

**International Encyclopedia  
of  
Systems and Cybernetics**



# **International Encyclopedia of Systems and Cybernetics**

2nd Edition

Charles FRANÇOIS  
Editor

**Part I**  
**A – Metron**

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## Introduction to the Second Edition

### The challenge to reason

The first edition of this Encyclopedia has been well received and, I dare hope, useful to those who took interest in it.

During the seven years after its appearance, so many events happened worldwide, that this kind of work can now be seen in a quite different light.

I never believed that it would concern only scholars and, among them only those not affected by specialized tunnel vision.

It has not of course reached Jane and John Citizen, at least not yet.

Their world, our own world, has been however violently shaken and deeply troubled by new challenges as well as by insidious but pervasive doubts about basic beliefs and even perhaps about the very survival of our species in the near future.

As stated by Bertrand RUSSELL (quoted by Sören BRIER): "The whole problem with the world is that fools and fanatics are always so certain of themselves, but wiser people so full of doubts". This is still truer today than it was when Russell was observing the confuse and confusing spectacle of mankind, i.e. until his disappearance in 1970.

Meanwhile the challenge to reason is worsening day by day. It is not merely its negation by the "fools and fanatics". As Stafford BEER pointed out, it has even more to see with the ill-informed, sloppy and/or devious use of reason itself. Moreover such a fake rationality is frequently put at the service of ill-conceived (and in cases, abusive) designs, proposals and decisions. Just to take an example, let us ponder the massive Aral Sea disaster. ("see site <http://www.dfd.dlr.de/app/land/aralsee/>)

We are evermore victims of what Jean FOURASTIE called "the ignorance of ignorance"(much worse than simple ignorance, as it leads to insolence and imprudence). In a similar way we sink into the swamps of "underconceptualization"(John WARFIELD)

### Personal musings on the systemic path

Now, how could Systems and Cybernetics be of any use about all this?

Of course, it could help to ward off the territories of ignorance and deepen the understanding of what happens, and why we are generally so helpless about it.

At least my own inquiry has brought me food for thought about a number of brand-hot present issues.

Only one example will do. I became in the recent years more and more interested in the so-called neural networks, as models for multi-

ple interactions among a great number of elements within a specific area of activity and in accordance with some rules of communication and action.

I quickly discovered that neural networks could help to transform analogies into models for very different kinds of situations. They better the understanding of insects societies, but also the propagation of epidemics (AIDS for example) using the complementary model of "small world". They better explain the progress of forest fires, or stock market crashes, or the swift diffusion of ideologies or fads, with the help of "memes". It makes clearer the changing world economy, or the workings of the world-wide electronic web.

It also changed the understanding of this editor about communication means and codes, be them pheromones, pathogens, money, electronic pulses or human languages.

Many other examples of this kind could be offered.

### The conceptual toolkit in perspective

In short, systems and cybernetic models, when organized into a coherent language, become an exceptionally valuable methodological toolkit for the study of any complex issue.

By the way, let us not anymore sink into the morass of controversy about so-called "theory of systems", what it is or not, what it should be or not. The topic is of course interesting, but it should not detract us from practical purposes, nor make us appear as abstruse and inconsequential.

As the spanish philosopher Ortega y Gasset once said, let us go to the "matters" ("a las cosas", i.e. to the issues at hand)

It is nevertheless also important to understand that systems thinking (and acting) introduces a new approach to the "matters" and is arguably the most significant conceptual mutation in Western thought, at least since Renaissance.

I tackled this subject in my 1997, 1998, 2002 and 2003 papers, in order to make clearer my own mind (and hopefully my readers minds) about the deeper meaning of this new way to manage our ideas and behavior.

In this sense, I am struck by some significant aspects:

- Systems thinking operates a general mental and psychological re-orientation (or "re-polarization") that implies a kind of impulsive self-reference about one's own way of thinking. This leads to the conscience of a conceptual implicate order (more or less in the sense of David BOHM's cosmic implicate order) in which the more specific "explicate" models create from specialized or discipli-

nary viewpoints, can be connected and put into a general perspective.

This is at least the feeling I acquired after more than 45 years of reflexion on the subject.

- In a parallel way, the "world out there"(of Heinz von FÖRSTER) has been massively transformed during the last 150 years through the impact of a more and more extended use of energy. Thousand of small, and more or less isolated communities and tens of supposedly "independent" nation-states are being forcefully connected within a "one world" in the making (as clearly seen already by Wendell WILLKIE, unsuccessful US presidential candidate in 1940.)

This is at the same time a "creative destruction" process (Joseph SCHUMPETER) and the emergence of a hyper-complex whole system through "dissipative structuration" (Ilya PRIGOGINE). Both aspects reflect a powerful new structural dynamics.

- Caught in the throes of such a dramatic transformation, human societies seem to suffer a kind of overpowering social pathology and are probably starting to undergo a groping immunological process somehow similar to the biological acquisition of antibodies.

- In my opinion the appearance of systems and cybernetics thinking during the 2<sup>nd</sup> half of the last century is an important- and possibly even one of the decisive events in this self-protection process. In fact, it is obvious that the ongoing deep and general transformation of man and societies evokes and tends to produce new ways of thinking and acting. Similar processes have been observed worldwide all along the historical evolution of societies and their cultures.

### The progress of systems thinking

A significant evolution during the 10 to 15 more recent years has been the nascent and/or growing interest in systems thinking in countries where it was practically unknown, or at least undeveloped.

In Europe for instance, very useful work has been produced in Belgium, the Czech Republic, Denmark, Finland, Greece, Poland, Russia, Slovenia and Switzerland, in addition to what is done since many years in Austria, France, Germany, Hungary, Italy, the Netherlands, Spain, Sweden and the United Kingdom.

Meanwhile Canada and the United States remain fully active.

Another very important development is presently taking place in China, Korea and Japan, where significant correspondances are discovered with the traditional oriental philosophies.

Latin America is also waking up. The oldest systems society, the argentinian, is now in good company with the active peruvian one and more informal groups in Brasil, Chile, Colombia, Mexico and Venezuela.

Signs of activity have also been registered in Australia, New Zealand and South Africa. In all these countries original work is produced and interest is growing.

In short, we seem to be on our way toward a worldwide awakening.

Now only Central and North Africa, the Middle East, Central Asia, India and Indonesia remain largely absent

The foregoing "stock taking" could indicate that we are slowly nearing the critical mass needed if systems and cybernetics were to be recognized as useful mental and practical tools.

### The Road ahead

Of course, we still need to fulfil some basic conditions before reaching such a stage in our progress.

1) Concepts and models must be translated into specific methodologies for design and action in administration, business, ecological and social issues, and politics. What has already been achieved must be diffused much wider.

The United Nations and specially UNESCO would have to play an active role in such translation and diffusion of the results.

Unesco already made a good start with the edition of the small but substancial books on education by Edgar MORIN and the publication of the "Encyclopedia of Life Support Systems" (EOLSS), whose conceptual foundation is systemic.

The Union of International Associations (Brussels) possibly could still expand its valuable Encyclopedia of World Problems and Resources, which structural organization is also quite systemic.

2- All that has been gathered until now in systemics and cybernetics must be transmitted to the new generations, who will need it still much more than their predecessors.

If this is not done, they would lose critical years to rediscover an already existing knowledge, ready for use, and on which they could start creative work of their own.

3- The already disponible information should be ordered and made available in more easy and convenient ways.

The quite limited diffusion of the systemic and cybernetic journals (some of which have even perished) is completely insufficient.

Much more should be done, particularly by creating a general repository of all existing past and present material. And of course, the www. should be used in a much more extensive (but precise) way.

Moreover, notwithstanding the fact that english is now the "lingua franca" of communication, the information needs of non-english speakers or readers should be taken care of.

As conversation and creative debate at all levels and places are essential, adequate basic material should be produced in the most important languages: arabic, chinese, french, german, italian, japanese, portuguese, russian and spanish. Ideally the list should also include bulgarian, hindi, hungarian, iranian, kiswahili, malay, polish, rumanian, turkish and urdu.

The International Federation for Systems Research (IFSR) could play an important role, helping those who would like to translate significant papers and books into their own language, or produce original information of general scope.

In this Encyclopedia's second edition, at least much more references in french, german, italian and other languages have been included.

But anyhow this will be useful only for those able to read this book in english, to begin with.

On the other hand, the inordinate proliferation of information and particularly doctored pseudo-information that characterizes our present time is now a problem in itself. Until-let us say- 1950 lack of information was the main hindrance.

On the contrary nowadays we are in danger to drown in a deluge of propaganda of the most various intentions, as well as proposed "good for all" models or pseudo-models offered by so-called "gurus".

From one side, our disponible time to gather information is strictly limited. We are thus obliged to select those inputs that are really significant and seem potentially useful to us. This is in itself a time consuming process.

We need also to adapt and readapt more and more frequently to shifting conditions in general and in our specific field of activity. As said by Gerrit BROEKSTRA, "no fit is forever". He could have added..."not even for long time".

### Conclusions

Accordingly, Systems thinking does not offer recipes for "solutions". What it proposes is a methodological approach that help us to conduce our thoughts in an ordered, renovated and more efficient way when confronted with new issues that are much more intricated and wide-embracing than even in a recent past.

In short, we must reconstruct our own mental and psychological competence if we are to assume efficient and personal responsibility in our behavior and decision making. If not, we would merely contribute to the growing general disorder and evermore turn into helpless social puppets. This is indeed also becoming true for the very puppeteers who believe that they all-pervasively control our strings. In fact we have frequently seen their power slowly eroded, if not suddenly destroyed by the unexpected reactions (for them!) of the social groups or systems that they fancied themselves to manage at will. This was the final fate of nearly all of the major political leaders during the last century.

As a conclusion, preparing this second edition has been for me a constant process of self-critical thinking. I had to evaluate in a recursive way what was significant, and how, and why, and applicable to what and when... and also what is connected to what else and in which stable or transient way. Moreover, integrating new ideas to the already existing material was frequently an arduous process.

Finally, the global result is again merely offered as "food for thought", but now also more intended as tools for reflexive and responsible intervention in better understood situations and issues.

I must once again tribute my gratitude to the many friends who helped me in a way or another to prepare this updating; to the valuable support of the International Federation for Systems Research, to my patient publisher, and once more to my wife Gloria in her triple quality of librarian, typist and generously understanding spouse.

Charles François, June 2004

## INTRODUCTION

"Socrates complained about writing. He felt it forced one to follow an argument rather than participate in it, and he disliked both its alienation and its persistence. He was unsettled by the idea that a manuscript traveled without the author, with whom no argument was possible. Worse, the author could die and never be talked away from the position taken in the writing" (Alan C. KAY, Sc. American, sept. 1991)

"It is the confusion of (the) different meanings that causes an intolerable babel ruling out any possibility of the strict explication of appropriate concepts. We believe that the way out lies in singling out that part of the content of these concepts which makes them specifically systemic ones, and in carrying out the necessary systematization on this basis" (I.BLAUBERG et al., 1977, p.287")

My first motive to start compiling a "Encyclopedia of Systemics and Cybernetics" has been grounded in my own doubts about various aspects of these new approaches, as reflected in the writings of numerous authors.

To begin with: Why did they appear and why did they so during the second half of this century?

We can perhaps go back to the founding fathers. Ludwig von BERTALANFFY was obviously wondering why very similar concepts and models were appearing independently in many different disciplines. And which was the basic nature, of such similarities? It seemed that some common substrate existed and, being this the case, that it could be useful for creating valuable synthesis and short-cuts in a number of disciplines.

BERTALANFFY never stated very clearly that all "systems" have in common their complexity, which is different and much more than complication, because it reflects some basic and coordinated types of internal organization and interesting similarities in the basic nature of external contexts, whatever their particular nature. He did however perceived these general features as the common basis for his inquiry.

As to Norbert WIENER - particularly inclined to mathematics and engineering - he observed the seemingly universal character of some specific relationships, that could be modeled through similar mechanisms in very different kinds of systems. He thus introduced feedback, leading to the basic notions of "Control and Communication in the Animal and the Machine". It became immediately clear that the feedback relation implied a closing loop, leading to nonlinearities and complex devices, that could be found in natural organisms or created to steer artifacts.

It is now confirmed that "complexity" is the master-concept. Emergence of complexity:

- 1) paralleled the emergence of a better perception of complex systems in nature (Living beings, ecosystems, animal societies) and man-made (in business, economical, social, political).
- 2) led to the dawn of our understanding of the intricate character of natural entities, either closely packed (a plant, an animal) or loosely interconnected (biota).

I have in this way been driven to the conclusion that Systemics and Cybernetics were interconnected and adaptive responses to complexity, either newly built in artefacts, or newly perceived in nature.

A serious problem for me, and probably for most of the would-be users of these new approaches has been the piecemeal appearance of numerous concepts and models, all somehow referred to complex entities, but in a haphazard and unconnected way. In effect, many systemic concepts have been elaborated under various guises and from different viewpoints by a number of systemists, or even by non-systemists. In some cases the correspondences are less than obvious, and many are probably yet to be discovered.

For example, as an afterthought, feedback seemed to be somehow related to dissipative structuration and hierarchies; variety to control; information to entropy; entropy to dissipative structuration; information to variety; etc... But these "somehow" should better be explained!

Many authors brought in numerous new notions, but it seemed to me quite difficult to find the significant linkages between them all. While, after all, a science of complexity must necessarily be complex itself, the crux of the matter is to discover a meaningful conceptual structure for the whole, if any.

Another very serious problem is that even nowadays, most self-styled "systemists" are interested in Systemics and(or) Cybernetics only within the limits of their own disciplinarian activity. This is understandable, but by doing so, they cut themselves out from the main and most important meanings of the new approach:

- a) a general understanding of their personal location within global science and global society;
- b) the emergence of a meta-language opening the real possibility for conversation, and most important, for true transdisciplinarian conversation.

Such metalanguage is now a much needed tool to compensate for the growing Tower of Babel syndrome which is a very unfortunate result of the evermore reduced and particularist scope

of an ever growing number of very specialized disciplines, whose increasing isolation was already denounced many years ago by Kenneth BOULDING.

It must however be recognized that the systemic movement still suffers from chronic un-systemism also denounced many years ago by Margaret MEAD, at the time President of the S.G.S.R. ("Who shall systemize the systemists?"). There exists practically no global overview of the whole field, even if some quite synthetic theories have been proposed (MILLER, HAKEN, SABELLI, Mc NEILL, for instance).

It seemed of utmost importance to try to put together a kind of encyclopedia about the systemic approach, embracing as much information as possible in order to:

- create an introductory compendium and source book for any interested newcomer
- put information until now widely scattered in time and space at disposal of seasoned systemists.
- open the field as a whole to comparative and creative debate.

Accordingly, the three basic aims of the encyclopedia are to define (when possible and useful); to comment and discuss; and to interconnect systemic and cybernetic concepts, models and meanings. This last aspect is properly the systemic one.

Practical realism has been another important motive to tackle this work. I had to see myself with many critical real life situations, including war, civil strife, decolonization, transcontinental emigration, authoritarian regimes, learning new languages and trades, enduring painful personal losses, etc...

I am also very much afraid that the present slide towards a general and worldwide crisis of civilization has still to reach its nadir - perhaps with a global ecological crisis in a still more or less distant future: 50, or 100 years?

Meanwhile, the present situation is characterized by a piecemeal approach to all complex situations, generally commanded by short-term political or economic expediency, if not downright by strictly limited personal goals (many times non-sancti). This is a trap from which escape will prove very difficult, and probably impossible without previous vastly-embracing "educative" catastrophes. If and when these occur, the short-term and narrow view will prove useless and the systemic understanding could become a decisive factor, if clear-minded and very courageous people happen to be at hand. Our present responsibility is to handle over "food for thought" to the new generations.

Accordingly, I feel it very important that systemics and cybernetics as a new "Weltanschauung" should as quickly as possible ex-

pand out of Academe. We - i.e. all of us - will evermore need good models of complex situations, that cannot anymore be understood, evaluated and amended by the exclusive use of our present linear and reductionist models. Some examples of such situations are: underdevelopment; the universal squandering of resources; the worldwide spread of unemployment; the hothouse effect; the new paludism and tuberculosis crisis and the AIDS one; the general ageing of populations; the growing cost of technified science, particularly medicine; the ethics of genetic engineering; etc, etc...

Accordingly, this encyclopedia also aims at transmitting systemic-cybernetic models and concepts to Jane and John Citizen, who need them urgently, and most of all to their children and children's children, who are going to inherit our blunders and our sins.

Consequently, I am impatient with esoterism in Systemics and Cybernetics. We need to be understandable if we want our models and methods to reach the decision makers who really could use them and probably will need them urgently in the coming years. They specially include spiritual and institutional leaders, managers, politicians, and educators.

I thus personally deplore the multiplication of terminology derived from the old Greek language: "Autopoiesis", "Homeostasis", "Isomorphy", "Stigmergy" and the like, which could have perfectly well been replaced with plain English wording: "Self-reproduction", "Stability within limits", "Total similarity", "Transmission through environmental context". Accordingly, I introduced and discussed such terms only because they bear real significance or are widely used as a kind of shorthand, while no plain English substitutes are known.

After 40 years of learning and thinking on systems, I still discover new aspects and insights into the systemic perspective. I have slowly reached the conclusion through personal experience that Systemics is the most important mental and psychical mutation since at least the Renaissance, and possible the Presocratic philosophers and, in a worldwide perspective, since Bouddhism, as a philosophy, and Chinese Confucianism and Taoism.

Also, after 60 years of being in four continents a more or less willing or unwilling actor and/or witness of this troubled finishing millenium, I must conclude that mankind is still far from the point where a sufficient number of people will acquire a reasonable non-magical and non-ideological understanding of the world they live in, even if general information and consciousness have very much progressed nearly everywhere since 1940.

Insofar as Systemics may further such understanding, and as much as my best ability will allow me, I feel a responsibility to cooperate to this progress.

## Personal limitations

This work has been prepared in Argentina by a French-speaking Belgian citizen, who never lived permanently in any English-speaking country. This implies some limitations... but also some advantages.

Nearly nowhere in South America is it possible to find any printed material on systems and cybernetics in English (and even in Spanish, very few translations are available). As a result, I depended basically on what I was able to find out for myself in Europe and the States, or on what important systemists leaders, or personal friends have been kind enough to supply me, as for example a photocopy of some specific out of print work!

As a former and now retired officer of the Belgian Foreign Service, I was also never a member of any university or college staff. Consequently, I had, and have still now, to cover personally all expenses related to Systemics and Cybernetics, as for instance subscriptions to journals (which are becoming evermore costly), participation to meetings, travels, etc. This has been a sometimes severe limitation.

While most of my sources are the original ones, I also had to rely on quotations, or on translations (for example from Russian), or even worse, retranslations, when the original was unavailable, out of print or out of my reach. This has been signaled in every case. I translated myself numerous quotations from French authors, as well as a lesser number of others from Dutch, German, Italian and Spanish. In every case, a considerable effort was made to reproduce the original meanings as best as possible.

Moreover, I am well aware that a given source may not be the original one, nor possibly the most up to date. I simply used either the best (in my opinion) to my knowledge, or the best one at hand. In some cases I did not return to the original authors, using instead some clear and synthetic summary by a recent author, who sometimes clarifies a subject better than the original author, who can be obscure or esoteric, or as Socrates feared, alas not anymore able to follow any "argument".

I did not introduce in the encyclopedia logical and mathematical formalisms for various reasons. The first one is that I do not feel really qualified to enter with any depth in this particular aspect of Systemics and Cybernetics. It is to be hoped that some other author will in a near future tackle the difficult task to gather and interconnect the works in this field by authors like LØFGREN, RENYI, VALLÉE, DUBOIS and many others.

There are also other reasons for not entering in formalisms:

- It seems more useful for the time being to try to explain the whole subject in terms understandable by lay people;

- It would be better for anybody interested in formalisms to go to the original sources, which I have tried to indicate in every opportunity.

## To whom this work is addressed

Paraphrasing POPPER on rational arguments, it could be said that people will not be moved by systemic arguments until they adopt a systemic attitude. This is of course a tall order.

It seems however decisive that any interested person should be able to find basic understandable information, collected in such a way as to avoid a very long and uncertain search in an enormous - but still probably quite incomplete - stack of scattered sources.

Accordingly, the general aim of the encyclopedia is to offer a tentative frame of reference for anyone interested. Anyhow, in Ernst JÜNGER words: "We cannot give *the* solution, as any solution is true only for who encountered it" (In his novel "Heliopolis", French translation, p.362).

Some items in the encyclopedia are quite elemental, others less so. As I see no reason why Systemics should remain restricted to higher level learning, my hope is that the work should even prove accessible at least partly at high school level for those young students who should become interested in the subject, or to any other intelligent person.

However, unfortunately but also inevitably, all that entered under the headings in the encyclopedia will not be immediately crystal clear for any user, even if great efforts have been made toward maximum transparency. Some notions are really difficult to grasp at the beginning. I myself needed many years to obtain a reasonable command of the whole subject, admittedly and partly because it slowly came of age during my own lifetime.

It is even possible that some concepts or models which presently appear to be significant could be seen as trivial or dubious in the future: in such kind of work, some risks must inevitably be taken.

## Basics: What does Systemics means

The really fundamental meaning and usefulness of Systemics is the acquisition of a new (but complementary) way to look more globally at the world, i.e. J. de ROSNAY's "Macroscope".

The mere use of some systems concepts or models applied to any specific situation is generally useful. But this should be only a very partial and insufficient response to the real challenge, which is the fabulous increase of complexity and the multiplication of complex situa-

tions that urgently demand a most global synthesis capability for understanding, forecasting, planning and coherent action.

Systemics, combined with Cybernetics, offers a holographic view of the real world, i.e. every systemic concept contains implicitly significant aspects of some or many other ones.

Only a more or less extended set of systemic models and/or concepts contains the essential of Systemics. However a start can be made through the serious pondering of any of them. Purely scholastic or reductionist exclusiveness is thus blocking systemic thinking and is anti-nomic to its essence.

Systemics implies a willingness to explore analogies and metaphors, in a critical but positive spirit. Many analogies and metaphors, specially most popular ones, reflects the perception by their users of some subjacent general rule, process or structure, worth of further inquiry. This is one reason why this work is more than a simple collection of definitions.

Donald McNEIL complains that, 45 years after von BERTALANFFY's first statements, we still have no General Systems Theory.

One critical question is precisely: Does a really all embracing General Systems Theory exist? And if not, should it? And under which guise?

My - different - purpose has been to create a kind of conceptual hologram of the whole field, as it is now. This is of course no General Systems Theory. However, looking at the hologram from any angle, systems concepts will appear in a connected way, revealing I hope, the general "skeleton" (in BOULDING's words) of which a genuine General Systems Theory could - or not - emerge and become clearly visible (see D. McNEIL, 1993b)

Another bone of contention is so-called "Systems Science". In John WARFIELD's words: "Unfortunately, there is a considerable confusion about what constitutes systems science, even among people who choose to identify themselves with systems-related areas" (in "Economy and Systems Science", 1990, p.67).

The encyclopedia does not pretend to rigorously define what "Systems Science(s)" is supposed to be, or not. It tries to collect as many as possible concepts and models related to complexity, most of which appeared in specialized disciplines without any clear a priori understanding of their general value. Examples are: Punctuated Equilibrium in paleontology; Stigmergy in entomology; or Hexagonal space filling in human establishments. Some of these are even now totally ignored by most systemists who, as a result, are unable to consider them as possible general models or concepts, fit to describe and, if possible, explain a number of situations in a number of different fields.

In any case, global or total knowledge is now impossible at the individual level. It should be replaced by as global as possible collective coherence in acquired knowledge, through conversation (which is in itself a systemic tool - G.PASK).

Outside her/his own professional specialization, a systemist is always treading a mine field when she/he refers her/himself to some really specific research. However, one of her/his most significant role is to create conceptual interrelations. This is not easy and, accordingly, one must more than once use prudent qualifications as for example "possibly", "probably", "could", "should", "seems to", etc...

