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Systems thinking and (the) systems science(s) in a system of ideas

On the discussion list of the Systems Science Working Group

(<https://groups.google.com/d/topic/syssciwg/evcQvi9T-S8/discussion>), there's a request to comment on the Overview of Systems Science wiki page

(http://www.bkcasewiki.org/index.php/Overview_of_System_Science) (draft version 0.5) that is part of the Guide to Systems Engineering Book of Knowledge (http://www.bkcasewiki.org/index.php/Main_Page).

Basic descriptions are hard to write. Asking the “what is ...” question is a challenge of ontology (<http://en.wikipedia.org/wiki/Ontology>), and may not cover the “why ...” question coming from the perspective of teleology (<http://en.wikipedia.org/wiki/Teleology>) or the “how ...” question coming from the history and philosophy of science (http://en.wikipedia.org/wiki/History_and_philosophy_of_science).

I appreciate that novices like definitions. In a scholarly style, I generally cite descriptions by individual thinkers who *each* have a *system of ideas*. In an attempt to appreciate commonalities and differences between prominent figures in the systems movement, I had been hosting a series of Systems Sciences Connections Conversations (<http://isss.org/world/connections>) aimed at traversing social ties between individuals. As a fun example, we asked Allenna Leonard (http://en.wikipedia.org/wiki/Allenna_Leonard) if Stafford Beer (http://en.wikipedia.org/wiki/Stafford_Beer) and Jane Jacobs (http://en.wikipedia.org/wiki/Jane_Jacobs) knew each other, as they both lived in the Annex neighbourhood in Toronto (http://en.wikipedia.org/wiki/The_Annex,_Toronto). Allenna's response was, of course, they would see each other in places like the drug store. Stafford Beer did use *Cities and the Wealth of Nations* as a foundation for his work in Uruguay (http://projects.isss.org/jane_jacobs_association_stafford_beer), but there wasn't really an occasion for ongoing collaboration. Developing a *network* of systems of ideas is a more modest endeavour than trying to create a *system* of system of ideas.

Describing the world in objective entities isn't the way I think. I'm strongly influenced by the idea of reflexivity (described in the context of social theory on Wikipedia)

([http://en.wikipedia.org/wiki/Reflexivity_\(social_theory\)](http://en.wikipedia.org/wiki/Reflexivity_(social_theory))). Pierre Bourdieu

(http://en.wikipedia.org/wiki/Pierre_Bourdieu) invited a path into his system of ideas as reflexive sociology

(<http://books.google.ca/books?id=rs4fEHa0ijAC>). George Soros

(http://en.wikipedia.org/wiki/George_soros) has a general theory of reflexivity

(http://www.soros.org/resources/multimedia/sorosceu_20091112/reflexivity_transcript).

For descriptions in this domain — not definitions, for which a dictionary might be a better source — I'll defer to International Encyclopedia of Systems and Cybernetics (http://en.wikipedia.org/wiki/International_Encyclopedia_of_Systems_and_Cybernetics), edited by Charles François. I have a copy of the 1997 first edition, which was superseded by a larger 2004 second edition that I haven't seen. Based on some entries in this encyclopedia, some Russell Ackoff readings, and my accumulated perspective on systems, I'll make some assertions.

- 1. Systems thinking and the systems sciences are parts of an ecology of knowledge
- 2. Systems thinking prescribes an ordering of synthesis and analysis, emphasizing superordinates (containing wholes)
- 3. The development of the “systems sciences” historically correlates with the rise of the “social systems sciences” program at the University of Pennsylvania
- 4. The systems sciences have a heritages in cybernetics and general systems theory
- 5. Systems thinking and the systems sciences manifest as systems approaches

For considerations of length, the Systems Science Working Group may split the content into two separate articles on systems science and systems methodology (https://groups.google.com/d/msg/syssciwg/evcQvi9T-S8/0_1Ji8d5Z70J).

1. Systems thinking and the systems sciences are parts of an ecology of knowledge

Systems thinking and the systems science could be seen as subfields of knowledge. They're related, yet distinct. Applying systems thinking on describing systems thinking leads to describing an ecology.

ECOLOGY of KNOWLEDGE

“The study of pattern of interrelationships among the various “species” (subsystems, sub-subsystems, etc.) and fields and subfields of knowledge with emphasis on:

- a) preserving the condition of dynamic balance between the “species” and their environment; and
- b) optimizing the overall symbolic fruits of synergistic interactions among them” (J.W. CLARK, 1972, p.168)

CLARK proposed a curriculum in “General ecology of knowledge” divided as follows in six sections, including among other subjects:

A. Systems Education Studies

Systems approaches; ... simulation; ... systems management; ... game theory; ... forecasting methods and operations research.

B. Basic Integrated Studies

General cybernetics; ... eco-cybernetics; ... meta- tools; ... meta-skills; ... metalanguages; ... general ecology of knowledge

C. Global Design Heuristics

Heuristic forecasting; ... synergetics; ... synectics; ... pattern recognition ...

D Heuristic Meta-Policy Studies

The anatomy of meta-policy; ... the anatomy of change; ... Psychology of mass movements; ... systems of signals and incentives; ... games for global involvement; ... the dynamics of feedback and re-inforcement ...

