose attributes effect the system as well as those objects whose attributes are changed by the behavior of the system. 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."

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 of the social system with which they work. When engaging in a systems study 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.

5.3. 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 components, 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:

- a. the deconstruction of that which is to be explained;
- b. the formulation of explanations that account for the behavior or properties of the components taken separately; and
- c. 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.

6. The Social Dimension of Systems Thinking



6.1. Contrasting Worldviews

Ways of thinking are not immutable. There are elements of systems thinking cropping up in many fields and in many strata of the population. A consideration of the old, mechanistic way of thinking in contrast to the new systemic mind-set serves to highlight the shift in perspective in the following table.

Mechanistic thinking	Systems thinking
Objects are separate from their environments; people are separate from one another and are replaceable in their organizations and communities	There are connections and interactions between people, and between people and nature, and there is irreducible unity and integrity in both the natural and the human world.
The economy is the arena for the struggle of competitors for profit and survival; the coincidence of individual and public good can be entrusted to the "invisible hand" discussed by Adam Smith.	Cooperation has higher value than competition, and the individualism of the modern work ethos must be tempered with tolerance and a valuation of diversity, and the courage to experiment with practices that foster harmony between people, and between people and nature.
Human beings can and should master nature for their own higher ends.	Humanity is an organic part within the self-maintaining and self-evolving systems of nature and should seek to fit into the embracing ecology of the biosphere.
Economic growth is the pinnacle of social progress, and the best way to achieve it is through greater consumption of energies, raw materials, and related resources.	The highest form of progress is through sustainable development, with flexibility and accommodation among humans, adaptation between humans and other species within the vital balances of nature.
The human body, like all organisms, is a machine whose malfunctions are best corrected by factual diagnosis and impersonal treatment; the ills of the mind are separate from the ills of the body and must be separately treated.	Body and mind are not separable; safeguarding the integrity and development of the whole organism requires empathy in addition to expertise, and attention to psychological, social, and environmental factors in addition to physical and physiological conditions.
The highest achievements of humankind are the applications of technology and the accumulation of material goods through a compete-to-win work ethos.	The true priority is access to relevant and meaningful information, and hence to education, communication, and human services.

6.2. Systemic Thinkers and Systems Thinkers

Even though the analytic atomistic modes of thought characteristic of mechanistic thinking seem prevalent, the roots of the holistic integrative modes that characterize systems thinking are deep. Systems thinking has not sprung *de novo* out of the last war effort, as some would have it, but rather is heir to a rich mix of philosophical traditions.

Although the term "system" was applied only during the twentieth century, it has a history that includes many well known thinkers. As a "natural philosophy", it has links to Leibniz's dream that all sciences, and in particular

those that now depend on facts, could approach a science of absolute truths as a sort of unattainable ideal. In a similar vein, it has antecedents in the work of Nicholas of Cusa on the coincidence of opposites; in the mystic medicine of Paracelsus; in Vico's and ibn-Khaldun's vision of history as a sequence of cultural entities (or "systems"); in the dialectic of Marx and Hegel. The list is far more extensive, and even includes literary thinkers such as Hermann Hesse, with his *Glasperlenspiel* (*The Glass Bead Game*), and Isaac Asimov, who created the fictional science of psychohistory in his Foundation Trilogy, both of whom saw the working of the world reflected in a cleverly designed, abstract pedagogy.

However, the groundbreaking work in systems thinking *per se* goes back to the 1920s when Ludwig von Bertalanffy and several other holistic thinkers first became puzzled about the obvious lacunae in the research and theory of natural and social sciences. Clearly, there have been those who have also thought along similar lines, including Whitehead and others as far back as 585 B.C. to Thales of Miletus. However, the formulation of a General System Theory, and the subsequent development of systems science (and the students of this field, the systems thinkers and systems practitioners) involves a particular condensation and crystallization of the concepts. So while one can be a systemic thinker it does not necessarily follow that one is also a systems thinker: the latter implies an understanding of the concepts of GST not appreciated by the former.

7. Recent Trends in the Humanities and the Systems Sciences



7.1. 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 (see, *Figure 1*).



Figure 1. The shape of the systems movement, indicating the progressive development of particular theoretical branches

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 other 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 (used as an aid to decision-making)—such as those employed in operations research.