This is the price to pay for advancing some speculations that may be stimulating and potentially useful.

Another point is that it is self-defeating, ill-advised and finally useless to try simply to convince specialists to become generalists. Specialists know best about their own work, which moreover is necessary and of utmost practical importance. This fact should be recognized once and for all, in order to eliminate a needless cause of controversy. The real point is to interconnect specialists and provide them with a meta-language or lingua franca in order to make them able to tackle *global* and *complex* situations, in collaboration with non specialized people, mainly managers, administrators and politicians, who also need systemic concepts and models in their own right.

The historical triumph of reductionism, manifest in our everyday life, led to a narrow technocracy, which tends regularly to micro quick fixes and empirical tinkering, or even brushing the problems under the carpet.

Many systemists should however share the blame, as their response has been too frequently a short-sighted, hostile and superficial critique of "reductionism". We should return to a 1984 paper in which L. TRONCALE established a list of performance criteria for "General Theory of Systems" (not "Theory of General Systems"), which unfortunately has been widely ignored.

From another perspective, it appeared to me with growing evidence that it is not possible to construct a systemic-cybernetic language without constant reference to the general conditions of existence of *any* language. This explains the presence and emphasis in the encyclopedia on semiotics (PEIRCE, ECO), general semantics (KORZYBSKI) and generally many psychological references to forms of learning; acquisition of meanings; to meanings of meanings and to their representations (WHITTHEAD, RUSSELL, BATESON, PIAGET, WATZLAWICK, von FOERSTER, von GLASERSFELD, etc.)

For similar reasons, systemic epistemology has been given wide attention, as it seems basic in order to stabilize Systemics as a scientific methodology. Accordingly, along the formerly

quoted authors, BUNGE, GÖDEL, van GIGCH, ROSEN, WARFIELD, and others have been given serious coverage, even if some of them are, or were, not specifically known as practican systemists.

Generally, the meaning of most of the formal mathematical and logical basements of systemics are still somewhat enigmatic. This is the case with fractals and self-similarities, cellular automata and self-reproduction, fuzziness, catastrophes, chaos, dissipative structuration, GÖDEL's incompleteness, BREMERMAN's limit, CHAITIN's algorithmic incompressibility, HEISENBERG's indeterminism, etc... As commented by John CASTI: "Ascertaining the exact nature of the relationship between a real world phenomenon and a mathematical model of that phenomenon is probably the most fundamental problem in theoretical science" (1984, p.282).

On the other hand, Systemics and Cybernetics are still widely in a state of flux. It is therefore difficult, and even possibly unsuitable at the time being, to fix them very well defined boundaries. As discovered by this compiler during his evaluation work, systemic-cybernetic semantics, epistemology and ontology are still in process of formation. Some concepts or models have somewhat fuzzy meanings (for example. "Preadaptation"). Some others seem to overlap (somewhat, or much). Some other ones are not, or not yet really general, or did not yet become fused with some other ones of general meaning ("Catabolism"?). These are good reasons to remain flexible.

One of the main aims of the work is to contribute to what John WARFIELD calls "referential transparency", here in Systemics and Cybernetics. This is no mean task, and I do not fancy to have it completed. However I have gathered a considerable number of elements that will probably be useful in order to come closer to transparency. In any case, a deeper understanding of some very important concepts, as for example those enounced by von NEUMANN, ASHBY, von FOERSTER, PRIGOGINE, MATURANA, to cite only some, is a must. The spirit of the work is to incite the user to go to the sources.

D. McNEIL rightly observed that an encyclopedia, specially an alphabetic one, cannot be a substitute to an integrated view of Systemics. This seems correct to me even if I tried to emphasize global views by cross-referencing and clustering. I hope that the present work could at least be a stepping stone:

- for those who want to acquire a basic understanding of the systemic approach;
- for anyone who would wish to attempt for her/himself LASZLO's "Great synthesis", i.e. not merely adding some specific view *on* systems.

My view is that the encyclopedia should be a linguistic and semantic system in the sense of de SAUSSURE: "An organized totality, made of

solidary elements, that can be defined only reciprocally in relation to their place in the totality". Only a frequent and critical use of such a language can produce a reasonable understanding of the ways meanings are interconnected or correlated.

Synthesis, as understood here is not a limiting or purely classifying one, but on the contrary, an open one, a multi-combinatory one. While the language as a whole acts as a global determinant, it allows also for a limitless open space for present and future variations: those produced by myself, and all those triggered in every user's mind.

In every case, I strenuously strived for clarity. No single quoted item entered the work without having been pondered. When necessary, comments and critique have been added, hoping to better the understanding of any notion that would possibly seem obscure for the reader. However, again, nothing can replace reference to the original authors.

Finally, I have tried to give a voice to as many people as possible, including many non-anglo-saxon authors, while still respecting the preeminence of the main concepts.

I tried also to interconnect various streams in the field by sometimes using information from less well known sources, as well as some frequently left aside because of language, or geographical, or simply diffusion problems. Examples are the Namur triennial International Congresses of the International Association of Cybernetics, or the works of the Systeem Groep Nederland.

## Conceptual contents

Before taking any decision about anything, we need to acquire an as good as possible knowledge of the system about whose future we want to decide, the conditions that may influence it, and have an idea of its possible futures. In P. ALLEN's words: "... the necessary precondition to a discussion of policy is to have a model", and such a model, as a rule, must be dynamic and nonlinear.

Accordingly, what *practically* matters in Systemics and Cybernetics is the combined use of concepts, analogies, homomorphies and isomorphies to construct complex models of concrete systems.

In consequence, I adopted a quite extended and many-sided view of the work's content.

Many not well known terms have been included, in accordance with the following criteria:

- that the term really introduces some significant systemic meaning, or at least some specific shade of meaning, for ex. H. PRAT's "aura", or P. GRASSÉ's "stigmergy";
- that it has been at least sometimes used in the literature, for ex. R. GERARD's "artorg" or L. TRONCALE's "discinym".

- that some significant relation to systemic situations could be found, as for ex. through G. CHAITIN's "algorithmic compressibility".

From another perspective, strictly speaking, a more or less limited systemic definition of "organization", for ex., could be given. However, many systemists offered complementary views on organization (ACKOFF, BEER, BOULDING, BROEKSTRA, LEMOIGNE, MILLER, SIMON, VAR-ELA, etc...) and this multi-dimensional perspective is so rich that it cannot be ignored in a work that tries to reflect as best as possible the wide content of Systemics.

It has also been taken into account that, between 1954 and 1997, a slow shift in systems terminology has taken place, as a commendable result of a progressive improvement of systems semantics, elimination of ambiguities, or even misleading uses of the original terminology: the differences between models of an isolated, a closed and an open system, or the precise meaning of "positive" feedback, are examples.

Some items of a seemingly very specific or specialized character have also been introduced (for example: "monoculture" - from Unesco-Unep Glossary) because of their general importance in systemic situations. On one side, this connects valuable information of special character to the mainstream of Systemics, with interesting generalizing possibilities. On the other hand, it may lead specialists to a better connected understanding of their own field.

Some terms were included:

- because it seemed useful to seek their meaning in the systemic perspective. This has been specially the case of some human sciences terms, like "ideology", "norm", or "value".
- as they seem to carry a potential for a general systemic meaning: "swarm", "symbiogenesis" or "Umweltlehre" are examples.
- mainly because they lead to a better understanding of the practical meaning and use of their *implicit* (and sometimes even enigmatic) systemic significance: "ethnocentrism", "parable of the boiled frog", or "Saint Matthews principle".
- for their practical value, as for example: "disasters: a systemic view", "patrimonial accounting", "perverse effects".
- because, while closely related to a specific discipline, their more general systemic nature, aspects or character are becoming more and more obvious: "anabolism", "autokinesis", or "catalysis".
- because of their relevance to Systemics for some particular reason: "Club of Rome", as a user of Systems Dynamics; "culture" as interpreted in systemic terms; "Dictyostelium discoideum", as a biological example of self-organization and sociogenesis.

A number of terms in the encyclopedia are related to para-systemic, or even anti-systemic views. They have been introduced for reasons of epistemological clarification, as it should be very difficult to understand some aspects of Systemics without the background of non-systemic situations or attitudes as "linearity", "reification" or "reductionism".

Some other terms have definite systemic and, simultaneously some non-systemic meanings, whose limits must be considered. An example is "memory".

A number of more or less technical terms were introduced because they are systemic in an implicit way or could be considered from a systemic viewpoint, even if many practitioners are working in a non-systemic style. Examples are: "research and development", "risk analysis", "sustainable development".

Some other terms, as for example "forecast", or "prospective", are used as stepping stones to define a systemic way of research and inquiry into the topic.

More items were incorporated, not so much for their intrinsic specialized interest (which may be considerable), but for their general systemic significance: "hysteresis", "Kondratiev cycle", "semiology", "thermodynamics", etc...

Considering their importance as modelization tools, logical and mathematical concepts related to Systemics have been presented, at least in general terms: "Boolean nets", "catastrophes", "chaos", "graphs", "KAM theorems", "neural nets", "topology", and others.

Superpositions in terminology have been discussed. Frequently different authors converge toward a systemic phenomenon through different ways. For example, the shaping of a system on a higher level of organization is termed by LASZLO as "emergence", by TURCHIN as "meta-system transition", by PRIGOGINE as "nucleation at bifurcation points through dissipative structuration", by researchers on networks as "spontaneous organization", etc... None of these concepts should be left out, as they give a kind of holographic view of various aspects of this type of phenomena. Even J. MILLER's taxonomy of living systems can be viewed as a photograph of the results of emergence.

Consequently, the encyclopedia is somewhat redundant, and intentionally so, as it is not possible to assimilate any systemic set of concepts without viewing these again and again from different but more or less interrelated viewpoints. It is hoped that this feature will help to the globally interconnected understanding of our subject as a coherent whole network of concepts and models.

Some users will possibly think - or even say or write - that this work is a very mixed bag. This may be true, but so is that hypercomplex world that we have constructed and in which we must live, using models and concepts as

different as the golden proportion, quanta theory, chaos, or organizational closure in perceptual and psychological terms.

Many examples are given, in order to avoid a purely abstract and theoretical character that could hinder the practical (and very much needed) uses of Systemics. In effect, as I believe that the systems approach and systems methodology are first rate tools to confront present and future complex challenges, I am critical of some tendencies that could exert a negative influence on their diffusion: excesses of superfluous abstract formalisms; exaggerated claims to a superficial universalism; unwarranted attacks against specialization; tendency to use jargon, etc...

A final caveat about the evaluation of concepts seems necessary. In my own comments, I have tried to avoid *loaded* adjectives like: "correct", "convenient", "desirable", "legitimate", "reasonable", "satisfying", "valid", and the like (or their opposites) as such notions correspond to implicit personal or socio-cultural criteria that may not be universally admitted. When quoted authors use such qualifications, which have been respected, their dubious character should always be remembered.

This is not to say that I believe in the practical possibility of absolute objectivity. But I would at least like that any user should stop in his/her tracks everytime these words appear, and think for a moment about their relative personal, social and cultural meaning.

## Linguistics and Semantics

We should now turn back to the Tower of Babel syndrome. As noted by John WARFIELD, establishing a satisfactory conceptual language has been in the past the condition for the success of many scientific disciplines. This was done for example by LAVOISIER for inorganic chemistry; KEKULE for organic chemistry; MENDEL and FISCHER for genetics; LEIBNIZ and BOOLE for logic; CRICK and WATSON for biochemistry; WEGENER for plate tectonics; and quite recently by PRIGOGINE for generalized thermodynamics.

Precisely, one of the problems of the systems movement is the persistently scattered character of its language, which has remained ill-connected, confuse and fragmented. Accordingly, the main objective of the present work is to correlate and unify the language of Systemics and Cybernetics, in order to transform it into an efficient tool for the study of complexity, for beginners as well as for advanced researchers.

Margaret BODEN writes: "The 'meaning' of an idea represented within a semantic net is a function of its place in the system" (1990, p.95). This is a very neat formulation of my own general concept of this encyclopedia as a network. Three aspects should be emphasized:

- Language is always a mirror for the mind and the culture. But it is not always a *faithful* one;
  - Every item has a potential for multiple linkages (TRONCALE), each of which adds - or restraints - some shade of meaning;
  - Semantics is also a process: the network becomes more useful and efficient when used.
- The encyclopedia offers a connectionist aspect, as it invites to "ramble" freely within the whole systemic and cybernetic conceptual space. It also proposes a constructivist way of use, as such a free rambling must normally lead to the progressive construction in the mind of any individual user of her/his own semantic net.

In a converging way, every concept becomes more like an attractor or the center of a semantic cluster, including what Margaret BODEN calls a "penumbra" of more or less closely related concepts (1990, p.96, 175).

There is some degree of redundancy in the whole of the work. This allows for a multidimensional view of these interconnected concepts. "Connection", for instance is not exactly or merely a "relationship". Moreover, it acquires a slightly different meaning in "connectionism" or in "connection machine". This is a useful feature to obtain a deeper understanding of the systemic language.

Some doubts should also be clearly stated.

A number of terms of frequent use have, in common language, a somewhat fuzzy character. Examples are: "action", "change", "class", "concept", "description", "effect", "learning", "object", "problem", "representation", or "situation".

These apparently quite universal and taken for granted terms should not be passed by without a short pause to remember that their meaning(s) should be pondered, as they can be less transparent than frequently believed.

In values - or norms- loaded words, there exists a kind of "semantic declination", comparable with the "magnetic" one. A non-systemic term like "democracy", for example means something quite variable according to countries and cultures. This may even be the case with a supposedly rational concept, as for example "order", or "organization". Here again we have a case for a reflexive pause.

Finally, I was not always convinced that some terms used by some systemists had really a systemic meaning. They could even in some cases be considered as contaminants in the systemic language. Not a few have however been included, generally with a critical evaluation, whose responsibility is assumed. The user should decide for her/himself.

In any case it seems better to remain open and tolerant.

I tried to alleviate as much as possible some practical linguistic problems.

In some cases, quotations from authors reproduce some combersome redaction. The original has always been reproduced without modifications, in order to strictly respect the authors work. Only in some serious cases have critical observations been made.

Most quotations are from the original texts. However in some infrequent cases, due to the unavailability of originals (out of print, out of reach), I had to retranslate to English from a translation in Spanish, French or German. This is not of course a very satisfactory method.

In some few cases, however, available original texts were not used because recent authors presented a specially clear and synthetic overview of a difficult concept. An example is K. DE GREENE crystal clear explanation of HAKEN's "order parameter" concept.

The whole work has been redacted in American English, with the exception of quotes from British or European authors, who may have used U.K. English, a feature that was respected. This is the reason why it is possible to find two different spellings in the encyclopedia, as for example "behaviour" or "behavior"

Jargon has been avoided as much as possible, as well as unnecessary (in my opinion!) abstractions: both act as a strong repellent against many potentially interested users. On the contrary, many examples and comments, some of them very close to popular common sense have been used.

## The fuzzy limits of the work

What should be included and what should be rejected in such a work? There are two complementary dangers: to be too tolerant with seemingly senseless or totally redundant terminology... or to be too intolerant.

This problem has already been encountered for example in relation to biological terms ("anabolism", etc...), introduced because of a possible generalization in systemic terms that could be duly established in the future. The same difficulty appears with terminology from artificial intelligence, computer science, ecology, ethology, expert systems, etc... Even some quite general notions, related to the not so rational way we sometimes assess issues and situations, mostly considered as "obvious", have been discussed, because of some new shades of meaning from a systemic viewpoint: "change", "choice", "cost", "efficiency", "goal", "object", for instance. Other similar cases have been considered above. In general, I preferred to err on the tolerant side.

Some more specific items have been included mainly to try a critical evaluation, (as for example R. SHELDRAKE's "morphic fields"), as they may have a systemic outlook, but are not (yet?) consensually accepted in the mainstream systemic thinking.

Furthermore, I suspect that some, or even many systemic concepts and models are still to be discovered. Some mechanisms, used in a specific discipline, could be possibly given a more general character. An example is "apoptosis", a general cellular mechanism of cell self-destruction, also present in the brain of Alzheimer's disease patients. Could such a mechanism be somehow active in other types of social networks? The "stigmergy" concept, introduced in this work, is obviously an example of such possible generalizations, that could be much more than metaphors.

Undoubtedly, much work remains to be done in many different directions; this explains why the encyclopedia is interspersed with question marks, an unexpected feature in such a work.

While I always tried to reproduce as fully and as faithfully as possible all authors views and concepts, it remains obvious that it is impossible within the limits of short articles or entries to express all the shades of meaning developed in a paper or in a book. Accordingly, every quoted item has been carefully referenced in order to allow and encourage the user to go to the source.

Basic information has been added on the main systemic organizations in the world.

## How the work is ordered and presented

The encyclopedia was constructed by progressive accretion, "reaping" terms corresponding to models and concepts from many and very different sources.

A curious result emerged spontaneously: a number of terms and expressions started to form clusters in the two following ways:

- "Blocks" of concepts corresponding to specific theories, as for example "Catastrophe theory", "Communication", "Thermodynamics of far-from-equilibrium systems", etc. At times some isolated elements came to accrue a cluster (or various ones): "Learning matrixes" obviously are related to learning, but they also introduce insights about the concept and uses of matrixes in general.
- Clusters tended to coalesce around some quite specific notion. Examples are "Control", or "Model".

While related entries are as much as possible clustered, they are not *fused*. It seemed more convenient to neatly individualize different aspects of the same concept in order to encourage due consideration of the corresponding shades of meaning.

Even so, the general ordering of terms remains somewhat arbitrary. For instance, abstract terms describing systems are all listed under "system", as for example "system, multilevel" or "system, stationary". But specific

concrete systems are at their corresponding alphabetic place as: "social system", "socio-technical system".

Generally, in composed expressions (as for example "circadian rhythm"), the alphabetic order chosen in the encyclopedia has been selected taking into account the meaning of the most specific term - in this case "circadian". However a reminder has been introduced at the corresponding place: "Rhythm, circadian".

The fact that such a work should in principle be alphabetic has some negative aspects, as for instance the need to separate items that are co-significant.

It would be advisable for the user to move "back and forth" (M. MARUYAMA, 1994, p.X), within the network of concepts and models in order to avoid unwarranted disconnections. While this may be difficult, the possibility has been created to criss-cross the whole work by using the net of terms printed in bold. It would be interesting in the future to consider a graphical representation of interconnections by linkage graphs (TRONCALE).

Nearly every term defined or concept explained in the encyclopedia is emphasized in bold types, *everytime* it is used. Some few exceptions are terms so basic and frequently used that the use of bold would be pointless: "Concept" "Cybernetics", "System", "Systemics".

The intention in using bold for general cross-referencing is double:

- That the user may know that she/he can find explanatory comments about the term within the work;
- To induce the user to stop and think for a moment when meeting anyone of these terms: "What is really the meaning, (or meanings) of "chaos", "cognition", or "regulation", for instance?"

When, in some cases, some connections between concepts or models are not so obvious, they are specially signaled by a comment of the type: See also "..."

Some terms with a specifically cybernetic or systemic meaning are also printed in bold when used in their everyday common sense, in order to sharpen the attention of the user to some shades of their meaning. examples are: content, class, issue, means, scale, situation, survival, etc...

The use of bold characters is not always closely related to a specific meaning of the emphasized term. The word "group" appears frequently with different significations, which may, or not, be related. In many cases it is useful to ponder the sense given in a specific case in comparison with what one knows about the various possible ones.

Some terms printed in bold do not refer precisely to a specific entry, but to a closely related one. For example: "Combination", or "environmental" are not in the encyclopedia, but "Combinatorics" and "environment" are.

Italics have been used moderately, mostly to emphasize some critical point, or some personal view. When within quotations, they are always the quoted author's ones.

References in Dutch, French, German, Italian, Portuguese and Spanish have been used. When possible, the reference to the original work, or alternately to its translation in English has been added.

The following special markers have been used, in order to enhance the usefulness of the encyclopedia:

- 1) **meaning** "systemic on a wide range", or "general information"
- 2) **meaning** "general abstract or mathematical model", or "methodology"
- 3) **meaning** "epistemological or ontological aspects", or "semantics"
- 4) **meaning** "practical in human sciences"
- 5) **meaning** "more specific or disciplinarian"

## Personal views, self-critique and acknowledgments

It seems only fair to admit that a number of personal views have been introduced in this work. For example: "The results of sociotechnical manipulation on any environment should be closely monitored", or: "Metacommunication frames relativize communication. This is a very significant situation, specially when metacommunication remains *implicit* as it is the case in many transcultural situations". No user is supposed to accept such opinions uncritically.

My aim has been to include practical insights into as many issues as possible. In my opinion, Systemics should be connected to complex *concrete* situations whenever possible, because many of their aspects are easily neglected by specialists and from purely technical viewpoints.

While, at a definite moment, one must decide to put a final stop to any work, it is obvious that this kind of work is open-ended. In a sense, this encyclopedia is still a kind of enormous draft, even if quite elaborated. This offers at once some negative and some positive aspects. In cases, sources could be completed or replaced by better ones. Many new information, and even some older one from still unused literature, could be introduced.

My intention is to go on incorporating more information into this work, even after publication, in order to prepare future updatings. I will gladly receive material or serious critique that users would find of possible interest.

On the other hand, being well advanced into my seventies, I would also be pleased to collaborate with quite younger systemists eventually interested in such updatings.

I consider probable that some internal discrepancies, or even errors may still be present in this final version, even after various painstaking revisions. I hope that users will find out for themselves and, hopefully, communicate me their views.

Aknowledgments are, in this case, a very difficult task. In a way, I feel thankful for the whole systemic-cybernetic community, past and present.

More to the point, this work owes much to the members of the Argentine Association for Systems and Cybernetics (or Study Group for Systems, as it is also known), to the members of the Fuschl Group, to the leaders of various international and national societies (American, Austrian, Belgian, British, Dutch, Danish, French, Greek, Italian, Peruvian, Polish, Slovenian, Spanish).

It also owes much to personal systemist friends, who I will not enumerate here because their names appear frequently within the encyclopedia... and because I would be very much afraid to unfairly forget some of them.

Last, but not least, I need to emphasize the considerable support given by my wife, Gloria NAZER, as a professional librarian and generally as a helping hand in readying the whole work.

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Spring 1997

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## A

0001

**ABDUCTION**<sup>3)</sup>

The invention of **concepts**, or logical and mathematical conjectures through the shaping of new hypothesis.

The notion – itself abductive – comes from C.S. PEIRCE, who applied it to new concepts emerging in our mind from witnessing unusual or unprecedented **situations** in which neither **induction** nor deduction can be used. J. WARFIELD stresses these differences. According to him, the origin of newly invented concepts remains a mystery. KOESTLER proposed **bisociation** as a **model** for this type of **creativity**, which like all other types is a product of neural and cerebral **networks activity**.

G. KLIR considers the computer as a valuable instrument in the abduction **process**, because it makes it easier to look “for regularities and developing thus empirical **support** for a mathematical conjecture. When the **support** becomes convincing, it is appropriate to try to prove the **conjecture formally**” (1991, p.103).

In fact, abduction precedes induction (and still more so, **deduction**). Ch S. PEIRCE observed that “induction has its role not in the forming of hypotheses, but (in certain **fields**) in testing the hypothesis arrived at by abductive inference” (as quoted by P.R. MASANI (1994, p. 45)

MASANI states for example that “statistical **inference** has to be abductive”(Ibid)

0002

**ABSTRACTION**<sup>2)</sup>

1) “A **representation** in a selected **code**, not directly reproducing the features of its **model**” (J.Z. YOUNG, 1978, p.289)

2) The search for regular **patterns** through **noise**.

As to the first definition, the “selected **code**” is of course a condition for the coherent search for **patterns**.

For G. KLIR, abstraction is: “The **isomorphic transformation** from an interpreted system into the corresponding **general system**” (1991, p.17). The *interpreted* system is already a somehow **homomorphic model** of some **concrete system**. Such **model** can then be generalized (p.73).