E. Meta-Policy Sciences

Behavioral sciences and general systems perspectives; ... designing and evaluating alternative futures; ... integrative workshops

For the discussed complete program, see reference (p 165-180).

This proposal, made in 1972, does not seem to have been seriously debated and, still less, applied anywhere. The institution of *interfaculties* programs of this type would possibly be the only way to seriously expand the systemic approach and methods. [François 1997, p. 111-112]

In the ecology of knowledge, both systems thinking and the systems sciences are challenged as interfaculty programs that require crossing disciplinary boundaries.

2. Systems thinking prescribes an ordering of synthesis and analysis, emphasizing superordinates (containing wholes)

My favourite practical description of systems thinking is related to the order of synthesis and analysis.

Synthesis, or putting things together, is the key to systems thinking just as analysis, or taking them apart, was the key to Machine-Age thinking. Synthesis, of course, is as old as analysis — Aristotle dealt with both — but it is taking on a new meaning and significance in a new context just as analysis did with the emergence of the Machine Age. Synthesis and analysis are complementary processes. Like the head and tail of a coin, they can be considered separately, but they cannot be separated. Therefore, the differences between Systems-Age and Machine-Age thinking derives not from the fact that one synthesizes and the other analyses, but from the fact that systems thinking combines the two in a new way.

Systems thinking reverses the three-stage order of Machine-Age thinking; (1) decomposition of that which is to be explained, (2) explanation of the behavior or properties of the parts taken separately, and (3) aggregating these explanations into an explanation of the whole. This third step, of course, is synthesis. In the systems approach there are also three steps:

1. Identity a containing whole (system) of which the thing to to be explained is a part.
2. Explain the behavior or properties of the containing whole.
3. Then explain the behavior or properties of the thing to be explained in terms of its *role(s)* or *function(s)* within its containing whole. [p. 16]

Note that in this sequence, synthesis precedes analysis. In analytical thinking the thing to be explained is treated as a whole to be taken apart. In synthetic thinking the thing to be explained is treated as part of a containing whole. The former reduces the focus of the investigator; the latter expands it. [Ackoff 1981, pp. 16-17]

The encyclopedia entry on “systemic thinking” goes back further to Angyal 1941. Angyal was a key reference in Ackoff’s program on social systems science at the University of Pennsylvania. François prefers the label of “systemic thinking” over “systems thinking” (with a separate entry for *Systems Thinking (Critical)* that refers to the work of Michael C. Jackson).

SYSTEMIC THINKING

A general approach to scientific inquiry that is specially interested in the study of complex situations and systems, using specific concepts and models.

Back in 1941, A. ANGYAL was already comparing the causal way of thinking with the systemic one, in the following terms: “In causal research, the task is to single out from a multiplicity of data, pairs of facts between which there is a necessary connection. In systems thinking the task is not to find direct relations between members but to find the superordinate system in which they are connected or to define the positional value of members relative to the superordinate system” (1941, p.24).

He added: “One thing ... seems clear, namely that systems cannot be deduced from relations, while the deduction of relations from systems still remains a possibility. If that is the case then the more general logical genus would be ‘system’, while ‘relation’ would be a reduced, simplified system which is adequate only for the logical presentation of very simple specialized constellations” (Ibid., p.25).

This viewpoint seems however somehow contradictory with the concepts and methods of KLIR’s reconstructability analysis. The ideas which seem to be lacking here are those about *relations between relations* and *relations inbetween levels*.

From a different viewpoint, M. BUNGE writes: “Some systems theorists believe that systemics belongs in mathematics. I submit that this opinion is mistaken, because, unlike pure mathematics, systemics is about real things. (Systemics has a mathematical formalism but a factual content). Others seem to believe that systemics is a mushy popular philosophy, rehashed romantic talk about unanalyzable wholes. This opinion too is mistaken, because systemics, unlike holism, analyzes systems, and furthermore it does so with the help of mathematics — a *bête noire* of all romantics” (1979, p.221).

It should be observed however that systemics uses evermore new mathematical tools of, at least, a partially qualitative character. [François 1997, p. 354]

I observe that most novices find Ackoff’s description of systems thinking easier. It’s easy to challenge someone who claims to be a systems thinker, but demonstrates analysis before synthesis. Angyal’s writing — which might be described as (i) part-to-part to (ii) subordinate whole — reflects the idea in a different way.

3. The development of the “systems sciences” historically correlates with the rise of the “social systems sciences” program at the University of Pennsylvania

The label “systems sciences” only has an etymology going back decades, not centuries. As a former president of the *Operations Research Society of America* in 1956 (<http://www.informs.org/About-INFORMS/History-and-Traditions/Miser-Harris-Presidential-Portrait-Gallery/Russel-Ackoff>), Russell Ackoff described his dissatisfaction in the scope of the field in the *UK Operational Research Society’s Annual Conference* in 1978. Ackoff saw the need for a new (*Social*) *Systems Science*.