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. Peter Checkland developed this classification to represent two ends of a continuum. *Hard systems* are easier 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.

7.2. 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.

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 Michel 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:

- a. critical awareness,
- b. social awareness,
- c. complementarism at the methodology level,
- d. complementarism at the theory level, and
- e. 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. (See, *Critical Systems Thinking*.)

7.3. 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.

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. 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.

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. (See, [*Total System Intervention*](#).)

7.4. 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 phenomena 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 join 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 Laszlo, Masulli, Artigiani, and Csnyi 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 tenets 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."

7.5. Social Systems Design

The design of open social systems is a relatively new mode of inquiry. The 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, 1996, 1999). Social systems design emerged recently as a manifestation of open systems thinking and corresponding soft-systems approaches. As a future-creating disciplined inquiry, it incorporates both a conclusion-oriented component and a decision-oriented component of inquiry. The former is concerned with research in the classical sense, involving the disciplinary, interdisciplinary, and multi-disciplinary investigation of phenomena and events in order to gain a deeper understanding of them. The latter is concerned less with research findings than with the outcomes of the application of knowledge, and as such tends more to transdisciplinary investigation of real-world concerns in order to create actionable change related to them.

The social 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 complex living systems. It implies that we take responsibility for the co-creation of our future in interdependence with all the stakeholders of the systems involved in design. As a consequence, social systems design is participatory by 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. Social systems design advocates *participative democracy*, where people directly

engage with the issues and activities which stand to affect them.

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.

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.

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."

7.6. Evolutionary Systems Design

Recent efforts to apply general evolution theory to social systems design have marked the birth of evolutionary systems design. Evolutionary systems design is an area of systems praxiology oriented to the creation of evolutionary pathways for the sustainable development of life on earth. 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.

Given the theoretical constructs of general evolution theory, and the methodological constructs of social systems design approaches, evolutionary systems design confronts the challenges posed by purposeful stewardship of the earth's life support systems. It implies that we take responsibility for the creation of our future in co-evolutionary interdependence with our social and natural 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. The orientation of this praxiology is captured in a writing that dates from well before the emergence of evolutionary systems design: "Having become conscious of evolution, we must now make evolution itself conscious. If we so willed it, the next leap in the development of human society can be intentionally guided". To do so, we must create a "holarchic path where individuals and communities collaborate of their own accord in flexible social systems."

Evolutionary 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 evolutionary systems design form an evolutionary learning community, and such communities make for the emergence of a culture of evolutionary design. This process is predicated on the development of "evolutionary competence." Evolutionary competence refers to the state of self-actualization (of individuals and groups) that is marked by the mastery of the knowledge, abilities, attitudes, and values required for co-evolutionary actions, and therefore for the pursuit of sustainable modes of being. Such modes of being concern both the products *and the processes* of change in terms of the degree to which they are:

- socially desirable,
- culturally acceptable,
- psychologically nurturing,
- economically sustainable,
- technologically feasible,
- operationally viable,
- environmentally friendly,
- generationally sensitive.

By monitoring all these aspects simultaneously, a process of development (individual, societal, or global) can be said to be evolutionary if it involves an adaptive strategy that ensures the continual maintenance of an increasingly robust and supportive environment. Evolutionary systems design seeks to identify opportunities for increasing the dynamic stability and self-sufficiency of an individual or group in interaction with the broader set of components of its particular time and place. It indicates areas of evolutionary potential to be developed to the advantage of the complex dynamic systems involved in ecosystemic interaction now and into the future.

The stewardship of evolutionary competence is one of the principal objectives of evolutionary systems design. Through processes that cultivate individual and collective empowerment in the creation of pathways of evolutionary development, current research in evolutionary systems design seeks to define and promote real-world models of evolutionary learning community (ELC). An ELC can be defined as a group of two or more individuals with a shared purpose, a common identity, and a commitment to the joint creation of meaning that develops evolutionary competence by learning how to learn in harmony with the dynamics of its physical and sociocultural milieu. ELCs do not adapt their environment to their needs, nor do they simply adapt to their environment. Rather, they adapt with their environment in a dynamic of mutually sustaining evolutionary co-creation. Situations of uncertainty are turned into opportunity, provided a basic level of evolutionary competence is attained to enable understanding of the principles that explain the patterns of change described by all complex dynamic systems with a throughput of information and energy. (See *Evolutionary Complex Systems*.)