R. LILIENFELD quotes the Spanish philosopher J. MARIAS: “Abstract **truths** do not refer to reality, but to diagrammatic rendering of reality”... while “...thinking about the concrete... presents much greater difficulties” and “... disciplines like logic and the theory of **knowledge** would assume a very different appearance if they were to state their **problems**

in all their radicality and amplitude, so that the present forms of these disciplines would be reduced to mere chapters corresponding to particular cases” (MARIAS.1975, p.126-7, quoted in 1979, p.5).

**Fuzzy sets and deterministic chaos**, for example, now justifies MARIAS' views (which may have implied a critique of premature oversimplifications in social sciences) In the same vein A.G. BARTO observes: “The disposition to reify abstractions is particularly strong when abstractions have been very successful in accounting for **observations**, i.e when **models** based on such abstractions have successfully undergone extensive **validation** testing and have displayed great predictive power” (1978, p.167).

As **pattern-forming** is the progressive recognition of regularities, abstraction is an emergent **phenomenon**.

(See BERTALANFFY's comments on **categories** formation – (1962, p.71-84).

In G. KAMPIS words: “...abstraction narrows down interest from the entirety of a natural system to a *phenomenal domain*. During abstraction, usually some units of investigation are named and a **set** of observables is assigned to the natural system” (1989, p.90).

Abstraction cuts through **complexity** by selecting only some limitedly characterized aspects of the **concrete system** under study, specifically by reducing in the **model** its **degrees of freedom**. Keplerian and Newtonian mechanics, as compared with POINCARÉ's **three bodies problem**, are good examples.

G. BATESON explains thus our need for abstraction: “**Habit** can deal successfully only with propositions which have general or repetitive **truth**, and these are commonly of a relatively high order of abstraction” (1967, p.254).

The basic condition for abstraction is thus the repeated recognition of some identified **signal** in multiple circumstances (See KORZYBSKI's **structural differential**) (1950).

Abstraction can however become a conceptual quagmire: We should never forget WHITEHEAD's caveat about the risks conveyed by misplaced reification of abstract **models**.

Finally a mathematically inspired view on abstraction could also be useful: the replacement of a **set** by another with a diminished level of cardinality, this leads us again to KORZYBSKI's **structural differential** (see fig. under the corresponding article)

0003

**ACCESIBILITY**<sup>1)2)4)</sup>

The possibility to reach **more** or **less easily** a place in **space**, from another point or place.

Accessibility can be studied by **graphs** modelling the different positions and routes in a specified **space**.

B. HILLIER, who created what he calls “**space syntax**” as a general theory of the social **organization** of **space** (1996), uses it practically to create an accessibility **hierarchy**, for example for a better **organization** of urban **space**.

According to HILLIER, “People use **space** intuitively, much like they use **grammar**”. This is because they have a “preference for easy journeys” (M. HAMER, 1999).

The subject is closely related to **stigmergy**. This hints to a much more general **perception** of “**space syntax**” in animals.

0004

**ACCESS TIME**<sup>5)</sup>

The time needed to retrieve some item of **information** stored in a **data** bank or **network**.

J.von NEUMANN gave the two following definitions of access time in a computer:

“First: The time required to store a number which is already present in some other **part** of the **machine**... – removing the number that the **memory** organ may have been storing before”.

(Observe the dubious metaphorical use of the word “organ”).

“Second: the time required to “repeat” the number stored – upon “questioning – to another **part** of the **machine**” (1958, p.31).

Both types of access time may be different, according to the **processes** involved.

In the **brain** as well, recall **processes** are not instantaneous, as if some specific **channels** have to be retraced in each case.

→ **Time (Access) for a generalized meaning**.

0005

**ACCOMMODATION**<sup>1)</sup>

1. “A system's-**environment interaction** or **process** by which the **environment** satisfies the changing requirements of the system”. (B. BANATHY, 1973, p.85).

2. “A temporary or lasting modification of the **organism's structures** under the influence of external factors” (S. SALTHER, 1989, p.189-208).

These definitions are so different as to be somewhat contradictory. While B. BANATHY sees an **interaction**, SALTHER sees merely a **process** within the system. In the first case it is the system that governs the **process**, while in the second one, it is the **environment**. The **process** is probably *reciprocal*. Evolving **symbiosis** and **co-evolution** could be examples.

In any case, functional modifications are as important as structural ones.

On the other hand, accommodation relates to *individuals* and does not normally become fixed in the genetic type, as LAMARCK would have had it (had he known the existence of genes): accommodation acts *on* the basic type, but does not modify it.

Accommodation may however become lasting, i.e. lead to **assimilation**, i.e. it may turn into the basis of a permanent **adaptation** at the individual **level**. Later on, for example through ethological **adaptation**, this may become a factor of future **evolution**.

0006

**ACCRETION**<sup>2)</sup>

A **process** of **growth** by gradual **addition** of **elements**.

In general accretion is governed by some geometric **rule** or **rules** of **space** occupancy, as for example **clustering** by **fractal aggregation**, or **hexagonal space filling**.

In most cases it also results of **dissipative structuration**.

0007

**ACCUMULATION**<sup>1)</sup>

The **process** of piling up of some class of **elements** in a system due to a **positive feedback** in its **production**.

When this **process** turns exponential, for the lack of a countervailing **negative feedback**, it may easily destroy the affected system, as for example in **runaway population explosions**. This is due to a double cause:

- internal clogging of the system, whose **functions** become impaired, due to its excessive **density**;
- starvation of the **elements**, deprived of a sufficient **environmental flux** of **resources** to maintain themselves. The death of the starving **elements** within the system, poisons it.

0008

**ACCUMULATOR**<sup>1)</sup>

Any device capable of storing some kind of **resource**, creating an available **reserve**.

Stored **resources** can be energetic, material or informative.

Before **storage**, some other **agent** within the system must in most cases put the **resource** in a form suitable for storing. See: "**Input transducer**".

0009

**ACT of a system**<sup>1)</sup>

"A system **event** for the occurrence of which no **change** in the system's **environment** is either necessary or sufficient" (R.L. ACKOFF, 1972 a).

R.L. ACKOFF comments: "Acts, therefore, are self-determined **events**, **autonomous changes**. Internal **changes** – in the **states** of a system's **elements** – are both necessary and sufficient to bring about **action**. Much of the **behavior** of human beings is of this type, but

such **behavior** is not restricted to humans. A computer, for example, may have its **states** changed or change the **state** of its **environment** because of its own **program**" (Ibid).

Systems able to 'act' in this sense are **autonomous**, i.e.:

- in P. VENDRYES' terms, able to determine their own **behavior**, up to a point;
- in H. MATURANA and F. VARELA's terms, endowed with **organizational closure**, i. e. able to maintain their **identity** and internal **organization**.

0010

**ACTION**<sup>1)</sup>

H. SABELLI defines action as "the product of **energy** in **time**". He adds: "Action exhibits two **asymmetries**; the **energy** potential and the direction of **time**. All actions share the **time dimension**, but differ from each other in at least one (**space**) dimension" (In "**Organización: Estructuras, Sistemas y Procesos**", to be published in "Encyclopedia of Psychiatry", RUIZ ALARCON, 1994) (pers. comm.).

Already in the 17th and 18th Century various European mathematicians "showed that motion and **change** were always achieved in a way that minimizes the "action" of nature. This action is a measure of the momentum and velocity associated with a moving particle and can be generalized in the case of more **complex systems**" (F. DAVID PEAT, 1988, p.54).

This principle of **least action** has reappeared under different guises in various fields, as for example **ZIPF's least effort principle**.

It is related to the internal **organization** of **fields** of forces and with the consequent **structuration** of form.

0011

**ACTION AND REACTION**

→ **Le Chatelier Principle**

0012

**ACTION CHAIN**<sup>1)5)</sup>

A behavioral sequence triggered by an initial **stimulus** (see: N. Tinbergen, 1965)

Action chains are present already in **complex chemical reactions** (**Belousov-Zhabotinski reaction** is an example)

However, in order of growing **complexity** the following sequences may be given as examples:

In **Biology**: the fertilization act that triggers the creation of a new living being...and the subsequent **developmental process** (the **homeobox**)

In **Ecology**: the emission of biochemical molecules by a tree under attack of a parasite, such as the molecule acts as a **pheromone** that attracts a specific parasite of the parasite

In **Ethology**: the hormonal **stimulation** of birds in spring that triggers the whole sequence of nest building

In **Psychology**: the frustration reaction of someone unable to stage a strong reaction against some offense or aggression and substitutes it by some symbolic gesture (as for example banging a table)

Action chains should also be researched in sociology. They seem to be present in honey bees and in foraging ants for example.

The way the behavioral sequence becomes established and thereafter stabilized and transmitted through biochemical or other **mechanisms** should deserve a general inquiry.

Examples of such **mechanisms** are imprinting and innate **response**, but their **operation** is not yet clearly explained.

0013

**ACTION (Ecology of)**<sup>1)4)</sup>

According to E. MORIN, future is not absolutely conditioned by some supposed rigorous historical conditioning. This is a kind of generalized **uncertainty principle**, (1999, p. 65-66), a wide ( and even somewhat hyperbolic extension of Heisenberg's **Indeterminacy relation**).

As a result MORIN proposes two principles for an "ecology of action":

1- any action, once carried out, triggers an ongoing and very complex interplay of **interactions** and retroactions ( **feedbacks**) A similar idea was already emitted by LEIBNIZ (1646-1716)

2- the ultimate consequences of an action become finally unpredictable

→ **Predictability; Prospective; Surrogate world**

0014

**ACTION GRAPHS**<sup>4)</sup>

"Paper and pencil diagrams of interpersonal exchanges of **energy** (labor), **information** (about self and others, affection, entertainment, practical, social and intellectual skills) and **matter** (money and property)".

These **representations**, created by H. SABELLI, in his **process theory** are applied by him to psychology and psychiatry. ("**Chaos** and Society Conference" – Univ. du Quebec, Hull, Ottawa, 1994).

0015

**ACTION LEARNING**<sup>4)</sup>

"A personal development **programme** where a **group** of people learn by working on real problems interactively and autonomously by questioning and reflecting in order to gain insight and **understanding** and considering how to behave/act in future"(G.S. MWALUKO & T.B. RYAN, 2000, p. 396)

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

The authors paper is inspired by L. WEINSTEIN's work (1995) but they propose their own systemic method for implementation.

0016

**ACTION THEORY** <sup>2)4)</sup>

In 1970, D. SILVERMAN published a "Theory of organizations". M. JACKSON reproduces in an adapted form the "action theory" proposed by SILVERMAN, as resumed in seven propositions:

- 1- the social and natural sciences have entirely different types of subject matter
- 2- sociology is concerned with **understanding** action rather than observing **behavior**. Action derives from **meaning** attached to social reality
- 3- meanings derive from society, become institutionalized and can be experienced as social **facts**
- 4- while society defines man, man also defines society. Particular constellations of meaning have to be continually reaffirmed
- 5- through their **interactions** men can modify, change and transform social meanings
- 6- **explanations** of human actions must take account of the meanings of those involved in the social **construction** of reality
- 7- positivist explanations asserting that action is determined.

This is basically a non-mechanistic approach.

JACKSON observes that SILVERMAN's views are widely interpreted as an alternative, critical of **systems thinking**: "following SILVERMAN's lead (many **management** theorists)...explored phenomenological, ethnomethodological, marxist and, eventually, postmodern approaches to organizational **analysis** without recognizing that systems thinkers were engaged in a similar exploration in their own discipline, albeit with practical action as the primary concern (CHECKLAND 1994, GALLIERS, JACKSON and MINGERS, 1997). In return, it must be said, systems thinkers largely ignored what was going on in organization theory" (Ibid, p. 65-66)

→ **Autopoietic systems; Consensus; Conversation; Observer; Social system (Human); Social order parameters; Stigmery**

0017

**ACTIVATION ENERGY** <sup>1) - 2) - 5)</sup>

The energy needed to start a **reaction**.

This notion comes from chemistry: A certain minimum **energy** is needed to prime any **reaction**, which may then become self-maintained, or tend to come to a standstill, or run away as in an **explosion process**.

It would be interesting to explore **analogies** in ecology, economy and society. Many **processes** affecting systems in these domains seem to be **triggered** by some more or less

precisely definite **input of energy**. However it also seems that these **phenomena** are very poorly understood and that in some cases disasters may result.

→ "chain reaction", "enthalpy", "runaway process".

0018

**ACTIVATION (Forward)** <sup>2)</sup>

The effect of a **feedforward** on a system endowed with a **predictive model** of itself, its **environment**, or both.

In order to avoid any **paradox** about a supposed "influence of the future upon the present", the concepts of **anticipatory behavior**, **feedforward**, **preadaptation**, and **predictive model**, or **predictor** should be carefully pondered. (R. ROSEN, 1967, p.11-23)

0019

**ACTIVATION (Spreading)** <sup>2)</sup>

A **pattern of activity** in a **network** that propagates from the input side to the output side, producing a **response** to a **stimulus**.

This **process** takes place in local processing **nodes** inside the **network**.

0020

**ACTIVITY of a SYSTEM** <sup>1) - 2)</sup>

"The ensemble of the variations in **time** of all the quantities under consideration at the given **resolution level**" (G. KLIR, 1965, p.30).

G. KLIR points out: "The **time** interval of the activity is either the entire interval during which we observed the relevant quantities (in the experimental investigation of the system), or the interval in which the variations in **time** are given and are to be realized" (Ibid).

The **distinction** between **levels** – for instance **micro-**, **macro-**, or **megascopic** – corresponds to the fact that **actions** very limited in **space** and/or **time** (in relation to the defined **observation level**) are *generally* not significant at a higher **level**, because they normally lack the sufficient **range** to have an impact on **processes** of considerably greater **amplitude** and/or much longer **frequency**. It may however be difficult to be sure that any **action** or **event** at a given **level** is not going to make a great difference, as in **chaotic phenomena**.

Indeed, in the proximity of an **instability threshold**, a quite small **action** even at a lower **level** can trigger a decisive **discontinuity** or **bifurcation**.

These quite abstract **models** can seemingly be observed in **concrete systems**, for instance in some ants societies where distributed **processes of task allocations** by **roles** switching have been discovered by D.M GORDON (1995, p.50-7) This seems to take place by a reciprocal and collective needs **assessment** leading to the global activity of the system.

→ "**constructs (synchronous)**"

0021

**ACTIVITY PATTERN (Rhythmic)** <sup>2)4)</sup>

Rhythmic activity patterns can be observed in many natural **phenomena**. Some examples are: Oceanic **waves and tides**; plants **growth**; activity in beehives and, probably, some types of human activities.

According to B. COLE, "... isolated individuals and individuals in sparsely populated **groups** have a pattern of activity-inactivity that is described as **deterministic chaos**. This is not a **random** pattern, but one which is so complex that it is impossible for an **observer** to predict what a particular ant will do next" (in B. GOODWIN, 1998)

Such **complexity** must depend on the **interactions** among individuals, which become reciprocally constraining, but with considerable leeway due to their scattering and the differential **delays** in their reciprocal **perception**.

GOODWIN and colleagues did modelize ants **behavior** through a **neural network of cellular automata** (p.34).

They observed that the **output** of the **network** was **chaotic**. Moreover, "increased **density** of individuals increases the amount of activity by individual, simply because of the higher **frequency of stimulation** between individuals..."

So model ants, behaving chaotically and interacting 'socially' by **stimulation**, can generate a collective rhythm through a **colony**. This is a clear example of **emergent behavior**... " (p.34) And "... the **model** showed that there is in fact a wide **range** over which the **sensitivity** can vary and still produce collective rhythms. This suggests that rhythmic activity patterns are robust consequences of colonial living. They may in fact be hard to avoid. Collective rhythms is an **emergent property** that has been described as "**order for free**" (p.34).

This could be usefully compared with the onset and development of the "**social phase**" in **Dictyostelium discoideum**, and is probably significant in numerous other gregarization **phenomena**.

GOODWIN adds: "There is another important property of colonial rhythms that the **model** revealed. Rhythmic activity emerges suddenly above a **critical density**. But what type of **discontinuity** are we dealing with? The **model** showed that it has the characteristics of what physicists call a **phase transition**: a sudden **change of state** from one type of **order** to another... At the **critical density**, what was a collection of individuals doing their own local thing begins to change as global **order** emerges via activation **waves** that propagate through the entire **colony**" (p.35)

0022

**ACTUATION RULE** <sup>1) - 2)</sup>

A behavioral rule automatically learned from experience by an intelligent system.

This concept is introduced by W. FRITZ (pers. comm.). It corresponds to any **connection machine** able to produce **rules** by progressive **adjustment** and **reinforcement** of a specific **behavior** resulting from repeated similar experiences. A good example is the "NetTalk", an electronic **network** aiming at modelling the **brain's neural network**, which is able to learn to pronounce more and more correctly English words. (J. BRIGGS and F.D. PEAT, 1989)

According to FRITZ, this is also the way people acquire their capacity for organized **behavior**.

→ **Algorithm (Back propagation) and Algorithm (Framing)**.

0023

**ACTUATOR**<sup>2)</sup>

That **part** of the **regulator** which applies the corrective **action** on the **input**.

This term is used by some authors (for example J. MILSUM, 1968, p.41) in lieu of the more common "effector".

0024

**ADAPTABILITY**<sup>1)</sup>

The capacity of a system (particularly a living one) to **accomodate** its **behavior** to a great **variety** of **situations**.

N. RASHEVSKY observes: "A very important characteristic of an **organismic set** is that, while its **elements** can potentially exhibit a number of **activities** necessary for the preservation of (its) **elements** and of the **set**, in general only a **subset** of the **set** of all potentially possible **activities** is exhibited" (1967, p.22).

RASHEVSKY shows by a biological example that many possible **adaptations** remain latent if not needed, i.e. become actualized only if some **environmental stimulus** awakens them.

Consequently: "The wider the **range** of potentially possible **activities** of an **element** of an **organismic set**, the greater is the **variety** of **environments** in which this **organismic set** can survive" (Ibid)

This is in accordance with ASHBY's concept that only (internal) **variety** can destroy external **variety**.

It is also obvious that, in many **organisms**, if not in all of them, the full **range** of adaptability is never revealed.

On the other hand, as expressed by RASHEVSKY: "The adaptability may be very great but it is always limited. No **set** of genes, no multicellular **organism**, and no society can survive in every conceivable **environment**" (Ibid).

In any case, as observed by E. LASZLO, systems of high **complexity** trade **stability** for richness in adaptability (1972).

0025

**ADAPTABILITY (Hierarchically organized)**<sup>1)</sup>

In **complex systems** there are various **levels** of adaptability. In human **social systems** for example, local and specific **adaptations** can be made without **control** or **regulation** from more comprising **levels**, provided they remain within the established **tolerance limits**.

The advantages of such local **autonomies** are obvious, in terms of **resources** as well as **time availability**. It may even be a basic explanation of general **evolution** toward **complexity**, in accordance with SIMON's **Hora and Tempus** famous parable.

0026

**ADAPTATION**<sup>1)</sup>

"The process of accomodating to **change**" (UNESCO - UNEP, 1983, p.5)

K. KRIPPENDORFF distinguishes two kinds of adaptation: "a) **Darwinian** adaptation... (through which) **organisms** change their internal **structure** when their **environment** makes existing **forms** no longer viable... e.g. ASHBY's **homeostat**.

"b) **Singerian** adaptation, after SINGER, who described how **organisms**, particularly man, change the nature of their **environment** so as to eliminate threats to, or prevent the destruction of their own internal **organization**" (1986, p.1)

For M. BUNGE: "The word "adaptation" is ambiguous, as it designates at least three different **concepts**, namely the following:

"A1. **Suitability** of a **subsystem**... to a **function** or high value of the **subsystem** for the entire **organism**;

"A2. **Adjustement** of the **organism** to its **environment**

"A3. **Fertility** of a biopopulation" (1979, p. 104)

The three concepts could be easily generalized to **sociosystems** or **technosystems**.

If adaptation is considered a **state**, then the **concept** is tautological: any **organism** demonstrates merely by its actual presence that it is adapted. On the contrary, it should not be here.

Adaptation is not possible without a device that reduces the cost of **regulation**, by modifying the **constraints** within which the system must function in such a way as to reduce the **amplitude** of its **fluctuations**.

As a **process**, adaptation has been described by D.T. CAMPBELL as successive "increases of fit of systems to **environment**" (1960, p.380), through selective retention of blind **variation**.

There could be more to it, since a continuous **evolution** of the **environment** takes place precisely through the permanent **changes** brought about by the various adapting systems within it.

N. BOTNARIUC pointed out that : "Adaptation is a **population** or **species level process** (i.e. supraindividual **level**) and it is different in nature from adequacy; it is the result of the historical action of natural **selection**" (1966, p.97).

0027

**ADAPTATION and ADAPTABILITY**<sup>1) - 3)</sup>

1. Adaptation is a supposedly **stationary state** which implies a minimal **strain** between the system and its **environment**.

2. Adaptability is a permanent **process**, by which the system produces new adapted **states** whenever necessary.

W. KARGL explains it in the following way: "As **ontogenesis** must be understood as **drift** of structural **change** in **organisms** and in **environment**, there are no better or worse adaptation, but numerous possibilities for the **organisms' relations** with their **environment**" (1991, p.577).

Adaptation and adaptability are thus quite antinomic. A perfectly adapted system depends on the perfect **stability** of the **environment** to which it has adapted. If this adaptation is so absolute that it cannot be modified anymore, the system is in great danger of being destroyed, should its **environment** start to change. On the contrary, if it has maintained a potential for new adaptations (i.e. adaptability), it is generally able to respond successfully to new **changes** in its **environment**.

Adaptability "consumes" **redundancy** in order to produce successive adaptive **states**.

→ "**Order from noise principle**"

0028

**ADAPTATION by step functions**<sup>2)</sup>

L.von BERTALANFFY writes: "ASHBY's **model** for **adaptiveness** is, roughly that of **step functions** defining a system, that is, **functions** which, after a certain **critical value** is overstepped, jump into a new family of differential equations. This means that, having passed a **critical point** on its **trajectory**, the system starts off in a new way of **behavior**. Thus, by means of **step functions**, the system shows adaptive **behavior** by what the biologist would call **trial and error**: it tries different ways and **means**, and eventually settles down in a **field** where it does not come anymore in **conflict** with **critical values** of the **environment**" (1956, p.7).

ASHBY's **homeostat** is an electromagnetic **model** of this adaptation **mode**.

The adaptive capacity of any system thus depends on the existence, at least potentially, of this type of **step functions**. This **model** can be usefully compared with other concepts related to adaptation: **Requisite variety**, **Hypercycle**, **Organizational closure**, **Catastrophes**, **Bifurcation**, **Stability** in **topological** terms, etc...

<sup>1)</sup>general information<sup>2)</sup>methodology or model<sup>3)</sup>epistemology, ontology and semantics<sup>4)</sup>human sciences<sup>5)</sup>discipline oriented

0029

**ADAPTATION by ULTRASTABILITY**<sup>1)</sup>

A **complex system** will adapt to a given **environment** "by providing **second order feedbacks** that veto all **states of equilibrium**, except those that leave each essential **variable** within its proper **limits**".

Furthermore: "The **organism's reacting part** is itself divided into **subsystems** between which there is no direct **connection**. Each **subsystem** is assumed to have its own essential **variables** and **second order feedback**". (ASHBY, 1960, pp.208-209)

This concept is obviously akin to:

- 1.- Vendryes' **autonomy** by internal **regulations**
- 2.- Maturana and Varela's **organizational closure**
- 3.- Eigen and Schuster's **hypercycle**

An important remark by ASHBY is that "The **environment** is assumed to be **polystable**" (Ibid). Of course, no adaptation would be possible in a totally incoherent **environment**.