In the early 1970s, I persistently argued ... with the faculty in OR that I had assembled at the University of Pennsylvania. Despite three years' effort I was unable to convince them of the need for radical change. A minority of the faculty and I felt this need for change so deeply that we separated from the OR faculty and initiated a new graduate programme in what we called "Social Systems Sciences." This name was selected for three reasons. First, it was the only one we proposed that no other department of the University objected to, for obvious reasons. Second, we could not conceive of a profession, a discipline or a society using such an awkward name, and we wanted to preclude such use. Finally, it suggests, however vaguely, what we are about. Nevertheless, we would not have changed the name if we could have changed OR. [Ackoff 1979a, pp 103-104]

There's humour in ensuring that the phrase "Social Systems Science" was awkward. Applying the theory to the organization itself, the approach to the *Social Systems Sciences* program was described in a second article, later in 1979.

The S³ programme is a product of continuous idealized design by Professors Thomas Cowan. Peter Davis, James Emshoff, Hasan Ozbekhan. Thomas Saaty, Wladimir Sachs, Eric Trist, a large number of students and myself. The programme is far from ideal but it is ideal-seeking and subject to continuous experimental modification.

The programme was created to serve three purposes: first, to develop and transmit a body of knowledge that is responsive to the needs of all the stakeholders (including the upper levels of management) of public and private organizations; second, to develop and test new pedagogical procedures; and third, to experiment with and develop participative organizational structures.

The S³ programme addresses itself to four major concerns that I have already dealt with in this presentation. I review them only very briefly here. The first arises out of our belief that organizational and institutional problems are abstractions obtained by analyzing social reality. This reality consists of complex systems of interacting problems which, because they are systems, cannot be decomposed into separately treated problems without loss of their essential properties. Therefore, the programme addresses itself to developing and applying methodology for dealing holistically with systems of problems, messes.

Second, because of the widely recognized accelerating rate of technological and social change, social learning by experience is no longer good enough, and optimal solutions to problems are neither optimal nor remain whatever they are for long. Therefore, the programme examines the design of social systems that can *learn* and *adapt* rapidly. and that can cope more effectively with increasing complexity.

Third, because social systems are purposeful and their parts have purposes of their own, often in conflict with those of the systems, it has become increasingly apparent that the ability of such systems to perform effectively depends on their ability to serve better the purposes of their parts and to provide them with an improved quality of life within the system. This gives rise to the third problem about which the programme is concerned: the *humanization problem*: how to design, plan for and manage social systems so that they better serve the purposes of their parts and do so in such a way as promotes systemic objectives.

Fourth, social systems are parts of larger social and ecological systems. their environments. Each social system affects and is affected by its environment. Social systems are increasingly held responsible for their effects on their environments and on the other systems that share their

environments. This gives rise to the fourth problem, viz., the *environmentalization problem*: how to design and manage systems so that they better serve the larger systems of which they are part and the other parts of these systems, and do so in a way that promotes systemic objectives.

These four concerns are addressed jointly by an interdisciplinary faculty and student body. To avoid turning out graduates from a common mould, there are no prerequisites for entry into the programme other than a reasonable level of intelligence; but there are exit requirements to which I will return in a moment. The large variety of incoming students increases the opportunity they have of learning from each other. To increase this variety even more, each student is required to design his or her own program without being constrained by any required courses. Students can use anything offered anywhere in the University. However, they must defend their designs before the faculty, but their designs can be changed at any time, again with defense.

Consistent with systems thinking, the S³ programme is not made up of an aggregation of independently given and taken courses that leave the difficult task of their synthesis to be performed by the student alone. The principal instruments of education are *Learning* and *Research Cells* which are collective efforts at synthesis, not analysis. We find the students quite capable of independently acquiring the information and knowledge that needs to be synthesized. [Ackoff 1979b, pp. 197-198]

The *Society for General Systems Research* became the *International Society for the Systems Sciences* in 1988. Since Ackoff was president of the organization in 1987, the prehistory in Operations Research foreshadows an alternative (if not parallel) path.

This history can be compared to the encyclopedic entry on systems science (in the singular, rather than the plural). The criticisms of the phrase — in contrast to the concrete organization context in which Ackoff was forming a system — come from perspectives on systems and on science, particularly with “hard sciences” versus “social sciences”.

SYSTEMS SCIENCE

“That field of scientific inquiry whose objects of study are systems” (G. KLIR, 1993, p.27).

The word “science” has evoked a serious resistance among “hard” scientists, because of the very general and abstract meaning of “system”, the supposed object of inquiry.

Still less adequate seems to be the expression “systems ScienceS” (as it appears now in the official name of the “International Society for the Systems Sciences”), evoking a more or less unorganized ragbag of scattered disciplines, and encouraging systemists to seek “a politically correct shelter for their work under the umbrella or orthodox science” (D. Mc NEIL, 1993b).

This has been sensed by quite a number of “system scientists”, as for instance L TRONCALE, who considers this expression as merely “a collective non-specific term” ... and a questionable use or the term “science” similar to that found in “social science” (1984, p.45).