In relation to the humanities, evolutionary systems design 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. The fact that evolutionary systems design arose "as an attempt to evolve SSD [social systems design] into a form of critical systems thinking by also serving an emancipatory interest means that ESD [evolutionary systems design] draws from wellsprings of soft systems thinking, critical systems thinking, and emancipatory systems thinking in addition to GET [general evolution theory] and life-long evolutionary learning orientations. The result is a humanistically oriented systems approach comprised of a meta-methodology that facilitates the critical application of various systems perspectives to real-world situations."

Given the insights born of this particular systems design praxis, a normative imperative is emerging 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 evolutionary learning community.

7.7. In Service of Humanity

The increasing complexity and interrelatedness of societies highlight the need

for a systems science that combines the humanities and the sciences in a 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 great measure on their ability to adapt to changing realities. A systemic orientation in the humanities is needed to maintain a 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. Just 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. (See, [A Systems Design for the Future](#).)

8. A Bridge between Two Cultures and the Future



The above insights have led to the development of an orientation in the systems sciences that may provide a solid bridge between systems theory and humanistic action. In this context it is useful to recall Rapoport's description of the fundamental aim and orientation of general system theory in the 1968 edition of the *International Encyclopedia of the Social Sciences*:

"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."

The erstwhile future of systems thought is now the practice of the contemporary action-oriented systems theorists. Evolutionary systems design, drawing on emancipatory systems thinking and based in evolutionary systems theory and social systems design, presents the humanistic manifestation of systems theory in its fullest expression. In the context of individual and collective human activity systems, evolutionary systems design is a rigorous future-creating area of inquiry and action. Much as Rapoport suggests, 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.

Through action-oriented systemic inquiry on issues of human survival in partnership with Earth, it may be possible to guide social systems design efforts in ways that create adaptive strategies for evolutionary development by ensuring the continual maintenance of an increasingly robust and supportive

environment. Design efforts that re-align contemporary cognitive maps with the imperatives of evolutionary development can be brought to individuals and communities through the vehicles of participation and empowerment. Evolutionarily empowered individuals not only perceive the dynamics of change of which they are a part and are conscious of the urgency for responsible interaction with their evolving socio-ecological system, but manifest their perceptions and consciousness in value shifts that re-align individual cognitive maps with the new realities of the world around them.

Evolutionary systems design presents an approach for realizing the vision of a sustainable and evolutionary *learning society*—a *paidea*, as the ancient Greeks called a society where the promotion of lifelong learning and the achievement of the human potential in the broadest sense was a central priority. A *paidea* can be considered a social system of syntony. The educational vehicle to facilitate evolutionary learning and transformation for its emergence is the evolutionary learning community, and beyond it, communities of evolutionary learning community, or evolutionary learning ecosystems. As such, evolutionary systems design holds out the hope of creating the conditions in which individuals and groups may gain the evolutionary competence needed to co-create sustainable evolutionary pathways for humanity—in interactive ways that allow other beings as well as earth's life support systems to evolve sustainably, with dignity, and in harmony.

Related Chapters



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Glossary



CAD	:Computer Aided Design.
CIM	:Computer Integrated Manufacturing.
Dissipative structures	:A term invented by Ilya Prigogine to describe complex chemical structures undergoing the process of chemical change through the dissipation of entropy into their environment, and the corresponding importation of "negentropy" from their environment. Also known as <i>syntropic systems</i> .
Embeddedness	:A state in which one system is nested in another system.
Emergence	:The appearance of novel characteristics exhibited on the level of the whole ensemble, but not by the components in isolation.
Entanglement	:A state in which the manner of being or form of existence of one system is inextricably tied that of another system or set of systems.
Evolution	:A cosmic process specified by a fundamental universal flow toward ever increasing complexity 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 open dynamic systems with a throughput of information and energy. In other words, evolution relates to the formation of stars from atoms, of <i>Homo Sapiens</i> from the anthropoid apes, as much as to the formation of complex societies from rudimentary social systems.