0030

**ADAPTATION (Cumulative)**<sup>3)</sup>

W.R. ASHBY demonstrates that: "...for the **accumulation** of adaptations to be possible, the system must not be fully **joined**" (1960, p.155)

This is a very important statement. It explains the reason why adaptation is, in some way **antagonistic** to **adaptability**. The **living system** needs a high degree of basic adaptation, which is obtained by **organizational closure** (related to a specific kind of **environment** and genetically shaped), which in turn limits **adaptability**. A very restrictive **organizational closure** implies that the system is strongly **joined**, as for example in the case of immunological rejection.

It could be also inferred that a high degree of **artificial intelligence** could be attained only by loosely **joined systems** of many **elements** and **subsystems**, which seems also to be the way the **brain** is organized.

0031

**ADAPTATION (Noogenetic)**<sup>4)</sup>

An adaptive ability proper to **human systems** able to understand specific adaptive needs and plan corresponding adaptive **modes**.

This notion has been derived from K. BOULDING: differentiation between biogenetic and noogenetic evolutionary **forms** (i.e. whose **evolution** is strongly influenced by their **brain**).

Noogenetic adaptation produces an acceleration of the **rhythm** of adaptation, which also explains the **evolutive acceleration** of mankind, that does not depend anymore merely on biological **change**. (F. MEYER, 1954, 1974)

0032

**ADAPTATION (Obstacles to)**<sup>1)2)</sup>

Some of the most significant obstacles to adaptation are:

- Difficulty to evaluate former **performance** due to:
  - a) incomplete **data**
  - b) poor **criteria** for defining positive or negative **performance**
  - c) difficulty to distinguish between different **causes** of poor or good **performance** (causal multidimensionality implying **nonlinearity**)
  - d) difficulty to distinguish between short, medium and long **trends in performance** (a poor **performance** can be a near **random short-term fluctuation** or a **symptom** of a deep seated problem)
- Difficulty to discover **elements** or conditions that may lead to a better **performance**, including difficulty to select the most useful ones
- Difficulty to distinguish and overcome negative factors that induce poor **performance**
- Difficulty to arbitrate **trade-offs** between desired but contradictory **performances** (speed versus capacity in a **network** of roads, for ex.)
- Difficulty to avoid future local **optima** that may become dead ends

0033

**ADAPTATION (Pre-)**

→ **Pre-adaptation**

0034

**ADAPTATION (Reciprocal)**<sup>1)</sup>

The **process** through which two or more systems or **populations** adapt to each other.

The systems must be compatible and more or less **complementary** in order to allow for a **process** of reciprocal adaptation.

For example, some plants, when attacked by a parasite, produce terpenes, which in turn attract parasites of the parasite. As a result, a global fluctuating **equilibrium** (even if frequently **chaotic**) tends to become established.

This **process** has been called "rivalrous adaptability" by H.G. BURGER, who sees it as a requirement for **complexity** (1967, p.211)

The **stability** of reciprocal adaptation can be altered among interacting **populations** if one of the partners starts to evolve. In such a case, reciprocal adaptation can still be maintained if the other partners succeed in turn in producing workable evolutive ways to respond to the **change**. We then have **co-evolution**.

0035

**ADAPTATION (Second level)**<sup>1)</sup>

In case of necessity a **long-term** adaptation may replace a **short-term** one. G. BATESON gives the example of high altitude acclimatiza-

tion, as a human being will after some time, replace panting and heart acceleration by complex physiological **changes**. This 2nd level adaptation is more permanent than the 1st level superficial **changes**.

BATESON calls this type of adaptation "defence in depth" (1973, p.321).

This kind of adaptation is somehow **hierarchical**, as thus explained by W.T. POWERS: "... lower-order **reference levels** become the **means** by which higher-order systems act; the higher systems freely adjust the lower-order **reference-levels**, to create the lower-order **elements** of **perception** which will result in the specified higher-order **perception**. This creates a **hierarchy** of adaptation" (1976, p.84)

Ethological examples are also known and it would be interesting to try to find cultural ones.

0036

**ADAPTATION (Serial)**<sup>1)</sup>

An adaptive **process** that follows a sequential **order**.

ASHBY, who introduced the notion, comments: "A great deal of **learning** occurs in this way. Mathematics, for instance, though too vast and intricate for one all-comprehending flash, can be mastered by stages. The stages have a natural articulation which must be respected if mastery is to be achieved" (1960, p.200).

ASHBY shows through other examples that serial adaptation is quite a general **pattern of behavior**.

0037

**ADAPTATION PLAN (Genetic)**<sup>2)</sup>

A naturally existing, or artificially installed plan for adaptation in a system..

The adaptive plan must respond to the following fundamental questions, as stated by J. HOLLAND:

"To what **parts** of the **environment** is the **organism** (system, **organization**) adapting?

How does the **environment** act upon the adapting **organism** ?

What **structures** are undergoing adaptation ?

What are the **mechanisms** of adaptation ?

What part of the history of its **interaction** with the **environment** does the **organism** **retain** ?

What **limits** are there to the **adaptive process** ?

How are the different hypotheses about **adaptive processes** to be compared ?

Moreover, as we attempt to answer these questions in different contexts, essentially the same obstacles to adaptation appear again and again. They appear with different names and

guises, but they have the same basic **structure**. For example, "**nonlinearity**", "false peak", and "**epistasis effect**" all designate versions of the same difficulty" (1992, p.2)

"False peak" is equivalent to "**local optimum**".

A general genetic adaptive plan may produce a number of different plans more precisely adapted to more specific conditions.

0038

**ADAPTEDNESS**<sup>1) - 3)</sup>

Good **adaptation**.

H. PATTEE discussed this ambiguous concept in the following way: "How do we go about determining adaptedness? If a species is well-adapted, does this mean that **selection** pressures are low and we should not expect rapid evolutionary **change**? Or is evolutionary **creativity** an important component of **adaptation**?" (1972, p.33)

In other words, which one is better adapted: the amoeba, which has survived changeless for hundreds of millions of years by cloning itself, or man, a rather more recent, complex and "efficient" being, but whose future **survival** is anybody's guess?

In PATTEE's opinion, different criteria of adaptedness should be used at different **levels of complexity**.

0039

**ADAPTIVE BEHAVIOR**<sup>1)</sup>

1. Any behavior that safeguards or enhances the **survival** ability of a **living system**.

2. "A form of behavior which maintains the essential **variables** within physiological **limits**". (W.R. ASHBY, 1960, p.58)

ASHBY starts with a sharp critique of the behavioristic concept of adaptive behavior: "The suggestion that an animal's behaviour is "adaptive" if the animal "responds correctly to a **stimulus**" may be rejected at once. First, it presupposes an **action** by an experimenter and therefore cannot be applied when the free-living **organism** and its **environment** affect each other reciprocally. Secondly, the definition provides no **meaning** for "correctly" unless it means "conforming to what the experimenter thinks the animal ought to do. Such a definition is useless".

Thereafter, he introduces the quoted definitions.

ASHBY's concept derives directly from Walter CANNON's **homeostasis** and indirectly from Claude BERNARD's "constancy of the inner **medium**".

Further along, ASHBY states "Adaptive behavior is equivalent to the behavior of a **stable** system (i.e. a system endowed with **dynamic stability**), the **region of stability** being the **region** of the **phase-space** in which all the es-

sential **variables** lie within their normal **limits**". (p.64). ASHBY proceeds by citing authors as diverse as STARLING, CANNON, PAVLOV and McDUGALL, who expressed much the same idea.

The individual adaptive behavior should be distinguished from the collective **adaptability** of a species, which is quite wider and in some cases at the expense of many individuals.

The concept should be extended to psychological and sociological behavior, even if these are very difficult to define in terms of measurable **variables**.

In more evolved **living systems**, adaptive behavior is obtained through **learning** or training. However, as stated by ASHBY: "The direct intervention of **consciousness** is evidently not necessary for adaptive **learning**" (1960, p.11)

One could argue that this is true only for **training**, if one considers training as non-conscious **learning**.

0040

**ADAPTIVE CHANGE**<sup>1)</sup>

According to G. BATESON: "Whatever the system, adaptive change depends upon **feedback loops**, be it provided by natural **selection** or those of individual **reinforcement**. In all cases, then, there must be a **trial and error process** and a **mechanism** of **comparison**. But **trial and error** must always involve **error**, and **error** is always biologically and/or psychically expensive. It follows therefore that adaptive change must always be **hierarchical**.

"There is needed not only that first-order **change** which suits the immediate **environmental** (or psychological) demand, but also **second-order changes** which will reduce the amount of **trial and error** needed to achieve the first-order **change**" (1973, p.245)

One wonders how this could be translated to cultural adaptive **change**. (A good case for research would be the shaping of the European Union)

0041

**ADAPTIVE PROCESS**<sup>1)</sup>

"The **process** whereby a (biological) system responds to its **environment** so as to adjust to the **constraints** of the **environment** and to take greater advantage of the environmental circumstances" (T.F.H. ALLEN & T.B. STARR, 1982, p.261)

Actually, the authors have defined "adaptation". in this way. However, "adaptation" would better describe some **state** at some instant. The global result of an adaptive **process** is a **sequence** of adaptive **states**, while the adaptive **process** mirrors the adaptive capacity of the system, i.e. its **adaptability**.

ALLEN & STARR coined their definition in relation to biological systems, but systems made of many **living systems**, especially human ones, are also adaptive.

0042

**ADAPTIVE PROCESS (Statistical)**<sup>2)</sup>

"A **process** in which the **chance** occurrence of appropriate or inappropriate **behavior** is positively or negatively **reinforced**, respectively" (A. H. KLOPF, 1972, p.59).

According to KLOPF: "Such a **mechanism** eventually produces a **network** that, to some degree, models the **organism** and the **environment**. As the **model** becomes increasingly refined, the statistical aspect of the adaptive **process** becomes less apparent and **behavior** appears more directed" (ibid.).

Using KLOPF's terminology, as well as ASHBY's, one may say that the **heterostat** tends towards the **homeostat** when its **behavior** tends to **stability**. On the other hand, they stabilize because any system must become **autopoietic**: its **coherence** can be maintained only if, in some defined **environment**, some types of **behavior** are either impossible, prohibited, strongly **constrained** or, on the contrary highly favored.

The system goes on, constructing progressively its own **algorithm**, by a **trial and error process**. Besides, it constructs this **algorithm** in a specific way, because it does not start from scratch, but from some **archetype**, which allows only for a pre-defined **repertory** of admissible **variations**.

0043

**ADAPTIVE SHIFT**<sup>1)</sup>

A **process** in a **population** through which individuals resistant to some destructive factor become gradually more numerous, while non-resistant individuals are eliminated.

This **process** had been observed already in the 19th century, for instance in a moth living on the bark of birches in England, adapting to the blackening of the colour of the bark due to industrial pollution and as a result of selection pressure exerted by predator birds.

The danger to produce similar **side-effects** by the use of insecticides or antibiotics, was signaled as early as 1953, but not heeded. Adaptive shifts have now produced the appearance of resistant **populations** of many insects and pathogens. The lesson has however not yet been learned, as shown for example by the dubious use of genetic engineering to create selective resistance to chemical killers in cultivated plants with the hope to selectively kill weeds, which supposedly could not acquire such resistance.

0044

**ADAPTIVE SYSTEMS (Basic characters of)<sup>1)</sup>**

To begin with, as observed by L.A. ZADEH, "... all systems are adaptive, and the real question is what they are adaptive to and to what extent" (in G. KLIR, 1991, p.143). Indeed, a non-adaptive system could not survive at all.

KLIR observes, furthermore, that even a **goal-oriented system** must maintain its **goals** within a **range** allowing for its own **survival**, "which implies that the (very) **goal-seeking element** must be capable of **adaptation**" (1991, p.149)

It is also difficult to conceive an adaptive system that should not be endowed with at least a modicum of **anticipatory behavior**.

A. WILDEN establishes the following list of characteristics of adaptive systems, inspired by M.C. MARNEY and N.M. SMITH (1964):

1. Auto-differentiation or **growth**
2. Characteristic **response**: A **response** or a **set** of possible **responses constrained** by the limited **semiotic liberty** of the system. This **response** could be modified at the "**learning to learn level**" and also by **evolution**
3. **Selectivity**: The capacity of distinguishing **stimuli information** from **noise**, the **form** from the **background**.
4. **Learning**: Capacity of modifying the characteristic **responses**
5. **Homeostasis**: **Synchronic stability** within **limits**
6. **Homeorhesis**: **Diachronic stability**, of first **order** also within **limits**.
7. **Redundancy**: Protection of the system against **random perturbations** (implied in 5 and 6).
8. **Memory**: The sine qua non of **communication**, depending of the clues.
9. **Simulation**: Some form of **behavior**, mediated by **memory**, application, reduction, **semiotics**, **language**, including the capacity of **reproduction**.

"This enumeration is not supposed to be absolutely complete, nor to establish ordered priorities among the mentioned characteristics" (WILDEN, 1972 ,p.61)

It may be objected that **homeostasis**, as well as **homeorhesis**, is **diachronic**, if one admits that the first word is synonym of **dynamic stability**. The difference between **homeostasis** and **homeorhesis** is that, while **homeorhesis** characterizes the **growth** period of the system, **homeostasis** is proper to its maturity (specially in biological systems), when the system only maintains, without wide modifications, its **structures** and **functions** within more or less narrow and invariable **limits**.

As to **redundancy**, it only protects the system if it can be used to enhance its **variety** or at least to reveal it.

0045

**ADAPTIVENESS<sup>1)</sup>**

"The ability of an individual or system to modify itself or its **environment**, when either has changed to the individual's or system's disadvantage, so as to regain at least some of its lost **efficiency**" (R.L. ACKOFF & F.E.EMERY 1972, p.124).

ACKOFF & EMERY write: "The definition of adaptive implies four types of **adaptation**:

- Other-other **adaptation**: an individual's or system's reacting or responding to an external **change** by modifying the **environment**;
- Other-self **adaptation**: an individual's or system's reacting or responding to an external **change** by modifying itself;
- Self-other **adaptation**: an individual's or system's reacting or responding to an internal **change** by modifying its **environment**;
- Self-self **adaptation**: an individual's or system's reacting or responding to an internal **change** by modifying itself"(Ibid)

0046

**ADAPTIVENESS (Limited)<sup>1) - 2)</sup>**

It stands out of ASHBY demonstration that "...for the accumulation of **adaptations** to be possible, the **system** must not be fully **joined** (1960, p.155)" that any further **adaptation** tends to increase the degree of "jointness" of the system, or in other words to increase **constraints**. As the system's **variety**, even if considerable, is limited, there seems to be a progressive increase of the defined possible **states** and a reduction of the potential for defining new ones, i.e. of adaptiveness.

In ASHBY's words: "**Adaptation** (we would say "adaptiveness")...demands not only the **integration** of related **activities**, but the **independence** of unrelated **activities**" (p.157)

0047

**ADDING JUNCTION<sup>2)</sup>**

The spot where two **energy flows** of similar type add up.(adapted from H. ODUM - 1971, p.39)

0048

**ADDITION<sup>2)</sup>**

"The **relation** of the joining of **parts** so as to increase their number" (J. FEIBLEMAN & J.W. FRIEND, 1969, p.33)

Only the **composite systems** seem to offer this extremely simple way of reunion and **growth**. Examples are the accumulation of grains of sand forming a dune under the action of wind, or the gathering of locusts changing from solitary to gregarious phase, or a reunion of many non-related people to attend some sport **event**.

0049

**ADENOSINE TRIPHOSPHATE (ATP)<sup>1)5)</sup>**

A rich energy-producing nucleotide (J. ECCLES, 1977, p. 233)

ATP's formula is C<sub>10</sub> H<sub>16</sub> N<sub>5</sub> O<sub>13</sub> P<sub>3</sub> and is an **energy** source in many **metabolic** reactions in living beings

ATP acts as a neuro-transmissor. Its action can be affected by Adenosine triphosphatase which is "an enzyme splitting of phosphate from ATP and so producing **energy**"(Ibid)

→ **Chemotaxis; Dictyostelium discoideum**

0050

**ADJUNCTION<sup>2)</sup>**

"Kind of **organization** whose governing **relation** is **symmetrical independence**" (J. FEIBLEMAN & J.W. FRIEND, 1969, p.36).

According to these authors, in this type of ordering: "**Parts** can survive their separation" (Ibid).

This corresponds to the case of **colonial systems**, or **colonies**. If, for some reason, the **links** between **elements** or **parts** become severed, each of them remains able to survive as an **autonomous** entity. Such is the case of the **elements** of a sponge, or the multiple clones in a **colony** of poplars, if the connecting roots are severed, or also in plants which propagate through rhizomes or stolons.

Starting from the adjunction mode of **organization** it is in principle possible to advance toward more **integration** or to return to **independence**.

0051

**ADJUSTER<sup>2)</sup>**

A system which is merely able to a limited degree to "hold its internal **variable** constant in spite of **changes** in the external **variable**".

G. BATESON, following C.L. PROSSER, proposes to distinguish **adjusters** and **regulators**, the latter ones being better able to maintain the **constancy** of their internal **medium** (Crf. Cl. BERNARD and P. VENDRYES).

BATESON gives the following examples: "... the homoiothermic animals are classified as **regulators** in regard to temperature while the poikilothermic are **adjusters**. The same **dichotomy** can be applied to aquatic animals according to how they handle internal and external osmotic pressure" (1973, p.331)

BATESON added to these two categories the **extraregulators** (like man), which are able, up to a point, to control and modify their **environment**.

0052

**ADJUSTMENT**<sup>2)</sup>

"A systems-**environment interaction** or **process** by which the system responds to the changing requirements of its **environment**". (B BANATHY, 1973, p.85)

Adjustments, according to B. BANATHY "are **changes** that a system brings about in order to modify its **behavior, structure** and characteristics so that it can produce improved system **outputs** or **system states**" (Ibid.)

The capability for making adjustments is the general condition for **adaptability** in any system.

Speed is a crucial factor in adjustment. N RASHEVSKY states: "...whenever any system is displaced from its **equilibrium configuration**, it always takes a finite **time** to reach that **equilibrium** again" (1967, p.72).

If the need for new adjustments appears before the first one has been completed, complex **effects** related to the **time lag** mechanism may introduce new **phenomena**, as for example **hysteresis**.

0053

**ADJUSTOR**<sup>2)</sup>

Device for potential **regulation** in a system built in such a way as to be able to take account of certain possible **variations** of the **environment** and to produce appropriate compensatory **behavior** of the system.

A. LOTKA introduced the idea in 1924 and constructed an experimental **model** in the guise of an artificial mechanical insect fitted with a pair of antennae which act as a spatial **sensor** at some distance (1956, p.341,382).

Such an artificial device throws light on the nature of adjustors in *natural* systems:

- The adjustor is *specific*. It is able to interpret some **data** of a certain **class**, as for example evaluate the **critical** distance away from some obstacle.
- It must be able, at least potentially, to use the **data** transmitted by **effectors** and **elaborators**.
- It must be able to carry out the needed comparisons between the captured **data** and the registered **norms** ... (for example maxima length, or maximum tolerable potential or weight)
- In view that its **action** aims at avoiding potential inadmissible **situations**, it evokes in our minds the illusion of intentionality.
- Its registered **norms** imply a **range** of possible futures, which gives us the illusion of (perfect) **predictability**.

One may conceive the need for adjustors of adjustors, for **coordination** of complex **behaviors**. Such a notion is very stimulating for the study of neuro-physiological **behavior**, as well as social **regulations** or **artificial organisms** "physiology" or "ethology".

The "timer" concept, introduced by Jessie MILLER is an important development of the adjustor's concept. (1990)

0054

**ADVANTAGE (EQUAL) PRINCIPLE**

→ **Boundary of equal advantage; Density (Optimal)**

0055

**AFFILIATION**<sup>1)4)</sup>

F. ROBB resumes as follows G. AHRNE's concept of affiliation (in his critique of this author's book in Syst. Practice and Action Res.12(3), p. 312):

"People are related (in **organizations**) by "affiliation", which is usually compulsory in the cases of kinship and citizenship and which is usually entered into by **choice** in other cases (i.e. in enterprises and voluntary **organizations**) "Affiliation allows access to certain material **resources** accumulated by the **organization** and it entails the **performance** of some more or less well-defined obligations.

Almost all goods...are owned and controlled by **organizations**. Hence, if people want to have access to anything more than the most simple goods, they have to join **organizations**, and promise to come back again.

"To become an "affiliate", you have to be admitted, perhaps by passing some test, and to be recognized by others in the organization as having a unique **identity**: but only an identity in relation to the **organization**. You have to exchange a loss of some **autonomy** for access to the **organization's** collective **resources** and power, you have to promise to submit to surveillance, recorded **control**, and coercion, and you must return to the **organization**. But all affiliates are substitutable, no one is indispensable to the viable **organization**"

While in this description affiliates are human, members of human **organizations**, it is obvious that affiliation is a feature in different forms of all **elements** of all types of systems, from **cells** in the living being to ants in the anthill. It is in fact a basic feature of **sociality**.

→ **Immunity**

0056

**AFFORDANCE**<sup>1)</sup>

The kinds of **behavior** the **environment** allows to a **living system**.

This concept is introduced by J.J. GIBSON (1986, p.36-37). A typical example is as follows: "A **path** affords pedestrian locomotion from one place to another, between the terrain features that prevent locomotion... (as) obstacles, barriers, water margins, and brinks (the edges of cliffs)" (p.36).

Affordance defines thus the **tolerance limits** of **constraints**. According to GIBSON, the concept derives from K. LEWIN's *Aufforderungscharakter* (i.e. invitation character). Affordance is obviously related to the **competence** of the user of the **environment**, who has to *learn* which **behavior** is affordable in different circumstances.

0057

**AFSCET**<sup>1)</sup>

Association Française de Science des Systèmes Cybernétiques, Cognitifs et Techniques

This french society organizes symposiums on a variety of scientific and social **issues** from a systemic or cybernetic viewpoint. Recent examples are: Integration du vivant au social (2003) and Evolution du vivant et du social (2002)

AFSCET also has specific interests groups, among them:

- Aspects systémiques du développement durable
- Intelligence artificielle et processus de décision
- Systémique et biologie
- Systémique et société

AFSCET publishes a journal: "Res-Systemica", which is sponsored by the Systems Science European Union. (<http://www.res-systemica.org>)

The web address of AFSCET is:  
<http://www.afscet.asso.fr>

0058

**AGEING**<sup>1)</sup>

Ageing could be understood as a **process** of **information** saturation in the system. As the system becomes more closely adapted, by the precise definition of evermore numerous internal **states** in **response** to external **noise** formerly assimilated, it seems to use up its **redundancy**. Thus, as it becomes better adapted, it also loses in a progressive way its potential for **adaptability** and its **thresholds** of **instability** become narrower, which implies a growing danger to cross one of them irreversibly and to destroy itself.

Ageing seems also related to **growth limits**. The system seems to become clogged with a growing number of **constrained interrelations** between **subsystems** and **elements**. It thus turns more rigid and less responsive to **disturbances** from its **environment**, until it reaches a **state of sclerosis**.

Altogether the system may become too voluminous, or overextended. In this case the **cost** of maintaining long and heavy **communication** lines becomes an additional burden.

<sup>1)</sup>general information   <sup>2)</sup>methodology or model   <sup>3)</sup>epistemology, ontology and semantics   <sup>4)</sup>human sciences   <sup>5)</sup>discipline oriented

Generally speaking, life is a **nonequilibrium process** submitted to the laws of **thermodynamics** and ageing is a disorganizing, or over-organizing **process** dominated by a growing difficulty to maintain a low internal **entropy**.

0059

**AGENCY**<sup>1)3)</sup>

"The degree to which a person believes he or she can chose and act freely"(W. McWHINNEY, 1995, p. 5)

McWHINNEY writes: "People vary in the degrees to which they recognize **free will**, that is, on how much they can personally and collectively control **behavior** in their **environments**" (Ibid p. 4)

For a better appreciation of this notion, see "**Autonomy**" and more precisely P. VENDRYES's (1908-1989) views.(1956 and 1981)

0060

**AGENT**<sup>1)</sup>

An active **element** in a multi-**elements system** or **network**.