KLIR himself adds: “Unfortunately, this definition, which appears reasonable on the surface, only begs the question. To make it operational, and thus useful, we have to establish some broad and generally acceptable characteristics of the concept of a system.”(Ibid). The whole of this KLIR’s paper on the subject is dedicated to a “guided tour” of this difficult task and can be used as an introduction to the subject.

Some interesting statements by KLIR:

“Classical science, which is predominantly oriented to thinghood properties, and systems science, which is predominantly oriented to systemhood properties, are two distinct perspectives from which scientific inquiry can be approached. These perspectives are complementary. Although classical scientific inquiries are almost never devoid of issues involving systemhood properties, these issues are not of primary interest to classical science and have been handled in an opportunistic, ad hoc fashion While the systems perspective was not essential when science dealt with simple systems, its significance increases with growing complexity of systems in our current interest’ (p.28-29).

On the role of the computer in relation to “systems science”, KLIR states: “The computer has, in fact, a dual role in systems science. In one of the roles, it is a methodological tool for dealing with systems problems. In the other role, it serves as a laboratory for experimenting with systems” (p.38).

(This last aspect is now becoming very significant in the field of artificial life).

KLIR also states that the study of “systemhood” starts with the development of “... a comprehensive conceptual framework by which the whole spectrum of conceivable systems is divided into significant categories. The second step is to study the individual categories of systems and their relationships, and to organize the categories in a coherent whole. The third step is to study systems problems that emerge from the underlying set of organized systems categories. Finally, we address methodological issues regarding the various types of systems problems” (p.38).

“Simplification methods are crucial for dealing with phenomena of organized complexity. Since organized complexity is the prime territory of systems science, these methods play a key role...” (p.47).

F. HEYLIGHEN states: ‘Systems science (including cybernetics) is not a traditional discipline concerned with the study of a particular domain, but a meta-discipline, concerned with the domain-independent modelling of general systems (van GIGCH). As such, it does not aim to find the one true representation for a given type of systems (e.g., physical, chemical or biological systems) but to formulate general principles about how different representations or different systems can be constructed so as to be effective in problem solving” (1990a, p.423).

Should there be *systems scientists*? G. KLIR so believes: “The role of developing and applying the systemhood expertise must be undertaken by a scientist of a different kind, a *systems scientist*, whose specialization is this very expertise” (1991, p.23). This seems at the same time correct and doubtful. It is correct because we undoubtedly need people able to understand, explain and, in many cases, manage complex systems. A systemic formation should be a very general feature or knowledge acquisition. This explains however why the idea could be questioned: If systems science becomes an academic specialty, it could promptly be relegated in some more or less secluded academic cloister and become lost for the millions who really need it.

Systems science is a meta- or trans-discipline (on possibly better, a meta-methodology) for everybody and should not be simply *reduced* to a discipline status, even when and where it must be taught. In KLIR’s words: “Systems science has also its own methodologies, which I view as a coherent collection of methods for dealing with those types of systems problems that emanate from a particular conceptual framework. Furthermore, systems science has its own metamethodology. Its purpose is to determine characteristics of individual methods (such as computational complexity, performance, and range or applicability) and utilize these characteristics for selecting the right method for a given problem in a specific context.

“In spite of all its science-like characteristics, I argue ... that systems science is not a science in the ordinary sense, but rather a *new dimension in science*” (1991, p.352).

This has much to see with the future of Systems Science, another subject widely tackled by KLIR (1991, p.185-90). On one hand, concepts, principles, methods and models — i.e. the scientific aspects — should be constantly extended in order to increase complexity understanding for practical and theoretical uses. On the other hand, a general strategy and tactics should be devised to bring systems knowledge to those who could benefit from it — i.e. the sociological and ethical aspects, in terms of the systemists responsibility.

According to G. ANDERSEN: “Systems science can be considered as a human evolutionary system with emergent properties — the structure of the components changes over time and new information is created out of this process” (1995, pers. comm.). [François 1997, p. 362]

So, approaching systems as a science has impacts on the definition of science — at least the classical definitions of science. There’s a spirit of not becoming a discipline, yet science traditionally has progressed along disciplinary lines.

4. The systems sciences have heritages in cybernetics and general systems theory

Few would debate that any definition of the systems science would have a heritage in cybernetics.

Cybernetics has a strong history of foundational work from the 1940s. The domain has been self-critical, and evolved from first order to second order.

CYBERNETICS

1) “The field of control and communication in the animal and the machine” (N. WIENER, 1948, p. 19).

N.WIENER’s original view is in fact quite mechanistic and corresponds to what became known as 1st Cybernetics or Cybernetics of the 1st order (The latter, including 2nd Cybernetics).

2) “The study of systems that are open to energy but closed to information and control — systems that are information tight” (W.R. ASHBY, 1956, p.5).

ASHBY’s view is quite close to WIENER’s. “Cybernetics deals with all forms of behavior insofar as they are regular, determinate or reproducible ... What cybernetics offers is the framework in which all individual machines may be ordered, related and understood” (p.2).

WIENER’s and in a lesser measure ASHBY’s viewpoint, have aroused considerable resistance in human sciences researchers.