Evolutionary Learning Community (ELC)	:A community that strives toward sustainable pathways for evolutionary development in synergistic interaction with its milieu, through individual and collective processes of empowerment and evolutionary learning. ELCs do not adapt their environment to their needs, nor do they simply adapt to their environment. Rather, they adapt with their environment in a dynamic of mutually sustaining evolutionary co-creation.
General System Theory	The concepts, principles, and models that are common to all kinds of systems as well as to the isomorphisms between and among various types of systems.
Heterarchy	:An ordering of things in which there is no single peak or leading element, and which element is dominant at a given time depends on the total situation; often used in contrast to hierarchy.
Hierarchy	:A vertical arrangement of entities (systems and their subsystems).
Holarchy	:A concept invented by Arthur Kestler to describe behavior that is partly a function of individual nature and partly a function of the nature of the embedding system.
Holism	:A reductionist, descriptive, and investigative strategy for generating explanatory principles of whole systems. Attention is focused on the emergent properties of the whole rather than on the behavior of the isolated parts. The approach involves and generates sympathetic, experiential, and intuitive understanding.
Human Activity Systems	:Designed social systems organized for a purpose, which they attain by carrying out specific functions.
ISDN	:Integrated Services Digital Network communication systems.
JIT	:Just-In-Time inventory control.
Learning	:A lifelong process that challenges the learner's perspective and facilitates the expansion of his/her worldview; promotes human fulfillment; enables the learner to cope with uncertainty and complexity; and empowers the learner creatively to shape change and design the future.
Synchrony	:Also synchronicity. In engineering; concurrence of periods and/or phases; simultaneity of events or motions contemporaneous occurrences. In evolutionary systems thinking; a fortunate coincidence of phenomena and/or of events.
Synergy	:The process by which a system generates emergent properties resulting in the condition in which a system may be considered more than the sum of its parts, and equal to the sum of its parts plus their relationships.
Syntony	:In evolutionary systems thinking; evolutionary consonance (as a state) or the occurrence and persistence of an evolutionarily consonant dynamic regime (as a process). The embodiment and manifestation of conscious evolution; a purposeful creative aligning and tuning with the evolutionary flows of one's milieu. In radio engineering; resonance.
Syntropy	:The process of negentropy-importation. A syntropic system is a dissipative structure.
System	:A group of interacting components that conserves some identifiable set of relations with the sum of their components plus their relationships (i.e. the system itself) conserving some identifiable set of relationships to other entities (including other systems).

Systems approach	:A view that perceives phenomena as a system and deals with problem situations and opportunities that emerge by the application of systems inquiry (e.g., systems thinking and systems design).
Systems design	:A decision-oriented disciplined inquiry that aims at the construction of a model that is an abstract representation of a future system.
Systems thinking	:An internalized manifestation (in the thinking of individuals or social systems) of systems concepts, systems principles, and systems models.
System types	:The members of a set of classifications that arrange human activity systems according to how open-closed, mechanistic-systemic, unitary-pluralistic, or restricted-complex they are. Differentiated on the four-fold continua, system types include those that are rigidly controlled, deterministic, purposive, heuristic, and purpose-seeking.
Wholeness	:In reference to systems, the condition in which systems are seen to be structurally divisible, but functionally indivisible wholes with emergent properties.

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Biographical Sketches

Alexander Laszlo, Ph.D., is Co-Founder and President of Syntony Quest. He is also Senior Research Fellow of the International Network of the Center for Knowledge Systems and former Director of the Doctoral Program in Management at the Monterrey Institute of Technology (ITESM), Mexico. Currently Full Professor of Learning and Human Development at the California Institute of Integral Studies, he also serves on the Board of Directors of the Unity Foundation, on the Sages Advisory Panel of the Council for Global Education, and as Co-Chair of the Special Integration Group on *Evolutionary Learning Community* of the International Society for the Systems Sciences. He is on the Editorial Boards of *Systems Research and Behavioral Science*, *World Futures*, and *Latin American Business Review*, recipient of the Sir Geoffrey Vickers Memorial Award, active member of several systems science societies, and author of over thirty journal, book, and encyclopedia publications.

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