J. ERCEAU and J. FERBER describe the following types of agents, at different **hierarchical levels** in the active multi-agents **system**:

- "**reactive agents**: these are at the lower **levels**. They merely dispose of a reduced **protocole** and **communication language** and ... their abilities rely only on a **stimulus/action rule**. The reactive agents **class** include various **levels**, according to their **group-forming** ability and capacity to produce global **behavior**;
- "**communicating agents**, which possess a complete **communication protocole**, but whose conversational and behavioral **parts** are **interdependent**;
- "**rational agents**, which possess precise abilities, beliefs and a partial **representation** of their **environment**, specially of the other agents within the system;
- "**intentional agents**, at the highest **level**, possessing explicit **goals**, specific plans which allow them to fulfill their **goals**, as well as the possibility to commit themselves to specific tasks, that they are obliged to carry out, or to contract other agents to execute certain **actions**". (1991, p.757-8)

This could be a stimulating **description** for a **model** of any society.

More recently, J. FERBER (1999) has given a much more precise definition of an agent:

Agent is a virtual or physical entity which:

- 1) is capable of acting in an **environment**
- 2) can communicate directly with other agents
- 3) is driven by a set of tendencies (in the form of individual **objectives** or of a satisfaction/survival **function** which it tries to optimize)
- 4) possesses **resources** of its own
- 5) is capable to perceive its **environment** (but up to a limited extent)

6) has only a partial representation of this **environment** (and perhaps none at all)

7) possesses skills and can offer services

8) may be able to reproduce itself

9) whose **behavior** tends towards satisfying its **objectives**, taking account of the **resources** and skills available to it and depending on its **perception**, its **representation** and the **communication** it receives

"Having the properties 1-9) an agent can be considered as an "intelligent system"(Ibid)

From this description N. SAFFARPOUR (2000, p. 75) deduces the following characteristics of agents

- Agents are **autonomous**, i.e. have **control** over their own actions
- Agents contain some level of intelligence, from **fixed rule** to **learning engine** that allows them to adapt to **change** in the **environment**

- Agents don't only act reactively, but sometimes also proactively and don't simply act in **response** to **environment**, in other words agents are **goal oriented**

- Agents have social ability, that is they communicate with the user, the system and other agents as required

- Agents may also cooperate with other agents to carry out more complex tasks that those they themselves can handle

- Agents may move from one system to another to access remote recourse or even to meet other agents

- Agents are adaptive, that is change their **behavior** based on previous experience

All these specifications are quite significant in a general sense, even if some terms used may seem ambiguous (as f. ex. "intelligence", "move from one system to another")

→ **Adaptability; Artificial life; Autonomy; Behavior (Anticipatory); Intelligence (Distributed artificial); Stigmergy; Swarm**

0061

**AGENT ( Meta- )**<sup>1)4)</sup>

"An agent who is capable of some sort of **meta-level** reasoning about the multi-agent **community**". (M. PECHOUCHEK et al., 2000, p. 659)

The authors state that the meta-agent neither controls the **community** nor serves as a **communication centre**". It is thus neither a **controller**, nor a "**black board**"

The authors distinguish two types of meta-agent's **activity**:

- static **observation**
- dynamic **observation**"

Through static **observation** the meta-agent obtains a "state of affairs" picture

By dynamic **observation**, it may predict for ex. an "approaching critical **overload** of an agent"(note: or possibly of the whole system)

On the other hand "from the point of view of the meta-agents impact on the **community** we distinguish two principal **roles**:

"- **Passive role**: the meta-agent does not influence the **community life-cycle**...it (merely) provides the user with the **information** on how the **community** evolves in **time**...The meta-agent playing a passive role does not have any means how to modify directly the multi-agent community.

"- **Active role**: the meta-agent affects directly some other-agents within the **community**. Here the meta-agent usually revises (by directly delivered **messages**) the local **knowledge** bases of the agents. The proper active role should be ensured by means of dynamic **observation**" (p. 659-60)

→ **Multi-agents system**

0062

**AGGLUTINATION**<sup>2)</sup>

Mode of **organization** governed by "**aseriality**, where **parts** have **intransitivity**, **connexity** and **symmetry**" (J. FEIBLEMAN & J.W. FRIEND, 1969, p.36)

This is the kind of **organization** proper to **composite systems**, whose **elements** gather or separate from each other without any **order**, are in direct contact and whose relative positions may vary in an indifferent way. Such are the case for example of flights of gregarious locusts, or human crowds.

The existence of such systems is simply a result of the global statistical **behavior** of the **elements**. Individual movements are however closely conditioned by some general characteristics of the **environment** as for example the prevailing winds, the **circadian rhythms** or some ideological polarization.

0063

**AGGREGATE**<sup>2)</sup>

"A compound thing , the **components** of which are not coupled, linked, connected, or bounded" (M. BUNGE, 1979, p.4).

BUNGE gives as examples a celestial constellation, or a **random** sample of a biological **population**.

The only significative character of aggregates is a certain localization in **space** and permanence in **time**.

C. ZELLER constructed some **models** in order to establish the conditions of **stability** of aggregates (1967, p.53-55). This author states, for instance, that, in the case of geometric **elements** in a plane, **stability** "... is reached when six neighbours are gathered around a base **element**". (See: "**Hexagonal space filling**")

It depends, besides, on the shape of the **elements**, on the **initial conditions** and, probably on the nature of the substrate.

The **relations** among **elements** are thus not *absolutely random*. The aggregate, when submitted to certain variations of its **environment** may offer a degree of collective **behavior** which may even become repetitious and correspond to characterized **processes**, as for example **directional growth**.

The theory of **criticality** studies the **behavior** of such typical aggregates as snow or sand banks or the characteristics of aggregative **phenomena** as bush and forest fires, mud slides or stock market panics.

According to A. ANGYAL "Wholes cannot be compared to additive aggregations at all...

"In aggregates is significant that the **parts** are added; in a system it is significant that the **parts** are arranged" (1969, p.26).

And, besides: "... aggregation and **whole** formation are **processes** of an entirely different **order**" (p.27)

It remains nevertheless true that aggregates seem in some cases to be the forerunner of **as-association** and **differentiation**.

According to V. KREMYANSKIY: "In **chaotic** aggregates, the **interconnections** between the **elements** are comparatively uniform, but they are particularly simple when a relative organizational simplicity typifies the **elements** themselves. The nature of the **elements** is not changed by entering or leaving the aggregate. Where there is a large number of **elements**, **changes** in the **chaotic whole** depend more on **changes** in many **elements** than on solitary or small **groups** of **elements**. The total of its internal **interconnections**, and hence the internal conditioning of the **changes**, bears a predominantly statistical or "probability" character". (1969, p.126-7)

Some authors use the term "**congeries**" (plural) as a substitute for aggregate.

0064

**AGGREGATION 1**<sup>1)</sup>

A progressive **process** of **interconnections** between formerly unconnected **elements** or systems.

Aggregation is related to the existence of a **critical distance** between the **elements**. The **process** takes place when **crowding** becomes such as to hinder the fully independent **relation** of each **element** with its proper **environment**.

A famous example of aggregation – in **living systems** – is the life **cycle** of the slime mold *Dictyostelium discoideum*. The growing proximity of the individual amoebas (due to a combination of **population explosive growth** and the exhaustion of food) induces reciprocal **perception** of biochemical products and gregarious reactions leading to social **behavior**, in accordance with H. PATTEE's **statistical closure**. Aggregation thus seems to be a **process** basic for the shaping of social **living systems**.

One wonders if the massive intercommunication **process** presently in progress between human **groups** does not herald global mankind aggregation in the same way.

0065

**AGGREGATION 2**<sup>2)</sup>

The compression of a **set of data** into less numerous units which presents their common properties.

The most radical aggregation mode is statistics, a powerful **variety reductor**.

H. SIMON notes that, in many **complex systems**, analysis is much simplified by the fact that the influences on each **element** of all other **elements** are organized in a simple way. This is because the anonymous character of the specific **interactions** leads to a very important simplification, not only of the global system, but also of the **functions** which describe the **component systems** (1990, p.138).

→ (SIMON's Hora and Tempus parable)

While such a simplification is very useful, it also may be altogether sometimes questionable, because it may imply (and generally does) a loss of **information**. Furthermore, it is the *observer* who decides the **level** of aggregation, in accordance with his/her specific interest (and personal **blindspots**). This **level** can be for instance micro- or macrophysical, chemical, biological or sociological.

Another difficulty has been signaled by K. KRIPPENDORFF: "Aggregation leads to misleading indicators and theories whenever the whole collection exhibits an *organization* not expressed in a mere **summation**" (1986, p.1)

In complex systems, aggregation of **data** may occult relevant **interrelations**... or even introduce imaginary ones, when the "common" properties result merely from a mere unconscious and unwarranted hypothesis. These distortions may occur, for example, in the construction of complex **computer models**, needed in **systems dynamics**.

This problem turns worse if the aggregated **variables** do not any more correspond to observable **state variables**, as for instance in the global aggregate called "pollution". J. MARTINO observes: "... the effect of pollution on **population** actually occurs as effects of specific pollutants on specific individuals" (1979, p.17).

0066

**AGGREGATION (DIFFUSION LIMITED)(DLA)**<sup>2)</sup>

A **fractal** aggregation type of **model** constructed on a computer, that starts with a single seed particle and grows to form a **cluster** by allowing tiny circular particles to attach themselves, one at a time (After I. STEWART, 1992, p.14).

STEWART explains: "Successive new particles move towards the **cluster** in a "random walk", a series of **random** motions in all directions often likened to the motion of a drunkard. Wherever the particles hit, they stuck" (Ibid).

**Clusters** thus obtained "... offer a "random fractal geometry"...difficult to characterize in analytic terms; that is no one has a way of predicting the **pattern** that will be generated, short of doing an experiment and observe the result... (However)... surprising regularities emerge from apparently unstructured DLA **clusters**" (Ibid).

Furthermore, the observed **fractal patterns** bear a great similarity with a number of natural **forms** as in electrodeposition of metals and in the **growth** of bacterial **colonies**. Some kind of **order**, related to **fractalization**, seems thus to emerge from **randomness**, and seems to govern the progressive occupation of **space** under partially undetermined conditions.

0067

**AGIL imperatives**<sup>1)</sup>

A mnemonic for remembering "the four imperatives that must be adequately fulfilled for a system by its **subsystems** if that system is to continue to exist" (M.C. JACKSON, 1992, p.46).

"The **meaning** of the terms that make up AGIL is as follows:

A. **Adaptation** – the system has to establish **relationships** between itself and its external **environment**

G. **Goal** attainment - **goals** have to be defined and **resources** mobilized and managed in pursuit of these **goals**

I. **Integration** – the system has to have a **means** of coordinating its efforts

L. **Latency** (or **pattern maintenance**) – the first three requisites for organizational **survival** have to be solved with the minimum of **strain** and **tension** by ensuring that organizational "actors" are motivated to act in the appropriate manner" (Ibid)

As mentioned by JACKSON, these four imperatives were originally stated by T. PARSONS and N.J. SMELSER.

0068

**AGONOMETRY**<sup>1) – 2)</sup>

"**Adaptability** through rivalry" (H.G. BURGER, 1967, p.209-22)

According to BURGER: "... all types of **evolution** are different in **structure** but similar in **process**. They consist of a rivalrous **polymorphism** that awaits **environmental change**. Up through the ethological **level** the **change** is **exogenous**, such as climatic. At the ethnic and intercultural **levels**, an additional type of **change** becomes available through **perception**" (p.209).

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

**Polymorphism** is equivalent to **variety**. As to rivalry, it should not necessarily bring about the elimination of the (presently) ill-fitted. They can remain in a minority position as a **variety store** until circumstances change.

BURGER applied his **concept** from biology to sociology and even **linguistics (polysemy)**. It never became widely recognized, possibly because of its "struggle for life" undertones, arguably more apparent than real.

0069

**AGONISTICS**<sup>3)</sup>

A general **model** of dialectical **antagonisms** in biological and **social systems**.

This concept has been proposed by the French physician E. BERNARD-WEIL (1975). It is related to **stresses** in systems due to **dissymmetries** and maladjustments. The author uses the bow and the string as a **metaphor**. He studies numerous examples of such **antagonisms** and proposes a mathematical formalism. He acknowledges the old sources of the **concept**, as can be found in ANAXIMANDER, HERACLITES and the Chinese **concept** of YING and YANG.

The connexion with **symmetry-breaking** is also obvious.

0070

**ALEATORY (or random) PHENOMENON**<sup>2)-3)</sup>

According to M. BELIS: "Aleatory phenomena present a subjective aspect related to the **observer** and an objective one, which corresponds with their own nature. The subjective aspect consists of the difficulty to know (by **observation** or by **measure**) the perturbing phenomena which exert some influence on the results of the **process**. The objective aspect is precisely the fact that the **process** can be influenced by infinitesimal variations of the **environmental** phenomena, i.e. that it is **unstable**. While perturbing phenomena generally also take place in **deterministic processes**, the **stability** of these latter makes them invulnerable to **perturbations**. A phenomenon is either **random** or not, independently of the presence of an **external observer**, but according to the **instability** or **stability** of the causal **connection** which determines it. As POINCARÉ did notice, the movement of the heavenly bodies is a **stable, deterministic phenomenon**, independently of the degree of any terrestrial **observers** ignorance, while dice throwing is aleatory because of the **instability** of the **causal connexion** which determines the results" (1938, p.66).

However, POINCARÉ himself has been the first to show that, even objectively, the movements of the heavenly bodies are not rigorously **deterministic**. He demonstrated the impossibility to find a perfectly exact solution to the

**three bodies problem** and set the first bases of the theory of **chaos** which is presently being developed (Understanding **chaos** as **randomness** within **deterministic limits**).

M. BELIS pursues nonetheless as follows: "However, after a long succession of experiences a **stability** of the results appears in cases in which the **unstable causal connections** are a structural make-up of a number of permanent causes".

This is precisely how most aleatory phenomena, **random** at **short term**, show nevertheless at long **term** an embedding global **determinism**, which figures basically a kind of statistical **limit to randomness**.

0071

**ALERT CONTROL**→ **Control (Alert)**

0072

**ALGEDONIC LOOP**<sup>2)</sup>

A positive or negative reward **feedback**.

Algedonic means: by pain or pleasure, i.e. implying punishment or reward.

Rewards can be quite various in kind. St. BEER cites as examples: teaching, bribing, the **epigenetic landscape** (1968, p.368). The **concept** appeared in psychology with PAVLOV and was (over) exploited by B. SKINNER.

According to BEER the algedonic loop "... interferes with the alleged **randomness** with which the **variety generator** pose solutions, as well as vetoing further attempts to pose the same unsatisfactory solution as before. It biases the throw of the dice" (p.368)

Further along BEER explains how this reward **feedback** allows very **complex systems** to produce in due time – notwithstanding the necessity of considering many interconnected conditions for **action** – "... a very ingenious and appropriate **response**" (p.395)... and how, if corrective **mechanisms** "were highly stable, their **response** to gross **perturbation** would be too sluggish and would call for huge **control energies**" (p.396).

The algedonic loop could probably be usefully mimicked in **Artificial Intelligence**

0073

**ALGORITHM**<sup>2) - 3)</sup>

A step-by-step ordered and finite **set** of prescribed **operations** along an optimal **path**, whose use permits the solution of a specific **class** of problems.

Any algorithm implies **determinism**.

J.Z. YOUNG gives a definition related to computation: "A **program** by which a complicated calculation is reduced to a long series of simple ones" (adding: "that a digital computer can perform": see hereafter the comment on artificial – or natural - **neural networks**).(1978, p.289)

G. KLIR states: "The intuitive notion of an algorithm was formalized in several ways, including formalizations based on the concepts of **TURING machines**, **MARKOV** algorithms, and **recursive functions**, which were all proved to be equivalent" (1991, p.127)

An algorithm may be quite complex and contain a number of subordinated **routines** and instructions for their eventual use. However, the **TURING machine** is, at least in principle, a universal **representation** of all possible algorithms. The potential and global use of an algorithm is strictly limited to its **content**, which necessarily reflects an implicit and specific **representation** of its **field** of application.

GÖDEL's **incompleteness** concept is thus valid for any algorithm.

As to algorithms relations to natural or **artificial intelligence**, it can be argued that they are merely acquired properties of **brains** or computers. In the latter's case, they must be introduced in the **machine** as a product of natural intelligence. It is now however conceivable that artificial **neural networks** could become able to **construct** complex algorithms by **learning**.

According to R.W. FULLER and P. PUTNAM, this is precisely what the nervous system does: "... (the) basic operation of the nervous system: establishing a relative **dominance** among the members of a **class** of competitive motor **acts**" (1967, p.103)

**Knowledge** itself seems to be stabilized through algorithms. R. FISCHER, quoting H.M. COLLINS, writes: "... the discovery is generally re-constructed as if it followed an algorithm, a narrative receipt, with the experience of **contingency, trial and error** written off as irrelevant "**side effects**" (1992, p.229).

According to the Russian psychologist L. VYGOTSKY, children use private speech (i.e. speak to themselves) as a self-narrative way to acquire new skills, until the moment they dominate it. (L. BERK – 1994, p.60)

This possibly explains why **knowledge acquisition** through teaching is so different from discovery and self-training, and sometimes quite stultifying.

0074

**ALGORITHM (Back propagation)**<sup>5)</sup>

A procedure to compute the **errors** resulting of the **activity (EA) level** of a unit in a **neuronal computer net** (i.e. the difference between the actual and the desired **output**), and to correct accordingly the corresponding **error weights (EW)**.

In a neuron which processes **signals** (= **activities**) each **input** is multiplied by a number called the weight. The sum of the weights, as computed by the neuron, determines the **output** of the neuron through an **input-output function**.

If the **output** differs from the desired **activity**, i.e. when there is an **error** in **activity** (EA), this **error** is calculated as “the square of the difference between the actual and the desired **activities**”, as stated by G. HINTON.

The weights are then modified in order to reduce the **error** in **activity**.

The back-propagation algorithm – invented around 1974 by P. WERBOS – is thus basically a **feedback process**.

In HINTON's words, “The back-propagation algorithm is easiest to understand if all the units in the **network** are **linear**... For **nonlinear** units, the back-propagation algorithm includes an extra step. Before back-propagating, the EA must be converted into the EI, the **rate** at which the **error** changes as the total **input** received by a unit is changed”. (1992, p.106)

This corrective mechanism is iterative (see below)

0075

**ALGORITHM (Framing)**<sup>2)</sup>

The concept of framing algorithm surges from the successive applications of internal **rules** (for instance of **positional values**) to incoming **inputs**. Progressive betterment of their **assimilation processes** tend to stabilize into more closely defined **channels**.

M. MARUYAMA proposed to apply this **model** to embryology: “Since **information** is generated by the **interaction** between various **parts** of the embryo, it is not necessary for each **part** of the embryo to contain **information** regarding the body **part** it is destined to become. It partly receives the **information** from other **parts** ... and from its **relationships** to them” (1963, p.238).

This looks like a case of progressive **organizational closure**.

0076

**ALGORITHM (Genetic)**<sup>2)</sup>

“A **stochastic, iterative**, evolutionary general purpose search **strategy** based on the principles of **population** genetics and natural **selection**”.

The genetic algorithm was proposed by J.W. HOLLAND (1975, 1992) as a way to the **simulation** of adaptive **population** systems. He generalized it as “genetic **operators**” **models** that can be used for the study of **optimization** problems and more recently for **automata learning**.

The genetic algorithm, not being narrowly **deterministic**, does not lead to just a simple **solution**, but on the contrary opens the way for a progressive and adaptive search for better solutions in evolving conditions.

HOLLAND distinguishes the following transforming operations: crossing-over, inversion, **mutation**, **selection**.

These **operations** are found in nature. But they are frequent in any system wherein numerous **agents** act collectively as a **population** engaged in an adaptive search.

A. AGAPIE writes: “Genetic algorithms (GAS) are robust probabilistic algorithms for optimization, relying strongly on **parallel computation**. Their power comes from multi-point exploiting of the searching **space**” (2000, p. 35)

→ **Neural networks; Parallel distributed processing**

0077

**ALGORITHM (Iterative refinement)**<sup>5)</sup>

An algorithm which progressively produce better answers when iterated.

As “the **backpropagation algorithm** is just a steepest descent approach without any line search... it inherits the well known disadvantages of the **gradient method**: The **convergence** depends strongly on the starting **values** of the **parameters**. The direction of the local steepest descent is often far different from the overall direction where the minimum lies” and... “The algorithm... normally either **overshoots** the minimum (with the risk of **oscillations**) or – if the **gradient** is small – there is hardly any progress at all” (TRONCALE, 1985, p.449).

This difficulty is alleviated by the introduction of iterative refinement algorithms.

Such algorithms are constructed from a **set** of **rules** whose **operation** is *interactive* and not rigorously **preprogramed**.

It is however open to debate if such a kind of mental device really fits within the concept of algorithm.

0078

**ALGORITHMIC COMPLEXITY**<sup>2)5)</sup>

The degree of **variety** in a chain of **data**.

For example, the chain 001011101101001 is much more complex than 1010101010...., which can be reduced to a **program** “Repeat n times 10”.

0079

**ALGORITHMIC COMPRESSION**<sup>2) - 3)</sup>

“(Any) formulation which can explicate or reproduce an extensive **pattern** of **data** from only a few succinct **rules**” (D. Mc NEIL, 1993 b, p.3)

Mc NEIL sees science itself as a **process** of algorithmic compression: “The pursuit of science... results in **categorizations, classifications, taxonomies**, and formula which describe the **associations** and the **structures** attributed to **phenomena**. An ideal of a science is to design algorithmic compressions to describe its subject matter” (Ibid)

The paramount example is the search for the “theory of everything”. **Systemics** and **cybernetics** also try to discover algorithmic compressions, in the guise of **transdisciplinary concepts and models**.

0080

**ALGORITHMIC INCOMPRESSIBILITY**<sup>3) - 5)</sup>

The impossibility to reduce a string of **data** to a simpler algorithm that would permit to retrieve them.

G. CHAITIN demonstrated that: “A completely **random** string of digits cannot be reduced to a shorter **program** at all”. On the contrary: “... a regular string of 1s and 0s describing some **data** such as 0101010101... which continues for 1000 digits can be encapsulated in a shorter instruction “repeat 01 500 times” (1990, p.45-46)

Chaitin related this finding to TURING's **non-computability theorem** and showed that: “the **halting** probability is arithmetically **random**” (Ibid)

According to CHAITIN, TURING's “... result that the **halting** probability is **random** corresponds to TURING's assertion that the **halting problem** is undecidable”

From another viewpoint, St. KAUFFMAN states: “One measure of the **complexity** of an algorithm is the minimal **program** length which yields the desired **output**. The more minimal an algorithm is, the less **redundancy** it contains. Consequently, minor modification of minimal **programs** grossly alter the **output** of the algorithm. In contrast, minor alterations of highly **redundant** algorithms modify **output** only slightly” (1993, p.231). Thus, algorithmic compression may make an algorithm's **behavior** more uncertain.

0081

**ALGORITHMIZATION BY SELECTION**<sup>1)5)</sup>

The **process** of **reinforcement** of some neuronal groups in the **brain** and elimination of other groups.

This theory, proposed by G. EDELMAN (1987) as a “theory of neuronal groups selection”, seeks to explain the progressive **organization** of the **brain** as a result of the acquired **dominance** of some groups of **neurons** which become frequently reactivated through re-entries of **signal** impulses.

This **process** leads to the **stabilization** of some specific perceptive and ordering **patterns**, which become the basis for future evaluations of new **perceptions**. It seems to correspond to the progressive construction of **reference frames**.

→ **Experimental frames; learning rule**

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

0082

**ALGORITHMS (Genetic)**<sup>2)</sup>

"A family of **methods** that search for optimal solutions of difficult **problems**" (P. DENNING, 1992, p.12)

The concept of genetic algorithm was originally developed by J. HOLLAND as a computer **modelization** of biological **evolution**.