ASHBY himself however also wrote: “Cybernetics treats, not things, but ways of behaving. It does not ask, “What is this thing?” but “what does it do?”.... It is thus essentially functional and behavioristic... The materiality is irrelevant, and so is the holding or not of the ordinary law of physics” (1956, p.1).

And, moreover: “The truth of cybernetics are not conditional on their being derived from some other branch of science. Cybernetics has its own foundations” (Ibid).

German cyberneticians, at least until 1970 preferred a quite formal view, as may be appreciated in the four following definitions by K. STEINBUCH, H. FRANK, F von CUBE and G. KLAUS:

3) “Science of informational structures in technical and non-technical domains” (basically concerned with data treatment) (STEINBUCH, 1955, p.325).

4) “The theory and technique of systems which transform messages” (FRANK, 1969, p.30).

5) “(the) mathematical and constructive treatment of general structural relations, functions and systems” (van CUBE, 1967, p 11-16)

6) “The theory of interconnectedness or possible dynamic structural self-regulated systems with their subsystems” (KLAUS, 1965).

The Russian cybernetician V.M. GLUSHKOV proposed in 1956 a quite similar technical concept of cybernetics:

7) “(the general theory of the transformation of information, and ... the theory and principles of building various transformers of information” (1966).

GLUSHKOV included in his book theories of algorithms, of discrete automata, of self-organizing systems and of mathematical logic. V.G. DROZIN observes that “... its contents overlap somewhat with that of Computer Science as taught in our country” (i.e. U.S.) (1976, p.30).

8) “Discipline which studies regulations and communication in the living beings and the man-built machines” (J. de ROSNAY, 1975, (p.93)

Quite significantly, de ROSNAY uses the word “regulation” in lieu of “control” used by WIENER. As a biologist he is more attuned to the non intentional aspect of regulation. This seems better if one remembers that many biologists, psychologists and sociologists reacted negatively to cybernetic “controls”, that they considered a mechanistic reductionism, apt moreover to induce possible manipulations of human (and animal) behavior.

On the other hand, de ROSNAY adds; “A more philosophical definition, proposed by L. COUFFIGNAL in 1955, views cybernetics as “the art to ensure efficacy in action”. The word “cybernetics” has been reinvented by WIENER in 1948, from the greek word “kubernetes”, which means pilot or steering wheel. One of the very first cybernetic mechanisms of velocity regulation in a steam machine, invented by James WATT and Matthew BOULTON in 1788, was called “governor” ... Cybernetics has thus the same root as “government”: the art of managing and leading highly complex systems. (Ibid).

From 1960 on, a less mechanistic view of cybernetics started to emerge, with St. BEER, G. PASK, H. von FOERSTER, M. MARUYAMA, H. MATURANA, and other researchers.

According to St. BEER: “... cybernetics studies the flow of information round a system, and the way in which this information is used by the system as a means of controlling itself: it does this for animate and inanimate systems indifferently. For cybernetics is an interdisciplinary science, owing as much to biology as to physics, as much to the study of the brain as to the study of computers, and owing also a great deal to the formal languages of science for providing tools with which the behaviour of all these systems can be objectively described” (1966, p.254).

One wonders if BEER would still in 1996 use the word “objectively”, since it is now generally admitted that scientific knowledge may sometimes be “falsified” (POPPER), and results or a consensual process through conversation (PASK). Of course and notwithstanding, we still can safely *postulate* the existence of an objective reality and all this does not impair the usefulness of the cybernetics’ models.

Further along BEER adds: “... cybernetics is precisely *about organization* — for this is the medium through which control is exercised. Therefore cybernetics may also be defined, as it has been by certain Russian writers as the science of effective organization” (Ibid., p.425).

In any case, BEER's view is not mechanistic "Cybernetics begins where the possibility of algorithmization of the controlled system ends" (Quoted by V.G. DROZIN, 1976, p.28).

According to K KRIFPENDORFF: "In cybernetics, theories tend to rest on four basic pillars: Variety, circularity, process and observation' (1986, p.20).

As stated by this author, variety is closely related to information, communication and control. Circularity is a necessary result of feedback, and leads to autopoiesis. Process is implied in feedback, communication, regulation and control, and observation is the basic condition for decision making and control.

Historical note: The word cybernetics was used for the first time by PLATO in the sense of "pilot's craft" or "the art of leading men". R. VALLEE states that, in 1834, the French physicist AMPERE used it in his "Essai sur la philosophie des sciences" to name the "study of the means of governing".

VALLEE adds: "In 1843, TRENTOWSKI did the same with the word *kibernetiki* in a book on management written in Polish", and still: "(W.S. McCULLOUGH) liked to put cybernetics under the aegis of DESCARTES who proposed in 1664, an interpretation of cybernetical type, involving feedback, within the framework of his theory of nervous transmission. On the contrary WIENER considered LEIBNIZ as the patron of cybernetics" (1993, p.84).

Other important precursors of cybernetics were the Russian BOGDANOV (1921), the Rumanian ODOBLEJA (1938), as well as W.CANNON (1932). The French biologist P. VENDRYES discovered independently the mechanisms of homeostasis and autonomy (1942).

In fact, the cybernetic model is implicit in numerous concepts and artefacts, since Antiquity.
[François 1997, pp. 90-91]

There are additional encyclopedic entries for *Cybernetics (First Order)*, *Cybernetics (First and Second Order)* and *Cybernetics (Technical)*. If cybernetics is one of the systems sciences, we should also see General Systems Theory as part of the systems sciences — although the question of singular and plural can arise at yet another level.

GENERAL SYSTEMS THEORY

A collection of concepts, models and laws referred to the nature and behavior of complex systems.

M. BUNGE observes: “Paradoxically enough, this is not a single theory but a whole set of theories — automata theory, linear systems theory, control theory, network theory, general Lagrangian dynamics, etc. — unified by a philosophical framework... We shall call systemics this set of theories that focus on the structural characteristics of systems and can therefore cross the largely artificial barriers between disciplines” (1979, p.1)

This compiler agrees with BUNGE and consequently, the term “systemics” is generally used in this dictionary in place of the expression “General Systems Theory”.

G.S.T. tries to respond to the need to research organized complexity and is complementary to the study of organized simplicity (starting with classical mechanics and inorganized complexity (as f. ex. classical statistical physics).

According to V. BLAUBERE, V.N. SADOVSKV and E.G. YUDIN, the main tasks of the General Systems Theory are as follows:

- “1. The definition of the “system” concept and all other concepts related to it
2. The classification of systems and the discovery of laws pertaining to systems in general and to special classes of systems.
3. The construction of models (of various degrees of generality) of system behavior (functioning, development).
4. The development of a special formal apparatus (logical and methodological Included) for the solution of problems indicated in (1)-(3) and for formulating the general theoretical foundations of special systems concepts such as the theory of control systems, the theory of automata and the theory of information systems” (1977, p.162).

Of course, these very basic tasks should be constantly sustained and validated by the observation and study of the numerous objects that may be conceived and modeled as systems.

The cited authors add the following comment (by M. MESAROVIC, 1954, p.4,5): “General Systems Theory, as a theory of general models must encompass the specific theories concerned with the more restrictive types of models; e.g. the theory of linear systems, theory of Markov systems, etc. GST also unifies the theories of different aspects of system behavior such as communication, control, adaptation, learning, self-organization, theory of computing and algorithms, etc.”

“Accordingly, the greatest difficulty in constructing a general systems theory, in MESAROVIC’s view is “to find the proper level of abstraction” (BLAUBERG et al, p.166).

Possibly, we should work on different levels in order to define in every case the most properly adjusted one. [François 1997, pp. 151-152]

There’s an entry in the encyclopedia just on the history of General Systems Theory, as well as its mathematical aspects. General Systems Theory can be differentiated from the General Systems of Theory.

The encyclopedia includes a perspective on cybernetics, and its relationship to General Systems Theory.

CYBERNETICS (The scope of)

G. PASK formulated the following opinions about the scope of cybernetics:

“... though I can see the difference between cybernetics, General Systems Theory and Cognitive Information Science, I fail, completely, to see its practical significance unless a very specific piece of work is in mind; and, as a result of that, fail also to get in the least irritated if these terms are misapplied...

“I believe that Cybernetics (and the allied sciences) are peculiarly concerned with well formed analogies, the manipulation of metaphor and the epistemological / psychological / social problems that attend these pursuits.

“... Cybernetic theories comment upon these processes, which are excluded, strictly, from consideration by the run of other sciences, except when viewed from the special perspectives of metaphysics or of metamathematics.

“As a result, all Cybernetics theories are relativistic and some of the more interesting theories are also reflective (becoming “objective” only at specific points, where sharp valued independent measurement is possible). For example, with my psychological hat on, but still retaining a Cybernetic orientation, I insist upon *dealing* with consciousness, not *excluding* it (hence, with self-referential and other referential systems).

“... I am prone to regard the use of information measures and statistical accounts as only one (quite useful) way of dealing with the situation. Since such methods are apt to objectify the phenomena, I think they are somewhat overrated. The chief hazard, is the temptation to use appeals to “complexity” as an excuse for not tackling the real issue of “reflexive” theories and their interpretation.

“... Amongst the more important growing points are: a) Theory of reproductive automata... b) The theory of metagames”... c) Fuzzy logics and concurrent computation... d) Categorical algebras... e) Aspects of topology... able to accomodate or represent knowable relations and cultural patterns” (1973, p.5).

As to Artificial Intelligence, in PASK’s opinion: “Perhaps the subject should be called “General Intellect” instead of Artificial Intelligence” (Ibid). As early as 1973, PASK perceived that the process of teaming was of paramount importance and that it was not possible to limit the subject to the clever application of problem solving techniques” (Ibid).

According to F ROBB, general cybernetics includes:

- Conversation theory (G. PASK)
- Autopoiesis (MATURANA and VARELA)
- Deviation amplifying mutual causal processes (M. MARUYAMA) (see also 2nd cybernetics)
- Self-organizing systems (I. PRIGOGINE)
- Self-steering systems
- Meta-system theory (J. van Gigch) which ROBB considers as “much intermingled streams of cybernetic thought” (1989, p. 51).