P. DENNING writes: "Genetic search algorithms cross-breed trial solutions and allow only the **"fittest"** solutions (those accorded the highest **value**) to survive after several generations" (Ibid) They are thus, up to a point, self-perfectible, and a possible **model** for an **evolutionary mechanism**.

The genetic algorithm avoids at least partly what is possibly the most serious inconvenient of algorithms: their premature **stabilization** at a **sub-optimization level**. This result is obtained by a kind of "cooperative **competition**" by recombination or cross-over between different "candidate" solutions and the introduction during the progressive constructive **process** of a very slight **variability** ("mutations") within each elemental **situation**.

Kenneth DE JONG quoted by P. DENNING, states that "a mutation probability on the order of 0,001 per **bit** is enough to prevent the search from locking into a local **optimum**".

In this way, premature **sub-optimal** solutions are avoided and a global **optimum** can be more easily reached.

C. EMMECHE resumes as follows the **procedure** of a genetic algorithm:

"1. Select **program** pairs on the basis of how well they have solved the **task** (one can thereby measure **fitness**). The better the solution, the greater the **chance** to be selected.

"2. Apply the genetic **operator** (cross-over, eventually combined with a small **chance** of **mutation**) to the selected **program** pairs in order to create offsprings in the next generation.

"3. Replace the least successful **programs** with the offspring created in step two, and repeat the **process**" (1994, p.115)

He adds: "Empirical investigations indicate that this crossing-over scheme operates specially well on problems that programmers otherwise regard as genuinely difficult.

The genetic algorithms are able to exploit the **population** experience in an optimal manner" (p.116)

→ **Parallel distributed processing**

0083

**ALGORITHMS' LIMITS**<sup>3)</sup>

In relation to algorithms' possibilities to mimic intelligence, P. DENNING states: "For me, the existence of multiple, incomplete interpretations actually supports PENROSE's basic claims about mental as opposed to computational **processes**. Like a system of logic, an interpretation cannot include all **phenomena**. Our

powers of conscious **observation** give us a capacity to step outside a particular interpretation and devise extensions or alternatives. Thus **consciousness** itself cannot be captured by any fixed **description** or interpretation. How then can **consciousness** be captured by an algorithm, which is by its very nature a fixed interpretation? This question applies also to algorithms that are apparently designed to shift their interpretations, because the **rules** for shifting constitute an interpretation themselves" (1990, p.102).

Include a "theory of everything." within an algorithm seems to be a hopeless task. However the **brain** itself becomes partly **constrained**, by **learning** specific skills and **behaviors**. Could this not be viewed as a partial algorithmization? As to the **rules**, should they not be left "open", as for example behavioral **rules** in a **network** in lieu of interpretation **rules** within an algorithm?

For an exhaustive debate on this topic see R. PENROSE's "The Emperor's new mind" (1989)

0084

**ALGORITHMS THAT CANNOT BE CONSTRUED**<sup>3)</sup>

N. KASKOV "demonstrated that the following mass problems could not be solved in the framework of the **General System Theory**:

- to construe an algorithm allowing to find all the **elements** of a given system
- to construe an algorithm allowing to find all the **connections** of a given system
- to construe an algorithm allowing to determine the **structure** of a given system
- to construe an algorithm allowing to determine all the **functions** realized by any given system (even if one knows its **elements, connections and structures**)" (BLAUBERG, SADOVSKY & YUDIN, 1977, p.205)

Any **complex system** seems to contain a power for innovative and unpredictable **variations**, due probably to its relatively open character.

0085

**ALL OR NONE TRANSITION**<sup>1)</sup>

A type of **transition** that admits only two opposite **states**.

These **transitions** are congruent with the **all or nothing principle**. They admit no **fuzziness**. Examples are: open vs. closed; outside vs. inside; positive vs. negative; one vs. zero.

→ (**flip-flop device**)

0086

**ALL OR NOTHING PRINCIPLE**<sup>1)</sup>

**Stimulus-response situation** in which **response** is unavoidably total, or nought.

J.C. TABARY notes: "Particularly at the sensorial neurons **level**, a univocal **response** appears when sufficient number of membranous **receivers** are simultaneously stimulated.

"The **organism** is informed about the **receivers stationary state**, but not on the peculiar characteristics of the stimulating **event** itself. Considering that, very generally, there are only two possible **states: information** is really restricted to one **bit** only". (1989, p.278)

0087

**ALLEE EFFECTS**

→ **Undercrowding**

0088

**ALLELOPATHIC**<sup>1)4)</sup>

"Character of a substance which has inhibitory effects on other **organisms**" (P. COLINVAUX, 1973, p. 605)

In a more general and somewhat **metaphoric** meaning, it seems that some **informations, values or norms** exert inhibitory effects in societies.

→ **Inhibition**

0089

**ALLOGENESIS**<sup>2)5)</sup>

A **phase** of adaptive **radiation** in an **evolutionary process**. (W. SCHWEMMLER, 1991, p.152)

0090

**ALLOMETRY**<sup>2)</sup>

Fixed or variable proportional **relationship** between different **parts** in one or various systems

It is already an old idea to try to compare the modifications of the proportions of various **parts** of the same system through **time** or the proportions of a corresponding **part** of various systems at the same moment of their **growth**.

The 19th century French paleontologist Georges CUVIER used the concept as a "principle of **correlation between parts**": "Any organized being forms a **whole**, a unified and **closed system**, whose **parts** correspond all to each other and converge towards the same definitive **action**... None of these **parts** may change without **changes** in the others too, and as a result, each separately considered shows and gives all the others" (CUVIER, 1812, as quoted by Stephen J. GOULD - 1983)

This idea has been reworked and considerably extended, specially in relation to **evolution** by d'Arcy W. THOMPSON (1916 - re-ed.1952) and later on by J. HUXLEY, alone (1945) and in collaboration with E.C.R. REEVE (1972, and in HUXLEY, 1945, p.267)

0091

**ALLOMETRY (Principle of)**<sup>2)</sup>

"As the **growth** of any particular **structure** proceeds, in the absence of **change** in the **pattern** of the **structure** itself, volumes will grow eight times as fast and surfaces will grow four times as fast as **linear dimensions**" (K. BOULDING, 1972, p.87)

As observed by L.von BERTALANFFY: "The simple relationship of allometric increase applies to many **growth phenomena** in biology (**morphology**, **biochemistry**, **physiology**, **evolution**)" (1962, p.12)

Commenting on this principle, K. BOULDING expresses that it also applies to social **organizations**, in a more subtle way: "... **organizations** eventually limit their own **growth** simply by the sheer difficulty in getting **communication** from the "surface" of the **organization**, where it is in contact with its **environment**, into the **decisions-makers** who are not in direct contact with the **environment**" (1972, *ibid*)

In this case, it is mainly a problem of **time lags**. However, even if **communication** is accelerated through technical devices, **strain** and **saturation** may well occur, by **overload**, or **chaos** may seep in.

0092

**ALLONOMY**<sup>2)</sup>

The property of a system characterized by **input-output relations** (LE PEUTREC, 1994, p.1553)

S. LE PEUTREC and M. COURANT explain: "Such a system needs an internal representation of its **environment**. The **environment** controls the internal functioning of the system" (*ibid*)

This is the case of common **regulators**: While they endow some larger system with some **autonomy**, they themselves are not autonomous.

Allonomy is a property somehow complementary to **autopoiesis**. According to P. VENDRYES, **autonomy** is not possible without internal **regulators**, registering external **perturbations** and reacting to them as kind of **buffers** allowing for the permanence of the systems **identity** and **processes**.

Or: "Allonomy is a logics of correspondence, while **autonomy** is a logics of **coherence**". (*ibid*, p. 1554). There is a kind of **symbiosis** between two **antagonistic behaviors**.

0093

**ALLOPOIESIS**<sup>1) - 2)</sup>

The production by a **network** of interrelated **component-producing processes** of a system, which does not however becomes able to thereafter reproduce its **components** and **processes**. (Adapted after M. ZELNY and N. PIERRE, 1976, p.150)

According to these authors: "... the actual realization of such systems is determined by **processes** which do not enter into their (own) **organization**. They are non-**autonomous**, since their realization and longevity as unities are not related to their **operation**" (*ibid*)

In another paper, ZELNY states: "Allopoietic systems are organizationally open. They produce something different from themselves" (1977, p.14)

Allopoiesis is of course the opposite of **autopoiesis**, which implies **organizational closure** and thus, **self-reproduction**.

ZELNY and PIERRE give as examples of allopoietic systems "crystals, formal **hierarchies** and concentration camps" (*ibid*)

Complex **artifacts** as for example cars or planes or machine-tools seem still more allopoietic: they are not self-created and are controlled from outside.

However, if the allopoietic system is to be really a system, it must at the same time be **autopoietic** in order to maintain its **identity** and **coherence**. This would be possible if we admit that the **boundaries** or other **subsystems** transform **inputs** into internally fitting **elements**, i.e. integrates them into the **organizational closure cycle**, while producing **outputs** by an inverse **transformation**. Some of J.G. MILLER **20 critical subsystems** do just that.

According to H. MATURANA, an **observer** may treat an autopoietic system as if it were allopoietic by considering the perturbing **agent** as an **input** and the modifications undergone by the **organism** (which maintain its **autopoiesis**) as the **output** (1974, p.425). This is, for example, the way of traditional psychiatry.

However, this treatment does not reveal the **autopoietic organization** of the system.

0094

**ALLOSTASIS**<sup>1)</sup>

The conservation of dynamic **stability** during a **process of change** in a system

Any system or **subsystem** is normally able to cope with a more or less wide **range of inputs**.

As expressed by ASHBY, a system counts with a defined **variety** which allows it to adapt to specific variations in its **environment**.

The french biologist P. VENDRYES, in turn, explained that the system is able to maintain itself within **limits** of adaptive **fluctuations** if it counts with sufficient **reserves** (or **resources**) disposable for use.

Allostasis has thus a qualitative and a quantitative aspect.

However if variety and/or resources are insufficient and tend to be exhausted, non adequately compensated **input perturbations** create **stress** in the system.

If stress becomes excessive or persists for long **time**, the system may undergo severe damage and, in extreme cases, be destroyed.

→ **Break down; Collapse; Criticality; Equilibrium; General adaptation syndrome; Heterostasis; Homeostasis; Regulation; Synergetics**

0095

**ALPHABET**<sup>2)</sup>

"An ordered **set** of characters which can be combined to form the ensembles, words or expressions of a **language** or to represent **data**" (K. KRIPPENDORFF, 1986, p.2)

Many kinds of alphabets are in existence: the very numerous different alphabets of written and spoken **languages**, the conventional combinations based on a **binary code**, and even the 20 basic amino-acids of DNA and RNA chains.

To express that an alphabet is an "ordered **set**" means that it corresponds to differentiated **symbols** and that its use is **constrained** by defined **rules**. For example "chtch" is a sound and a letter in Russian and the combinations "mb", "ng", or "nz" are admitted in Kiswahili, but none of these are normally used in English.

Any alphabet is thus a specific system.

In a sense, any **taxonomy** that uses a kind of ordering base of **classification** to be applied on the combinations of a limited number of well defined **elements**, could be considered an alphabet.

0096

**ALTER**

→ **Contingency (Mutual)**

0097

**ALTRUISTIC UTILITARIANISM**

→ **Utilitarianism (Altruistic)**

0098

**AMBIENT (= UMWELT)**<sup>1)</sup>

"The **set** of the small number of characteristics to which an **organism** reacts". (L.von BERTALANFFY, 1962, p.73)

This concept was introduced and developed by J.von UEXKÜLL and G. KRISZAT (1934, 1979)

BERTALANFFY explains the concept as follows: "...any **organism**, so to speak, cuts out from the multiplicity of surrounding **objects** a small number of characteristics to which it reacts and whose ensemble forms its ambient" (p. 73)

The **perceived** ambient is only a reduced **part** of the **environment**, which does not mean of course that non-perceived environmental conditions could not affect the **organism**. Exam-

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

ples would be the effects on human beings of ultra-violet or X-rays, which were completely unknown to our forefathers and that we are still unable to perceive directly.

BERTALANFFY also notes that: "...the organizational and functional plan of a living being determines what can become 'stimulus' and 'characteristic' to which the organism responds with a certain reaction" (Ibid).

von UEXKÜLL has given numerous and sometimes startling examples of ambients corresponding to various animals, showing how unexpected and even outlandish they can look for us.

This ambient concept, transferred to human organizations, may help to explain many failures of environmental perception in management.

0099

**AMBIGUITY**<sup>3)</sup>

The condition resulting from a sign or signal bearing different possible meanings for an observer.

Ambiguity results of the lack of a clearly selective context to allow for the clarification of meaning. It is a perceptive situation, related to languages (spoken, written, pictorial or other). E. BUCHBERGER observes that: "Multiple semantic meanings cannot generally be solved in an isolated way and lead to considerable difficulties" (1987, p.57)

Any receiver possesses his/her repertory of interpretations of signals, but this repertory has been formerly learned.

If, for example, we look at the well known young woman, old woman picture, only one of both possible perceptive gestalt intervenes for us at any moment, exclusive of the other. The potential for ambiguity is in the picture, but it reveals itself only through the shifting glance of the observer.

According to A. RAPOPORT: "Even mathematical statements, which most people consider to be absolutely exact, and therefore either absolutely true or absolutely false, have a certain penumbra of ambiguity as they are usually stated. This ambiguity is less characteristic of mathematical statements than of others, but it is there nevertheless because certain qualifications are likely to be tacitly assumed in every statement. It would simply take too long to make a statement irreproachably unambiguous" (1967, p.292)

This problem is obviously related to the need to recurrently resort to metalevels for distinction or validation (GÖDEL's incompleteness theorem)

0100

**AMPLIFICATION**<sup>2)</sup>

"A process whereby a small cause has a large effect" (W.T. POWERS, 1995)

Amplification is "achieved by drawing on the stores of energy and bringing them to bear on the creation of narrowly focused effects in the environment..."

This possibility "...arises from the fact that organisms can draw on internal power supplies which are independent of the energy contained in disturbances" (Ibid.)

This is the same condition that leads to systems autonomy in the sense of P. VENDRYES (1908-1989)

0101

**AMPLIFICATION AND STABILITY**<sup>1)</sup>

Amplification, if not compensated by for example a negative feedback, leads the function and the system towards an instability threshold and either a runaway catastrophe, or a process of dissipative structuration.

H. ODUM puts it this way: "In effect, a system is stable when the amplification factor of the feedback loop equals the potential energy losses along the circuit".(1971, p.181)

0102

**AMPLIFIER**<sup>2)</sup>

Any device suited to increase an input signal.

Amplifiers are generally incorporated within a feedback device. M.D. RUBIN even describes the feedback as "a unilateral power amplifier, with a fraction of the output of the amplifier subtracted from or added to the input of the amplifier" (1968, p.9)

H. ODUM describes a "constant gain amplifier", within an energy network in which: "...the amount of energy supplied from the upper flow is that necessary to increase the force expressed by the system by a constant factor, called the gain" (1983, p.39)

0103

**AMPLITUDE**<sup>2)</sup>

The maximum departure of an oscillating motion from its time-average value (T.F.H. ALLEN & T.B. STARR 1982, p.262)

0104

**ANABOLISM**<sup>1)</sup>

The process of absorption and assimilation of specific inputs by a living system

The anabolic process includes the following phases:

- Ingestion or transduction: the translation of material, energetic or informative inputs from the environment into the system through its boundary.

- Internal transfer: the internal translation from the absorbed inputs to the subsystems that should use them.

- Conversion: the transformation of an input by a specific subsystem to make it fit for the use of the system. In the case of information inputs, the conversion process is called "decoding".

- Production or association: For material or energetic inputs, the synthesis of specific components of the system, out of the converted inputs. For information, the first stage of the learning process.

For the respective roles of the concerned subsystems, see J. MILLER's 20 critical subsystems.

The elimination of products by a living system is called "catabolism", while "metabolism" is the generic term for the complete process of absorption, transformation and elimination of matter, energy and information.

In a more or less analogic sense, higher level living systems (enterprises, groups, organizations, communities, etc...) all analogize specific inputs.

0105

**ANAGENESIS**<sup>2)</sup>

"The step-wise evolution of the dynamics of self-organization itself, bringing into play new levels of systems with their appropriate self-organization dynamics" (E. JANTSCH, 1982, p.345).

JANTSCH, who introduced the concept, stated: "In microevolution, anagenesis arises from endosymbiosis of dynamic (or ontogenic) sequences of structures; in macroevolution from the coevolution of phylogenetic sequences of systems. It may be interpreted as self-transcendence in space-time" (Ibid).

This is the evolution of evolution modes. Anagenesis is probably to be connected with emergence of new levels of complexity through dissipative structuration.

This process also seems related to the appearance of higher levels of sociality (cells as societies of molecules, living beings as societies of cells, beehives as societies of bees, human societies) that produce new types of individuals on a higher complexity level.

The subject is very complex. JANTSCH's paper provides an interesting figure that makes it easier to understand.

0106

**ANALOG PROCEDURE**<sup>5)</sup>

According to J.von NEUMANN: "In an analog machine each number is represented by a suitable physical quantity, whose value, measured in some pre-assigned unit, is equal to the number in question" (1958, p.3).

The machine must be equipped with devices enabling it to operate suitable mathematical transformations on these quantities.

0107

**ANALOGICAL or DIGITAL**<sup>2) - 5)</sup>

Two different **methodologies** used in **simulation**.

Analogical **simulation** is based on **similarities** and uses mechanical, hydraulical or electrical **models** whose functional properties are sufficiently **similar** (i.e. **homomorphic**) to those of the **concrete system**. Reduced **models** of harbours, or scale **models** of **artifacts** are examples.

Digital **simulation** uses numerical analytical **models** that can be translated to **programs** adequate to be run on a digital computer.

0108

**ANALOGUES**<sup>2)</sup>

"...systems which are physically different but dynamically equivalent" (R. ROSEN, 1972, p.56)

According to ROSEN: "... dynamical or functional properties can be studied essentially independently of specifics of physicochemical **structure**, while **fractionation**, or other **reductionist** techniques, are bound up with these specifics in an essential way" (Ibid)

0109

**ANALOGY**<sup>3)</sup>

"A resemblance between the **relations** among things (rather than between the things themselves) (Adapted from J.W. SUTHERLAND, 1973, p.122)

K. KRIPPENDORFF states: "In the theory of **models**, an analogy between two systems is explained by one simpler system that **models** both, but by different **homomorphisms**" (1986, p.3) An analogy is thus a *limiting* conceptual **constraint**.

According to J.W. SUTHERLAND: "... the analogy is in the first and last instance a conceptual device designed to call attention to **isomorphisms**, and to engine the attempt to induce **causality** specific to a **phenomenon** by imposing a general **causality**" (p.123)

The first aspect does not seem objectionable. However, the second one could easily lead to dangerously sweeping generalizations by "embracing creeds" (POPPER, quoted by SUTHERLAND - p.117)

Further on, SUTHERLAND adds: "...analogies are properly used... as **masks** with which an a priori **chaotic situation** can be at least partially ordered, subsequent to empirical **validation** of the **causality** proposed by the **mask**. Grand operational principles then, in the hands of the serious scientist, simply become systemic, encompassing **heuristics** whose utility lies not in their reification but in their perspective".(p.127)

0110

**ANALOGY (Abuse of)**<sup>3)</sup>

A number of serious abuses of analogy have been registered in the use of **cybernetic** and **systemic models**, generally by neophytes carried away by their initial enthusiasm for a **methodology** which seemed to them to promise grand solutions to intractable problems.

Obvious examples are the illusion of rigid **control** by **regulators** of mechanist types in biological, economic and social systems; some "**catastrophic**" (no pun!) **models of behavior** in **social systems** and, more recently some misunderstandings about **chaotic models**.

A subtler case can be found in J. FORRESTER's "**World Dynamics**" as it was applied in the famous first **Club of Rome** Report. This outstanding piece of work suffers from an excessive rigidity due to the presence of numerous cybernetic **loops** whose *simultaneity in action* is never considered (C. FRANÇOIS, 1977). In J.W. SUTHERLAND words: "... both human beings and the collectivities they form would have to be considered "dynamic, **goal seeking systems** that change their **environment** and are not merely passive victims of it" (F. GEORGE, 1970, p.21) and, if this is the case, then "the simple servoanalogy breaks down, as does our ability to collapse all relevant **behavioral** determinants into a simple, fabricative **state-variable**" (1973, p.124)

In any case K. BOULDING expressed: "If analogy is dangerous and leads to the development of untrue systems, the remedy is not to throw it overboard altogether, for there are **situations** in which no other **method** of systems development is open to use. The remedy for false analogy is not *no* analogy, but *true* analogy. This involves the development of a critique of analogy and a theory of **simulation**... It is ... one of the principal concerns of the **general systems** enterprise" (1974, p.36)

0111

**ANALOGY-BUILDING**<sup>3)</sup>

As an attempt to transfer **similarities** from a **phenomenon** to another one, analogies imply some aspects that should be consciously assumed.

According to J.W. SUTHERLAND: "... analogy-building is an extension of **assumptivism** (note: see: **Assumptive Analysis, Reductionism**)...But the fundamental difference between **assumptivism** and analogy-building is that, in the latter case, we are imposing an entire **system of relations** rather than single **parametric values** or **sets** of predicates (cum first premises)" (1973, p.123)

St. BEER showed that the **process** of analogy building, or "scientific analogizing" consists in connecting conceptual **homomorphic models** of two or more **situations** (1968, p.111)

Using the example of the controversy around the **validity** of the analogy between **computers** and **brain** ("The **brain** is a **computer**" **metaphor**), A. RAPOPORT observes; "The controversy is obscured by clashing philosophical convictions.... The answer... is not to be found in what a **brain** and a **computer** "are" (such questions are vestiges of pre-scientific metaphysics), rather in what **brains** and **computers** do" (1966, p. 9)

We should add: and in which way they are doing it, as the **brain** seems to be working, at least partly, in a **simultaneous** manner, as a **network**, while the computer, at least the **digital** one, is basically sequential.

Ironically, analogy-building, in search of **homomorphisms** or **isomorphisms**, ends up in some cases as just a more refined **reductionism**. Systemists and cyberneticians should beware of this !

0112

**ANALYSIS**<sup>3)</sup>

"The separation of an intellectual or substantial **whole** into constituents for individual study" (The American Heritage Dictionary)

One of the most severe and persistent **semantic** muddle is the careless use of the term "analysis", even by systemists.

When a system is "analyzed", most or all of the **nonlinear interrelations** among its **parts** are unwittingly severed. As jokingly stated by J.L. LEMOIGNE, cutting a chicken into slices like a sausage does not yield an intelligible **representation** of the chicken. (1990)... and it should be quite more difficult to do.

Worse still, many people are not even aware of this problem. And different **observers** may "slice the chicken" in different ways, none very faithful to the original.

Analysis is perfect on its own (studying the **components** and at most their **linear** relations), but, as it generally leads to cutting the more complex **interrelations** between **interacting parts**, it is never a satisfactory substitute for the systemic global view, which is also indispensable for the study of **complex systems**.

Ideally, analysis should always be conjugated with **synthesis**, i.e. the synthetic view of the **whole**. Moreover this should also be a back and forth **movement**: analysis is useful and makes sense only in relation to the synthetic view and synthesis without a good **knowledge** of the interacting **parts** does not make much sense because it offers merely empty generalities that do not offer tools for action

0113

**ANALYSIS (Functional)**<sup>2)</sup>

The functional analysis of a system includes:

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

- an identification as precise as possible of the distinct **functions** of the system and their **interactions** or interferences
  - in this way potential disfunctions and **risks** can be identified and, as a result, possible risks can be discovered and assessed. This can be done by "hazards and operability studies"; "analysis of possible failures of **components**"; "**critical effects** study"; causes and consequences diagrams"; "**failures trees**"; and others.
- Statistical analysis is one of the main tools in this kind of analysis, as well as **Petri nets** and **Markovian processes models**.
- **Cindynics**

0114

**ANALYSIS (Sensitivity)**→ **Sensitivity**

0115

**ANALYSIS SITUS**<sup>2)</sup>

"The study of those properties of **space** which are independent of shape or **size**

Analysis situs or situational geometry is practically a synonym for **topology** and was first used in this sense by H. POINCARÉ. It is concerned with the properties of **forms, contiguity, connections...** conserved through continuous deformations, stretching or contraction, but exclusive of tearing or folding.