Of course, none of these concepts and theory can ignore the original basic concepts of feedback, regulation and control. [François 1997, p. 91]

In a parallel entry, there's an entry from the perspective of General Systems Theory that looks as the association with cybernetics.

GENERAL SYSTEMS THEORY and Cybernetics

As observed quite early by L. von BERTALANFFY, General Systems Theory should not be confused with cybernetics in general. And still less so with WIENERS's much more limited in scope first cybernetics, strictly related to communication and control. There has however been a growing connection between the two subjects, specially since W.R. ASHBY's "Introduction to Cybernetics" (1956) and M MARUYAMA's "Mutual causality" as pattern generator (1963).

W. CANNON's homeostasis (1932) also is basically a cybernetic concept, while understandable only as a systems property. On the other hand, positive feedbacks tend to throw systems out of dynamic equilibrium and, as a result, they escape from the cybernetic mechanisms of regulation and control. Classical (i.e. 1st order) cybernetics could thus be evaluated as the province of the homeostatic systems.

von FOERSTER cybernetics of 2nd order as well as PASK's cybernetics of cognition and learning and, later on, MATURANA's autopoiesis, while having their roots in cybernetics, are in fact systemic theories.

G. KLIR, in turn, describes as follows the innovations introduced by G.S.T:

"1. A new way of looking at the world has evolved in which individual phenomena are viewed as inter-related rather than isolated and complexity has become a subject of interest

"2. Certain concepts, principles and methods have been shown not to depend on the specific nature of the phenomenon involved. These can be applied without any modification, in quite diverse areas of science, engineering, humanities and the arts, thus introducing links between classical disciplines and allowing the concepts, ideas, principles, models and methods developed in different disciplines to be shared.

"3. New possibilities (principles, paradigms, methods) for special disciplines have been discovered by making investigations on the general level" (1969, p.16).

In the first years of G.S.T. (and cybernetics), this was not so obvious. However during the last twenty years, or so, the conceptual "toolbox" has grown apace, specially in the mathematical field: Fuzzy logic, Theory of Catastrophes, Fractals, Percolation theory; but also from other sources: Dissipative structuration, Organizational closure, neural networks, etc... [François 1997, p. 152]

In practice, making distinctions about which concepts belong to cybernetics and which to general systems theory — and vice versa — is counter to the anti-disciplinary nature of both pursuits. The commonality of ideas across multiple perspectives should be seen as a strength.

5. Systems thinking and the systems sciences manifest as systems approaches

While systems thinking might be described an art, and the systems sciences as having more "scientific" attitude, the communities encouraging development of both tend to mix. The overall direction could be described as a "systems approach".

SYSTEMS APPROACH

In general

J. van GIGCH enumerates many different aspects of the systems approach, which “can be regarded as:

“A methodology of design

A common conceptual framework

A new kind of scientific method

A theory of organizations

Systems management

A method related to systems engineering, operations research, cost effectiveness. etc...

Applied General systems Theory“ (1978, p.34)

van GIGCH completes his overview establishing a taxonomy of sciences and systems, divided into “hard” and “soft” systems in physical, life, behavioral and social sciences (p.39).

Logical aspects

BLAUBERG, SAUDOVSKY and YUDIN consider that, from the logical viewpoint, “the development of systems research presupposes:

a) The construction of formal logical systems describing the process of reasoning as applied to certain aspects of the systems approach or special systems theories (e.g. the logic of relations, bio-logics, the logic of reflexive reasoning, etc...)

b) The formulation of the logical apparatus of the general systems theory

c) The metamathematical and metalogical analysis of systems formalisms” (1977, p.125).

Methodological aspects

According to the same authors, the methodological aspects of the systems approach “cover the following tasks:

“a) The explication (including the formal explication) of the basic concepts of the systemic approach, such as system, element, connection, structure, wholeness, part-whole relation, etc...

”b) The classification of systems, including the discussion and comparison of the various approaches to this problem

“c) The identification and analysis of the specific methods of systems research — the systemic (integral) representation of a system object, the investigation of a system together with its environment, the isomorphy of systems concepts and laws, systems analysis and synthesis, etc...

“d) The methods for constructing the theoretical knowledge of systems — both in the case of special systems concepts and in formulating a general systems theory (1977, p.125).

J. SUTHERLAND, from another viewpoint on methodology, proposed what he called the syncretic approach, “... to insure that the systems models we use comprehend to the fullest extent possible both qualitative and quantitative constructs” (Quoted from J.D. WHITE, 1977, p.68).

As to the basic nature and limits of the systemic approach, J.C. LUGAN writes: “The systemic approach consists in isolating a number of elements n . emphasizing certain types of relations that would give a degree of autonomy to the system in relation to a more extensive set N of elements.

“This global character of systemic modelization should not be understood as aiming at exhaustivity. To begin with only those properties considered as essential from the modelizer’s viewpoint are taken in account. The model can be enriched ... (but will never be complete). In other words, systemic modelization should tend to be an evolutive process, conscious of its limits between a kind of exhaustive perfectionism and an excessively reducing simplification (1993, p.24).

Psycho-sociological aspects

E. HERRSCHER writes: “The point can be made that the systems approach comprises both rational and non-rational elements. Particularly since soft systems thinking took the lead from the hard system approach, many social, political and psychological issues became more relevant, weakening the rational part of the rational/non-rational mix or, at least introducing (in the words of C FRANÇOIS) a psychical and sociological rationality, complementary to the hard systems approach. Few social scientists would object, but some quantitative or closed-model-oriented scientists might” (1995).

The systemic psycho-sociological rationality aspects are of different kinds:

- 1) The systemic inner and relational workings of societies, autopoiesis, conflict, hierarchies, interactions with the environment, networks, processes, side effects, stigmergy, subsystems, etc...
- 2) The ways these inner social workings translate into attitudes, situations and issues: values, norms, ideologies, prejudices, power relations, etc...
- 3) The ways the modelizer understand (or not) his/ her observer role and choices when modeling some social system, and perhaps his/her relationship with members of the latter who required the intervention. [François 1997, p. 357]

At this point, I think that I’ll give the descriptions on systems thinking, systems sciences and cybernetics a rest. Compiling the encyclopedia was a life’s work for Charles François. I’m happy to have it as a resource upon which I can lean.

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- 2016/12/09 09:15 Karin Knorr-Cetina, “The Technosphere of Finance: Three Transitions and then What?”, IFIP WG8.2 (<https://ingbrief.wordpress.com/2016/12/09/20161209-0915-karin-knorr-cetina-the-technosphere-of-finance-three-transitions-and-then-what-ifip-wg8-2/>)
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- Validated that @WebHostCanada online chat works at 2:30...
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- Service Platforms, Living Labs, The Future of Open Innovation | Henry Chesbrough | Sept. 2016 | Berkeley Exec Ed (web video) (<https://daviding.wordpress.com/2016/12/23/service-platforms-living-labs-the-future-of-open-innovation-henry-chesbrough/>)
- 2016/05/11 “Apache Open Tech is fueling tomorrow’s game changing innovations” | Todd Moore | ApacheCon North American 2016 (web video) (<https://daviding.wordpress.com/2016/08/07/20160511-apache-open-tech-is-fueling-tomorrows-game-changing-innovations-todd-moore-apachecon-north-american-2016-web-video/>)
- 2012/03/13 Tim O’Reilly interviewed by Andrew McAfee, “Creating More Value Than You Capture”, SXSW Interactive (<https://daviding.wordpress.com/2016/07/02/20120313-tim-oreilly-interviewed-by-andrew-mcafee-creating-more-value-than-your-capture-sxsw-interactive/>)
- Cognitive overload as business opportunity for IBM since 2005 | Ginni Rometty | June 1, 2016 | Code Conference (web video + audio) (<https://daviding.wordpress.com/2016/06/11/cognitive-overload-ibm/>)
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Roberts Library:

When the e-version isn't available, a quick trip to the library stacks works. University is still quiet after holiday season, yet there's still some people on computer terminals after 9 p.m. When I was an undergrad, I visited this section frequently. (Robarts Library, 11th floor, St. George Street, University of Toronto, Ontario) 20170103

01/04/17 (<http://davidng.tumblr.com/post/155372214479>)



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Nathan Phillips Square:

Afternoon traffic jam amongst skaters on the rink, while roads are empty and most businesses closed for New Year's Day. Pedestrian volume high in the Eaton Centre across the street, more browsers than buyers enjoying an indoor stroll. Temperature above freezing and sun encouraged bicycle ride, bundled up with winter wear. (Nathan Phillips Square, Queen Street West, Toronto, Ontario) 20170101

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Glorious Chinese Cuisine:

Family lunch, after sons returned from foreign travel, and before farther departs. Catching up on friends and families from afar. Lunch special of barbeque duck with dimsum, plus a noodle dish more than sated appetites. (Glorious Chinese Cuisine, Denison Street, Markham, Ontario) 20161231

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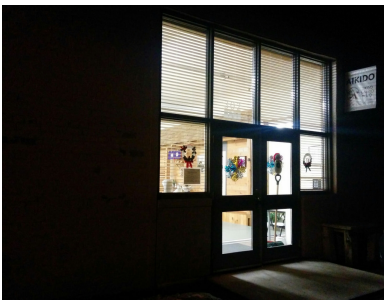


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Glorious Chinese Cuisine:

Fish in tank by entry of restaurant shouldn't expect a long future, with hundreds of lunch patrons inside. Saturday on a holiday weekend led us to choose a less popular venue, wait time was 10 minutes for a table for 7. (Glorious Chinese Cuisine, Denison Street, Markham, Ontario) 20161231

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Aikido Shugyo Dojo:

Adult basic martial arts class of one hour is long when it's one-to-one with senior instructor. Dojo remains true to posted hours during holiday season, even with regular class leaders away. Learned stretching, moving, then wrist locks. Many details to perfect over time. Had tried out dojo last spring, my attendance should more predictable over the next few months. (Aikido Shuygo Dojo, Carlaw Avenue, Leslieville, Toronto, Ontario) 20161229

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