0116

**ANAMORPHOSIS**<sup>1)</sup>Trend toward an increasing **complexity**

This concept, introduced by WOLTERECK (1940), "has been indicated as a primary characteristic of the living, as opposed to inanimate nature ... and was often used as a **vitalistic** argument" (L.von BERTALANFFY, 1969, p.79)

In BERTALANFFY's opinion organizational laws exist at all **levels** in the universe. To search for them is one of the basic goals of **General Systems research**.

In fact, it seems evermore well confirmed (see for example Carsten BRESCH, 1977) that this same tendency is – or was – already active at the micro-physical **level** and that it is linked to the very general **phenomenon** of **structuring dissipation** researched by **thermodynamics of irreversible systems**.

Note: Another (unrelated) meaning of this term is: "A mode of distortion of an **image** such as it can be viewed only from a special angle or with the help of some instrument".

These optical deformations were used by the Milanese painter ARCIMBOLDO (1527-1593)

0117

**ANARCHY**<sup>1)</sup>

On this concept, FLOOD states: "Anarchy itself suggests **disorder** and lack of government; however the argument is not one of **entropy**, but as follows. Anarchy can cause such **strains** on a system, including **positive feedback**, that the system itself may go through a **transition**. In many cases anarchic **behavior** is a **catalyst** of a system **transition**, not from a **state** to another (within a predetermined **state space**, one to one **mapping** of the **state variables**), but rather from one nature to another. That is, some essential qualities are replaced by another **set** of essential qualities" (1991, p.188)

FLOOD does not elaborate much as to the causes of anarchy. There seem to exist basically two:

- Weakening of the **control** of the system upon its **parts**;
- **Overload** of **inputs** from the **environment**, basically excess of **energy** or **information** inflow, which produces local or general unresponsiveness or confusion by **saturation** of **communication channels**.

FLOOD states that: "The system's **label** however, may well remain the same: France was still France after the revolution" (p.181). True enough about the "**label**". But what about the deep **identity** of the "France" system? This is a good example of how difficult it is to apply even systemic concepts to socio-cultural **situations**. **Metaphorically**, one could speak of destructive anarchy, as for example in cancer, and constructive anarchy as in the case of ebullient **elements** breaking down some established **structures** and producing, as a result, some more efficient or encompassing **global organization**.

Besides, anarchy as a concept whose systemic **meaning** is still ill defined, should be clearly distinguished from **chaos**.

0118

**ANASTOMOTIC NET**<sup>2) - 5)</sup>

A **model** of **neuronal net** "in which each neuron listens to many and speaks to many" (W. McCULLOCH, 1974, p.14)

This definition corresponds to a **model** created by S. WINOGRAD and J.D. COWAN in McCULLOCH's laboratory.

These authors used such **nets**: "... in such a way as to incorporate the **redundant error-correcting codes** used in **coding** for **noisy communication channels** into the logical **functions** computed by each neuron in the **net**. The probability logic which results from their construction is **functionally redundant**, there are many more possible **functions** stored in the **net** than in our own anastomotic **nets**, and it is this **redundancy** which is used to obtain reliable computation. Given the assumption that the **rate** at which neurons malfunction is not

tied to the number of **inputs** playing on each one, the WINOGRAD – COWAN construction is in a one-to-one correspondance with that of SHANNON's which led to the **noisy channel coding** theorem and the existence of a **channel capacity**. On this basis there is an **analogous** computational capacity for reliable computers made of unreliable **components**" (Ibid)

In view of the recent developments in **neuronal nets** applications to **robotics** and **connection machines**, and their possible use for the study of **sociality**, this was indeed, in the fifties, inspired work.

0119

**ANASTROPHE**<sup>1)</sup>Sudden appearance of some new **entity**.

This neologism has been seldom used. It is obviously the opposite of **catastrophe**. According to the catalan systemic historian P. VOLTES BOU, it has been introduced by C. RENFREW (Pers. comm.)

→ **Dissipation; Emergence; Thermodynamics; Zero-System**

0120

**ANDRAGOLGY**<sup>1)3)4)</sup>

The discipline that studies human **action**. Andragology is a creation of Gerard de ZEEUW and has been developed by him in Holland at the University of Amsterdam, as well as in conferences organized by the **Systeem Groep Nederland**; and in the journal *Systemica* of which he was editor in chief. Martha VAHL, a close collaborator of de Zeeuw, writes "Andragology... combines interests both practical (adult **education**, social helping, support through the built **environment**) and theoretical (the acquisition of supportive **knowledge**). In terms of the breadth of this definition, andragology, as a field, remains more or less unique to the Netherlands" (2002, p. 101)

This reference to the Journal "Systems Research and Behavioral Science" is a fundamental one about de Zeeuw and his collaborators work, being a Festschrift in his honor.

The same issue also offers a listing of de Zeeuw's publications compiled by M. Vahl and, generally, an abundant bibliography of the field.

→ **Conversation; Facilitation; Perspectivism**

0121

**ANIMAT**<sup>1)5)</sup>

An artificial **organism** whose **structures** and **processes** are as similar as possible to an animal ones.

The problem is however in the way an animat acquires such **structures** and **processes**.

There are three possible **models** of animats (at least!)

- animats can be made to learn **behaviors**. This can be done endowing them with a **neural network**, thus making them adaptive

in a range of experimental situations through a **set** of interacting **rules** organized as to cope with external **changes** that may have an impact on the animat

- animats can be made evolutive. Again this can be obtained through an appropriate neural network and a set of rules. But the need for **evolution** can be installed by introducing a measure of **randomness** in the **rules**.

However, none of these animats models seems to tackle all the aspects of modelling animal **behavior**, specially "intelligent" beings.

E. VACCARI and M. D'AMATO write: "**Cognitive systems** are composed of multiple **sub-systems** which are simultaneously active and interacting. Their cognitive **behaviors** are pervaded by both continuities and discreteness and their kind of **structures** emerge over time. Further **cognitive processes** operate over many **time scales** and **events** at different **time scales** interact" (2000, p. 173)

In short, a good animal model should never become an **homeostat** in the sense of ASHBY.

Or, even the existence of **constraints** cannot totally prescribe all the modalities of **change**, and still less, stop **change** altogether.

Already in the 18<sup>th</sup> century LEIBNIZ (1646-1716) stated that any **change** in one **element** in an entity is conducing to modifications of all the other **elements**. Such a **process** takes necessarily place at multiple **levels**, in different ways, at variable **time scales**, and can thus be modellized only in a conjectural and imperfect way, be it for an animal, or an animat.

0122

**ANIMORG**<sup>1)</sup>

"A type of self-adaptive system that has the properties of complex **organization** in **dynamic equilibrium**, **regulated behavior**, and the ability to change, grow and reproduce"

This term, introduced in 1940 by R. GERARD, corresponds more or less to J. MILLER's "**living system**", but did not met with wide acceptance. (1956, p.158; 1974, p.121)

As a subclass of animorgs, GERARD distinguished "**epiorganisms**", i.e. **colonies** or societies made of individuals. (1956, p.158)

0123

**ANISOCHRONICITY**→ **Isochronous**

0124

**ANISOTROPY**<sup>2)</sup>

Character of any entity whose properties vary in line with different directions.

Any system is more or less anisotropic, generally very much so. Anisotropy is closely related to **structure** formation and maintenance, and reflects **disymmetries** resulting from **symmetry-breaking**.

0125

**ANTAGONISM PRINCIPLE**<sup>2)</sup>

"Every system results from two antagonistic forces mutually binded" (S.LE PEUTREC & M. COURANT, 1994, p. 1550)

The principle was originally proposed in France by S. LUPASCO (who constructed a "logic of contradiction" – 1947): "It is antagonism, i.e. the coexistence of forces that attract o repel each other, or **conflict** with this attraction, that constitutes the fundamental mechanism, sine qua non of the physico-chemical **objects**, with more or less strong domination of some of them over the others... It is the nucleus where the antagonistic forces become most strongly equilibrated that constitutes the most resistant system, the one... most difficult to disintegrate" (1972, p.100)

Under this somewhat philosophical guise, it is easy to recognize C. LAVILLE's, or K. DE GREENE's, or D. Mc NEIL's views about **interacting fields**, or **vortexes**, or **toroids**, or H. SABELLI's theory of **processes**, all of which are basically **dynamic**.

LUPASCO, significantly, used the words "attract" and "attraction", long before **attractors** became a pass-word in so many systemic **models**.

In systems, we may observe the antagonism principle, for instance in **environment-system** antagonism, or inside of a system, the construction-destruction antagonism.

According to LUPASCO, the principle is rooted in a reflexive combination of the 2<sup>nd</sup> Principle of **thermodynamics**, that prescribes the increase of **entropy**, and PAULI's **exclusion principle**. LUPASCO gives as examples the **development** of an embryo, or the shaping of a hurricane; still another important research on the subject has been d'ARCY W. THOMPSON's on "Growth and Form"(1916)

LUPASCO also stated that "the antagonism principle appears...as the formation principle of any system, as well as the bedrock of systems logics"(1982)

0126

**ANTHROPIC PRINCIPLE**<sup>3)</sup>

J.D. BARROW and F.J. TIPPLER formulated this principle (1986). According to them, the nature of the physical world must necessarily be such that the perceptive and intelligent **observer's** existence be possible.

A **universe** without witnesses would of course be a different **universe**... or would it "exist", i.e. is existence possible without self-**consciousness** (even of a **part** observing the **whole** – or at least a larger fragment of the **whole**)?

It is difficult to evaluate the possible systemic **meanings** of these recollections from PLATO and BERKELEY. Whiffs of **solipsism** are floating around!

A more acceptable view of the Anthropic Principle would be that the **coherence** of multiple characteristics of the universe as we know it (microphysic and macrophysic constants, **space-time** characteristics, gravitation, etc.) merely implies that our own existence as conscious **observers** (after a very long evolutive **process**!) became possible, or even normal.

But this kind of extraordinary stretched cosmical **tautology** does not lead to any new and significant rational **development**. It may be more useful for theology than for science. (WALD, 1994, p. 123-31)

0127

**ANTHROPOCENTRISM**<sup>1)3)</sup>

The mental attitude and worldview that tends to interpret **facts** as significant only or merely in relation to man or mankind.

Of course, it would be probably impossible to do otherwise. However, as the self-understanding of specific people depends of the historical (or transient) circumstances, the anthropocentric view should be carefully and permanently scrutinized. Indeed even the most abstract **concepts** and **models**, as well as the supposedly "objective" **observation** remain necessarily products of the human senses and mental organization.

From the Ptolomeic cosmology to the so-called **anthropic principle**, we should all be always ready to recant from our own imaginations and illusions. **Conversation**, reciprocal critique and Popperian **falsifiability** are tools that should be put to more frequent use.

→ **Culturocentrism**

0128

**ANTHROPOMORPHISM**<sup>1)4)</sup>

The attribution of human characteristics, **behavior** or motivations to animals, physical **events** or imaginary beings (good or evil spirits, gods).

Considering its universality, anthropomorphism could be, according to J.Z. YOUNG (1978, p.289), a clue to an inherited **brain program**.

0129

**ANTIBIOSIS**<sup>5)</sup>

An antagonistic relation between two types of **living systems**.

When two species are in such a **relation**, one species may eliminate the other. A variety of antibiosis is allopathy, where a species produces some toxic substance which impedes other species to establish or maintain themselves.

<sup>1)</sup>general information<sup>2)</sup>methodology or model<sup>3)</sup>epistemology, ontology and semantics<sup>4)</sup>human sciences<sup>5)</sup>discipline oriented

0130

**ANTICHAOS**<sup>2)</sup>

A **process** through which "some very disordered systems spontaneously "crystallize" into a high degree of **order**" (After St. KAUFFMAN – 1991, p.64)

According to KAUFFMAN: "Computer **models** suggest that certain **complex systems** tend toward **self-organization**" (Ibid). The subject is closely related to the **behavior** of **composite systems** and their **self-organized criticality** (developed by P. BAK et al. in 1988; 1989; 1991).

It is not however the true antithesis of **chaos**, since **chaos** does not generally disorganize **complex systems**: it only makes the prediction of their **behavior** quite difficult, or downright impossible.

0131

**ANTICIPATORY BEHAVIOR**

→ Behavior (Anticipatory)

0132

**ANTICIPATORY SYSTEM**<sup>1)2)4)</sup>

A system able to define its own **goals**, or at least able to behave in order to tend in a permanent way to maintain itself in the future.

Human beings are more or less conscious of their **goals** and in many cases able to define and describe them. In other living beings the **goals** remain implicit and probably totally unconscious.

The study of anticipatory systems is quite difficult. B. EKDAHL writes: "Anticipatory systems are a result of **evolution** and the characteristic of them is that they consist both of **description** (genotype) and **interpretation** (phenotype). Many such systems are not conscious of their own interpretations and can be regarded as having only a built-in theory and no **language** in which its interpretations is described. Such systems show an algorithmic **behavior** and can be simulated on a **computer**."

"Systems which can also make a (**semantic**) **model** and moreover have a possibility to reason about this **model** cannot be reduced to computation since in no other language its **interpretation process** can be described than in the **language** itself.

"As a consequence, model-based anticipatory systems cannot completely be described by mathematical means but have to be **holistically** considered in order to give a reasonable **explanation** of their **behavior**. The way to look upon a system as a mathematical **structure** is not applicable in such cases" (2000, p. 13)

0133

**ANTISYNCHRONY**<sup>2)</sup>

The condition of two **oscillators** which are half a **cycle** out of **phase** with each other.

J. COLLINS and I. STEWART write: "The anti-synchronous motion has its own **symmetry**: the **oscillation pattern** is unchanged if the two **oscillators** are interchanged and their respective **phase** shifted by half a **cycle**"

Furthermore: "Coupled **networks** of three or more **oscillators** have more complicated **oscillation patterns** that just **synchrony** and anti-synchrony and some of these **patterns** are highly **counter-intuitive**" (1994, p.39)

0134

**ANTISYSTEMIC WAYS**<sup>1)</sup>

**Linear** thinking is still widely practiced and leads to the illusion that a specific **issue** of problem can be isolated from **context** or **environment** and "solved" through some specific intervention, without any **side effects** In this way a double problem appears:

1) the issue is artificially simplified and, as a result, misunderstood

(J. WARFIELD's **underconceptualization**)

2) **side effects** do indeed appear, and in some cases introduce new problems that may even be worse than those whose solution was sought.

Some are very dramatic, as for example:

- the Aral Sea disaster due to an ill-conceived river harnessing and an irrigation program that took no account of the possible effects on the **environment** of the whole region.
- the growing resistance of all kinds of pests to chemical insecticides, with for ex. the appearance of "super-mosquitoes" able again to propagate various illnesses that were thought to be controlled (Malaria, yellow fever, etc...)
- the growing resistance of pathogens to antibiotics and chemical medicines (Tuberculosis, malaria, hospital infections)

This does not mean that new ways to manage these **issues** (and many others) should not anymore be researched and used . It means that we need to become better chessplayers with nature and, specifically, that we should abandon our narrow views neatly characterized for ex. by the well known motto "**et ceteris paribus**", because, of course the conditions are never twice absolutely the same; or the illusions that any **event** has only one **cause** and produces only one **effect**, or yet that **predictability** is always perfectly and completely possible.

The **systemic approach** is becoming a full need in the complex world that we pretend to manage.

0135

**APOMORPHY**<sup>2) – 3)</sup>

The appearance of a new characteristic, derived from a former one, in a **group** of living **organisms**, leading to the recognition of one and only one new **group**.

The concept of apomorphy is basic to the **taxonomy** of living **organisms** known as **cladism**. A particular group of apomorphic characters is what defines a clade.

0136

**APOPTOSIS**<sup>1)5)</sup>

The **process** of **self-destruction** of the **cells** in the living **organism**.

Apoptosis is a very general **process**, active even at the embryological **level**, where it seems to be important for the progressive construction of the definitive **form** of the living being.

Every biological **element** or individual appears to include some **timer** device. The ways of apoptosis are becoming better known, but its deeper cause or causes remain obscure.

Its relation to **autopoiesis** as well as to **ageing** should also be researched more thoroughly.

This biological **process** discovered quite recently seems to imply a more general systemic **meaning**. It could mean that the need for the system to self-reproduce at its **level** of **complexity** corresponds necessarily to a longer **life time dimension** which is out of reach of its **elements**. This would be more generally an expanding **time dimension of complexity**

Human societies, for example, considerably supersede the living **limits** of their individual **components**, whose **ageing** seems to be commanded by some biological clock, i.e. a **timer**.

(For more on biological **apoptosis**, see "Science", Special issue , 281, nr.5381, 1998).

0137

**APPEARANCES**<sup>3)</sup>

G. BATESON observes: "Always the **process** of **representation** will filter out the *Ding an sich* – i.e the **object** in itself, so that the mental world is only **maps** of **maps**, ad infinitum. All '**phenomena**' are literally 'appearances'" (1967, p.429)

The same view was developed as early as 1933 by A. KORZYBSKI in "Science and Sanity" → "**Structural differential**"

0138

**APPRECIATIVE SYSTEM**<sup>3)</sup>

"The interconnected **set** of largely tacit standards of judgement by which we both order and value our experience" (G. VICKERS, 1973, p.122).

According to VICKERS: "... the **components** of **human systems** – active individuals attributing **meaning** to their **situation** – make it impossible to study such systems using the **methodology** of natural sciences. The only way to understand **decision making** in human

**systems** is to understand the different appreciative systems that the **decision makers** bring to bear on a **problem**" (M.C. JACKSON, 1992, p.135)

And... "It follows, according to VICKERS, that if **human systems** are to achieve **stability** and **effectiveness**, then the appreciative systems of their participants need to be sufficiently shared to allow mutual expectations to be met. **Human systems** depend upon shared **understandings** and shared cultures" (Ibid)

In each culture, specific **values** and **norms**, transmitted through successive generations by imprinting, **learning**, teaching and training produce the equivalent of **organizational closure** in biological systems.

This is reflected in the so-called "Culture of the enterprise", the French "Esprit de corps", the Spanish "Espiritu de la colmena", the German "Gleichschaltung" and many other similar expressions related to cultural or ideological unifying (and dividing) appreciative mental and psychological frameworks.

→ **Semantic reaction**

0139

#### APPROACH <sup>1)2)</sup>

"An internally coherent and theoretically grounded collection of **models**, **methodologies**, **methods**, and **tools** used to learn about the world and to act in it" (K. BAUSCH-Glossary of terms- personal communication)

BAUSCH adds: "It is a flexible and creative way of engaging in a disciplinary **inquiry**" "However the **cybernetic** and systemic "tools" are mostly **transdisciplinary** because they are in fact "meta-tools" i.e. they can be applied in a similar way in many disciplines."

As an example **feedback** as a tool (or a **model**, for that) is a very general **mechanism** that can be recognized and used in all **nonlinear situations**, wherein a cyclical **loop** exist in the form **cause-effect-cause**.

0140

#### APPROACH (Analytic versus Systemic) <sup>1)-3)</sup>

The cutting edge of the systemic approach is thus stated by M. BUNGE: "A systemic approach to any subject boils down to abiding by the principle that every **object** is either a system or a **component** of a system. The methodological consequence is obvious: Nothing can profitably be studied in isolation" (1993, p.210).

J.de ROSNAY explains as follows the differences between the two approaches: "The analytic and systemic approaches are **complementary more than opposed**. However they are not reducible to each other. The analytic approach aims at reducing a system to its most simple constitutive **elements**, in order to study them in detail and understand the types of **interactions** which exist among them" (1975, p.109)

A good example is the study of the **components** of water and the way they associate: H<sup>2</sup>O is one bivalent O associated to two monovalent H, due to complementarity of electronic shells.

"Next, one modifies one **variable** at once to try to deduce general laws permitting the **prediction** of the systems properties in very different conditions. In order to be able to obtain such **predictions**, the laws of **additivity** of elemental properties must be valid. This is the case with **homogeneous systems**, i.e. those whose **elements** are similar and present weak reciprocal **interactions**. In this case, statistical laws can be applied and produce an **understanding** of the mass, i.e. of **inorganized complexity**" (Ibid)

In this dictionary, "inorganized complex systems" are named "**composite systems**" and their **behavior** is considered under the heading "**Criticality**". "The **additive** laws of elementary properties are obviously not anymore valid in the case of highly **complex systems**, made of a very great diversity of **elements**, linked by strong **interactions**. Such systems must be tackled with new **methods**, such as those of the **systems approach**. Their **goal** is to consider a system as a **whole**, with its proper **complexity** and **dynamics**. By the use of **simulation**, for example, it becomes possible to "animate" the system (i.e. its **model**) and to observe in real **time** the **effects** of the various types of **interactions** between the **elements**" (Ibid) This is done by FORRESTER's **Systems dynamics**, which is a powerful tool, but has also its weaknesses, for example about the real possibility to modelize **simultaneity** of **effects**.

"The study of its **behavior** in **time** leads to the determination of **rules** for **action**, whose aims are the modification of the system or the conception of new ones. Better than a point by point **description** of the characteristics of both approaches, it seems more useful to oppose them in a (comparative) table, not starting... a debate about their respective advantages or drawbacks" (Ibid) *see table right column*

"This table, useful because of its simplicity is however no more than a caricature of reality. This too dualistic **representation** locks thought up within an alternative, apparently difficult to avoid. Many other comparison points should be mentioned. However, while not exhaustive, the table is useful by defining two complementary approaches, of which one (the analytical one) has been favored in a quite disproportionately large way in our whole education" (1975, p.110)

Within the systemic approach itself, R. RODRIGUEZ DELGADO distinguishes three aspects, as follows:

##### "a) Static approach

Systems basic **structures**, **Components**, **Subsystems** and **elements**.

##### Analytic approach

**Isolates**: centered on **elements**

Observes the nature of **interactions**

Relies on precise details

**Independence** from **time**;

**Phenomena** are considered **reversible**

Modifies one variable at once

**Validation** of facts obtained experimental proof within a theoretical **frame**

Precise and detailed rigorous **models** difficult to use in **action** (for ex. econometric models)

Approach is efficient when **interactions** are weak

Leads to a disciplinary teaching (juxta-disciplinary)

Leads to a detailed **programming**

Produces a good **knowledge** of details; but ill defined **goals**

##### Systemic approach

**Connects**: centered on **interactions**

Observes the **effects** of **interactions**

Relies on global **perception**

Integrates duration and **irreversibility**

Modifies simultaneously groups of **variables**

**Validation** of facts obtained by comparing the way the **model** is working, with reality

**Models** are not enough as bases for **knowledge** but are **useful** for **decision** and **action** (for ex. The **Club of Rome models**)

Approach is efficient when the **interactions** are **non-linear** and strong

Leads to a **multi-disciplinary teaching** (**Should lead to a transdisciplinary teaching**)

Leads to an action aimed at **goals**

Leads to **knowledge** of **goals**, but ill defined details

Communication channels (System's Anatomy)

##### "b) Dynamic approach

System and **subsystems functions**. **Relationships** with **suprasystems** and **ecosystems**. Organic **cycles**. **Homeostasis** (System's Physiology)

##### "c) Dialectic approach

Reproduction of systems. Mutations. **Structural transformation**. **Selforganization**. (System's **ontogeny**) – Individual **transformation** and phylogeny – Apparition of **emergent species** or **models**

"Research into these complementary aspects open new possibilities to transform **environmental** conditions, human **organizations** and systemic **goals**, making easier the elimination of **constraints** and limitations" (1993b, p.32)

Of course, such positive aspects become possible because of a better previous **understanding** of these limitations and **constraints**, some of which may correspond to unavoidable and even in some cases, desirable (while misunderstood) conditions. Let us avoid any triumphalism.

0141

#### APPROACH (Hazards of the systemic) <sup>3)</sup>

Joel de ROSNAY describes in the following way some distortions which could discredit the **systemic approach**:

"In order to better demystify the **systemic approach** and allow it to maintain a **transdisciplinary** attitude and a training for the **control** of **complexity** and **interdependence**, should

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

we not even reject the very term of **systemic approach** or **method**? Everyone can learn to "stand back". Global vision is not a preserve of the great managers, the philosophers and the scientists. To learn the use of the **macroscope**, to apply the systemic **rules**, to build more rigorous mental **models** and even to be able to control the interplay of **interdependences** (can be done)".

"But we should not occult the hazards of a too systematic use of the **systemic approach**. A purely descriptive approach from the exclusive relational angle leads quickly to a useless collection of **models** of the different natural systems. The excessive generality of the systems concept may also be turned against it. Its fecundity may be destroyed by sterile **triviality**. All the same, the ill controlled use of **analogies**, **homologies** or **isomorphies** may lead to some complicated in spite of clarifying interpretations because they are based on superficial **similarities**, more than on basic principles and laws common to all systems. According to E. MORIN, "too much unification risks to lead to abusive simplifications, obsession and thought recipes".

"Once more we are threatened with the dogmatic danger if we draw the systemic approach back to an intransigent systemism or to a **reductionist** biologism. We are threatened by the seduction of **models** conceived as results of insight instead of starting points for research"

"One of the worse risks which threatens the **systemic approach** is to be tempted by a "unitary theory" (a "theory of everything"), an englobing **model** which should have a solution for everything and could predict everything. The use of the mathematical **language** – generalistic by its nature and vocation – may lead to a formalism apt to isolate the **systemic approach** instead of opening it to practice. The "**General Systems Theory**" barely escapes to this risk: at times it secludes itself within the **theory of graphs** languages, the **theory of sets**, the **theory of games**, the **theory of (quantitative) information**, at times it becomes no more than a **set** of descriptive approaches, many times quite illuminating, but devoid of practical applications.

"The operative **systemic approach** is one way to reach beyond these alternatives. It avoids the risky pitfalls of paralysing **reductionism** and englobing systemism. It opens the way towards **knowledge transmission**, **action** and creation.

"About **knowledge transmission**, the **systemic approach** offers a conceptual **reference frame** which helps to organize **knowledge** in the course of its acquisition, reinforces its memorization and make its **transmission** easier.

"About **action** it enables to obtain **rules** to approach **complexity** and allows for the correct location and **hierarchization** of **elements**, basic for **decision making**.

"Finally about creation, the systemic approach catalyzes imagination, **creativity** and invention. It supports inventive thinking, while the analytic approach supports inquiring thinking. Systemic thinking should be tolerant and pragmatic, open to **metaphor**, **analogy** and **model**, formerly excluded from the "scientific method" and now rehabilitated. For the systemic approach, anything which ends partition of **knowledge** and releases imagination is welcome: it should be open, just as the systems it inquires" (1975, p.128-30)

0142

### APPROACH (The Ten Commandments of the systemic) <sup>1) – 2)</sup>

J.de Rosnay enumerates as follows the "10 Commandments of the Systemic Approach"

1. To keep **variety**
2. Not to open the **feedback loops** (i.e. not destroy the **regulators**)
3. To seek the **amplification** points
4. To establish **equilibria** through decentralization
5. To maintain **constraints**
6. To differentiate in order to improve **integration**
7. To evolve, by reaction to aggression
8. To prefer **objectives** instead of detailed **programming**
9. To know how to use **energy** (contained within **information**) for **management**
10. To respect **reaction delays**" (1975, p.122-127)

It is obviously possible to imagine other "commandments", less limited to human systems and, of course less operative, as for example:

- to define as precisely as possible the significant **environment** of the system
- to clearly define the main **objective** of the system and its subsidiary ones
- to find out the different **rhythms** of **activities** of the system and discover their interrelations
- to determine the degree of maturity of the growing system: just born, or emergent, in **steady state**, or in the **process** of **sclerosis**.

0143

### A PRIORI (Kantian) <sup>3)</sup>

F. GONSETH discussed the validity of KANT's (1724-1804) a priori, when viewed as an absolute and unquestionable beginning for philosophy. He did not accept that "the debate is closed even before starting" when it is admitted that a priori are the "sine qua non of all

**knowledge** and judgements" as they set the very forms under which **experience** must unavoidably manifest to us" (1955a, p. 6)

In fact "compare a priori with the results of **experience** (of whatever kind) is simply compare them with themselves. Nothing can emerge of this, if not that they must be as they are" (Ibid)

Indeed, the a priori is established by the **observer** (supposedly being the infallible philosopher) within his own **frame of references** and we are led to the **autopoietic** critique of the ways we observe **reality** and of what **observation** amounts to in these bio-psychological terms.

In short, no a priori can establish an absolute starting block, being out of reach of falsifiable research of any kind.

0144

### ARC <sup>5)</sup>

→ **Graph**

0145

### ARCHETYPE <sup>1)</sup>

The sum of interrelated characters, accumulated through **time** by former systems, which defines the basic **structures** and **functions** of a new system of the same kind.

Any archetype is a **more** or **less** abstract **model**, whose concept is Platonian in nature.

G. BATESON calls it a "**genotype**" and defines it as a "body of **memories**", as he refers himself basically to biological systems. (1973, p.287)

Nobody has ever given a definitive and rigorous explanation about the way archetypes become established. As to BATESON's "body of **memories**", F. DAVID PEAT connects in a hypothetical way Jungian psychoanalytical archetypes with the **hierarchic structure** of the **brain** which is "...often pictured as containing a series of evolutionary **levels** beginning with its primitive reptilian **brain** stem and working upward to the higher primate functions of the cortex. In addition, there are probably a number of evolutionary remnants present in the chemical pathways of the various neurotransmitters, peptides and other chemicals used in the **brain**" and while "such arguments contain more speculation than facts (they) suggest that the unconscious mind arises out from a more primitive **layer** of the **brain** which is not yet capable of secreting "higher" conscious thought" (1988, p.107).

It is anyhow undeniable that dogs engender dogs and cats, cats; and that such is the basement of identity and **organizational closure** in systems.

→ (see also: **Ideal-type**)

As explained by C. WADDINGTON, through his concept of **epigenetic landscape** (1977), evolutive **change** of an archetype does never occur freely in a vacuum.

As a result of its archetypical inheritance, any **organism** is endowed with *limited* (even if within a considerable potential for **adaptability**) possibilities of development from its **auto-genesis** on, and is thus able to construct itself only through a *pre-constrained morphogenesis*, in **interaction** with its **environment**.

0146

**ARCHITECTURE (von Neumann's)**

→ von Neumann's architecture

0147

**ARGENTINE ASSOCIATION FOR GENERAL SYSTEMS THEORY AND CYBERNETICS**<sup>1)</sup>

This Association was created in October 1976, originally under the name of Study Group of Integrated Systems. It was the first systems society in Latin America. Its main objective is the study and the diffusion of systemics and cybernetics through lectures, tutorials, seminars, and production of series of translations, and original papers and booklets ("Cuadernos", of about 100 pages each)

It organizes seminars and study groups on more specific subjects, or for disciplinarian groups. Since 1992, an annual meeting gathers Argentine systemists and cybernetists, around some specific subjects. The Association also promotes visits of foreign systemists.

It published in 1992, in Spanish, the first Dictionary of Systems and Cybernetics, in collaboration with the **Instituto Andino de Sistemas** of Perú.

0148

**ARGUMENT (Ad hoc)**<sup>3)</sup>

An hypothesis or conjecture introduced to solve an hitherto insoluble problem.

One wonders if some hypotheses very far away from **common sense** and not verifiable, introduced for example in some scientific **theories**, are not simply a way to "get out of the trouble". Changing the basic conditions of some **phenomena** and/or **theories** does not seem a very satisfactory option. (See John BARROW: "Is nothing sacred?", 1999).

These doubts were already aired by the French philosopher and epistemologist G. BACHELARD (1884-1962) ("La Philosophie du Non", 1949).

It is however doubtless that the very different **abduction** (PEIRCE)(1839-1914) is highly valuable in terms of **creativity**. Without the resulting "educated guesses", **knowledge** in general, and science in particular, would remain finally bogged down into static conservatism.

The difficulty is to differentiate **abduction** at its incipient state from useless imagination.

An example of genial **abduction** was WEGENER's (1880-1930) idea of continental **drift**, whose value was only recognized various decades later.

0149

**ARGUMENTATION ANALYSIS**<sup>1)2)</sup>

An ordered **presentation**, preferably in graphical or matricial form, of the various significant opinions that can be identified on some **issue**.

This **method** can be very useful in order to avoid what J. WARFIELD calls "**underconceptualization**", "**clanthink**" or more generally muddled thinking.

It provides a sound foundation for **conflict resolution**, **conversation**, negotiation and **design**.

0150

**AROGENESIS**<sup>1)5)</sup>

An emerging jump in an **evolutive process** (W. SCHWEMMLER, 1991, p. 152)

0151

**ARRAY (Activity)**<sup>2)</sup>

A **set of data** relative to a system's **behavior** organized in the form of a two- or three-dimensional **matrix**. (After G. KLIR, 1975, p.154)

G. KLIR uses such arrays – which can be processed – for experimental research.

0152

**ARTICULAR RELATION**<sup>2)</sup>

Any **connection** device that provides a number of **degrees of freedom** in a **relation** between two **elements** or **structures**.

This notion was introduced by the French physiologist P. VENDRYES (1973, p.88) and is a generalization from the articulations between bones.

VENDRYES explains that no movement would be possible if bones were rigidly united. Freedom of movement depends on the possibility to adopt a number of different relative positions, as flexion, extension, rotation, etc... However movement could not be coordinated if the **relations** were totally undefined. The ligaments and their **connections** with the bones and muscles provide a more or less extensive **program** for mobility **relations**. This **program** is framed within defined **determinisms**, but, at the same time, within this **frame** it allows for a **variety of combinations**, and much more so when there is a **chain** of articular relations, as for example from the shoulder to the fingers. In VENDRYES terms: "Thanks to its elasticity, a muscle admits articular **indeterminism**; by its contractibility it imposes a **determinism**" (p.90) As a result, a number of more or less

**random** options do exist. But any defined movement selects only one and thus imposes at some moment, in some situation and for a limited **time**, a specific **determinism**.

According to VENDRYES the articular relation concept can be generalized to any relation wherein a number of undefined possibilities co-exist, but where only one can be selected (excluding all others) at any specific moment.

As an example, he gives the articular relation between words in a **language**.

The **analogy** with **decision** mechanisms in general is also striking.

0153

**ARTIFACTS**<sup>1)</sup>

"Things fashioned by rational beings with the help of some technique whether primitive or advanced" (M. BUNGE, 1979, p.209)

BUNGE comments: "An artifact is not just one more thing but a thing belonging to a kind that did not exist before the **emergence** of man or some other rational being. Artifacts may be regarded as constituting a whole new **level** of reality, namely the **artiphysis**... Artifacts are at the heart of human society and have properties absent from natural things" (Ibid).

It should however be remembered that the beginnings of rationality are ill-delimited: some apes make and use very simple artifacts, and also some Galapagos finches observed by DARWIN. Even spider's webs or beehives could be considered as artifacts constructed either by individuals or by collectivities, not obviously rational in the commonly accepted sense.

Construction of artifacts seem to be a **living systems'** capability still in full course of **evolutive development**.

The multiplication of artifacts deeply transforms the relation between man and the planetary **ecosphere** because it tends to create a global human **invironment** more and more distinct from the global **environment**.

The same **effect** is also present at more local **levels**: we are becoming "synthetic fishes in a plastic aquarium", with ever lessened contacts with our natural **environment**.

0154

**ARTIFICIAL EVOLUTION**

→ Evolution (artificial)

0155

**ARTIFICIAL INTELLIGENCE**<sup>3) - 5)</sup>

"The creation of **algorithms** and systems that exhibit intelligent **behavior**, including activities such as adaptive and **heuristic programming**, cognitive **process modelling**, **expert systems**, natural **language** processing, and **neural networks**" (G. FORGIONE, 1991, p.64)

<sup>1)</sup>general information   <sup>2)</sup>methodology or model   <sup>3)</sup>epistemology, ontology and semantics   <sup>4)</sup>human sciences   <sup>5)</sup>discipline oriented

This definition covers a wide area of quite different subjects. It is much more than, in K. KRIPPENDORFF's words: "A branch of computer science concerned with the **programming** of computers so that they exhibit apparently intelligent **behavior**, e.g. the **design** of **robots**, chess playing **automata** or theorem proving machines" (1986, p.4)

The "apparently intelligent **behavior**" conforms to the **TURING's criterion** according to which a "**machine**" should be considered intelligent if an **observer**, unknowing that she/he is dialoguing with a **machine**, cannot differentiate it from a human being.

According to M. MINSKY, an A.I. device must have an **understanding**, at least rudimentary, of its own **problem solving processes**. He believes that, if one endows it with a **model** of its own workings, it could finally improve itself.

This seems questionable, at least for two reasons:

- **GÖDEL's Incompleteness theorem** may not allow any system to contain a complete **model** of itself.
- If the **model** is introduced from outside, the predominance and necessity of natural intelligence is reestablished.

FORGIONE's definition reflects the evolution of the field, already observed in 1980 by M. BODEN who wrote that: "Artificial Intelligence cannot be expressed in the terminology of traditional **cybernetics**, which focusses on **feedback** and adaptive **networks** and which defines **information-processing** in quantitative rather than qualitative terms" (1990, p.30)

E. ANDREEWSKY states: "Two main axes which, to judge by current debates, appear to be **antagonistic**, characterize the **cognitive models** of Artificial Intelligence: *the so-called 'classical' Artificial Intelligence* where **cognition** is considered from a "software" viewpoint (insofar as it concerns, as in computer **programs**, "computation" on **symbols**) and **Connectionism** where **cognition** is considered as if "emerging" from the **brain** and its neurons. These axes define different, but nevertheless very complementary, points of view on mind" (1993, p.189)

And "**Connectionism** is considered by the tenants of classical Artificial Intelligence as a resurgence of **Behaviorism**, with the negative connotations associated to this approach. For **connectionists**, classical Artificial Intelligence is merely a "Spanish inn", insofar as the **rules** (or the **meta-rules**) of reasoning are given to the system" (p.194) (Note: In Spanish inns of old you were supposed to find only what you brought in yourself)

In fact, the classical view on A.I. implies that no intelligent system can work without a **program** of **algorithms**, i.e. a software. This is probably true, but how are these very **algorithms** constructed?

The **connectionist** answer tries to explain this point through the concept of "spontaneous" upbuilding of **patterns** from unplanned **interconnections** in the **network**. Furthermore, the **representations** acquired by the **network** are seemingly spread out over the whole **network**, in a kind of **holographic** way. But how do these **patterns** become fixed and how are the **rules** to construct the **network** generated? The very general topic of **order** from **randomness** lurks behind these question marks.

The problem seems to be closely related to the **autogenesis** one and, as said by ANDREEWSKY, *both* viewpoints are probably needed. Remains to be seen how they can be interconnected and integrated.

→ "**Power laws in fractal structures**" and "**Autogenetic systems precursors**".

Still a different angle is generalization through **induction**, as for example in the famed BACON program which "rediscovered" several classic physical laws: KEPLER's law of planetary motion; NEWTON's law of gravitation and BOYLE's law of gases, among others.

Generally speaking, D. GREGORY describes as follows what he calls the basic "realist" axioms, **problems** and **goals** of A.I.

"**Axioms**:

- **Knowledge** is a commodity. We can trade it, teach it, learn it, forget it, remember it, represent it, discover it...
- **Knowledge** is distinct from its knower – just like **data** are distinct from computer disks
- **Knowledge** is **sets** of true **facts** together with **rules** for combining them
- **Knowledge** can be reduced to **sets** of primitives – just like **matter** is ultimately reducible to fundamental particles" (1993, p.67)

(All these views are controversial, some of them highly so: **Knowledge** should be only acceptably understood here in T. ÖREN sense (see "**Knowledge (Taxonomy of)**")

"**Problems**:

- To elicit **facts** that are free of the distortions produced by the way they are known or described
- To represent **facts** and their inter-**relationships** so as to capture the way the world really is
- To specify a utilization engine that arrives at conclusions that are true in the world" (Ibid) (The words "**facts**", "really" and "true" should be carefully pondered in order to cautiously relativize their use. See for example "**Club of Rome**" models and "**Systems dynamics**")

"**Goal**:

- To build an Artificial Intelligence: a disembodied, artificial subject matter expert with whom **conversations** are possible" (Ibid)

D. GREGORY's conclusion is that "A.I. research seeks to understand the principles by which pragmatically and **semantically** interesting **behaviour** can be produced with **syntactic** machinery" (p.63)

Such a **mechanistic** and more or less **reductionist** view is widely, but not universally accepted.

0156

**ARTIFICIAL INTELLIGENCE: dogmas and metaphors**<sup>3)</sup>

As stated by S. GOONATILAKE: "Broadly speaking, it could be said that there are two main aims of people engaged in AI research. The first is building 'smart' **machines** or what could be called 'technological AI'; the other aim of AI researchers is to build **models** of **cognitive processes**, thereby helping one to understand the mechanisms of the mind" (1991, p.108)

Both groups brought into the subject their specific preconceptions (or even prejudices)

P.R. MEDINA MARTINS and L. ROCHA consider that the following dogmas have, until quite recently, "framed not only the kingdom of artificial systems but also – more deeply – their designer's minds:

- the dogma of the logical mind
- the dogma of the disembodied mind
- the dogma of the timeless mind
- the dogma of the adult **observer**
- the dogma of **objectivity**
- the dogma of the "in" and the "out" (1992, p.683)

These dogma are rooted – according to the authors – into two main interrelated **metaphors**, i.e. "the **brain** as a *serial* computer" and "the mind like a computer"

The implicit use of this conceptual **frame** led to **reductionist** views on human **brain** and intelligence, which created a number of senseless problems in psychology and also brought artificial intelligence to a conceptual dead end (If and when one admits that A.I.'s only aim is or should be to mimic natural intelligence, which is not obvious). Gigantic, but rigid basically sequential **algorithms** can obviously not replace nor reproduce the simultaneous and parallel workings of **neural networks**, notwithstanding the fact that sequential computers and some **expert systems** obtain specific results which are out of reach of natural intelligence.

As noted by G.J. DALENOORT: "... artificial intelligence went on for some twenty years in constructing **programs** that could do something that on the outside was similar to what humans could do, without bothering at all how this capacity could have emerged in the human system" (1987, p.14)

As **meanings** are always "human" **meanings**, any **symbol** used in a classical A.I. **program** has necessarily been human constructed, and this also true for the **program** used, which is not endowed with anything more than rigid **binary logic**, sequently applied in a rigorously predefined way. **Binary** computers have thus no autonomous **learning** capacity and, consequently, are no satisfactory **metaphors** for natural intelligence.

0157

**ARTIFICIAL LIFE**<sup>5)</sup>

The creation of collective artificial units able to spontaneously construct complex **behavioral patterns** through **cooperation** and shared **information**.

Artificial life is, of course, not biological (Nothing to see with Dr. FRANKENSTEIN's creature). It is either computer modeled, or consists in devices assembled from mineral and electronic **elements**, which somehow mimic some **living systems behavior**.

The first A.L. device was Grey WALTER's **Machina speculatrix**, unfortunately merely considered at the time, as a kind of amusing **cybernetic** toy, after which it was forgotten for about 30 years (along with the French A. DUCROCQ's electronic foxes)

Artificial life is thus a quite new field of research. C. DELAYE et al in France, C. LANGTON's team in the U.S., L. STEELS in Belgium among others, are exploring "**cooperation** between distributed **agents** through **self-organization**" (STEELS, 1990).

Artificial life would be based, in terms of C. DELAYE and B. CORBARA on: "...reactive **agents** which would not possess any **representation** of themselves, nor of their **environment** and whose **behavior** is based on **stimulus/response mechanisms**" (1993, p.840)

This model is based on an **analogy** with some **colonial** animals, as for example **Dicystelium discoideum**. However, until now no specific socialization factor, comparable to cyclical AMP, has been demonstrated to exist.

In any case, artificial life, just as the natural one, is basically a social **phenomenon**, with eventually (in the French researchers terminology) various **emergent levels** of **complexity**: collaborating **reactive agents** into super-agents, etc... (ibid., p.841)

G. PASK has however argued that much of the qualities of **self-organizing systems** are determined by their fabric. As proteins are different from electronic chips, artificial life could be similar to natural one in the **self-organizing** aspects, but probably not much more than that.

→ **Automaton (Learning); Parallel Distributed Processing**

0158

**ARTIFICIAL LIFE 2**<sup>5)</sup>

The creation of new living **organisms** through the assembly in laboratory of new composite genomes.

This biological artificial life is widely different from either the creation of societies of cooperative **robots**, or **computer modelling** of possible artificial **organisms**.

Research in this field is just beginning at the Institute for Genomic Research of Doctors CRAIG VENTER and CLAIRE FRASER in Maryland (The Economist, January 30th, 1999).

The possible development of this type of project should be closely monitored, in view of its considerable potential for revolutionary **transformations** in biology and **ecology**.

0159

**ARTIFICIAL LIFE (The Seven Commandments of)**<sup>1)</sup>

The following is a shortened synthesis of the subject as presented by C. EMMECHE (1994, p.17-22)

"In its ambitious version, the **concept** of artificial life encompasses the following ideas.

"1. The biology of possible... artificial life deals with **life as it could be**... Biology today is only the biology of actual life. It must become a biology of any possible life-**forms**.

"2. **Synthetic method**. Where traditional biological research has placed emphasis on analyzing living beings and explaining them in terms of their smallest **parts**, the artificial-life perspective attempts to synthesize life-resembling **processes** or **behavior** in computers or other media.

"3. **Real (artificial) life**. Artificial life is the study of humanly created systems that exhibit **behavior** characteristic of natural **living systems**... They are designed by us. The **behavior** however is produced by the artificial life itself.

"4. All life is **form**. Neither actual or possible life is determined by the **matter** of which it is constructed. Life is a **process**, and it is the **form** of this **process**, not the **matter**, that is the essence of life.

"These four theses are related"

There are moreover "three additional commandments about the way in which artificial life must be constructed:

"5. **Bottom-up** construction. The **synthesis** of artificial life takes place best via a principle of computer-based **information processing** called "**bottom-up programming**": at the bottom many small units and a few **rules** for their internal purely local **interaction** are defined (This is the real **programming**). From this **interaction** arises the coherent "global" **behavior** at the general level: a **behavior** not previously programmed according to specific **rules**.

"6. **Parallel processing**. While **information processing** in a classical computer takes place sequentially ... the principle for **information processing** in artificial life is based on a massive **parallelism** that occurs in real life.

(Note: i.e., reflecting the **simultaneous activity** of many individual **elements**).

"7. Allowance for **emergence**. The essential feature of artificial life is that it is not pre-designed in the same **trivial** sense as one **designs** a car or a **robot**. The most interesting examples of artificial life exhibit "**emergent behavior**".

0160

**ARTIFICIAL SELECTION**

→ **Selection (Artificial)**

0161

**ARTIPHYSIS**<sup>1)</sup>

The global **set of artifacts**

This neologism is used by M. BUNGE (1979, p.209)

The present research into "**artificial life**" gives a much wider dimension to BUNGE's assertion that artiphysis is a whole new level of reality. It could become a kind of globally organized artificial **ecosystem** whose future **relations** with the natural one opens a whole field of new questioning.

0162

**ARTORG**<sup>2)</sup>

Artificial organism.

This neologism has been sometimes used during the fifties and sixties. It was never widely accepted.

0163

**ASCII Code**<sup>5)</sup>

A basic **code** made of **bytes** that is used to represent a common **language** in a computer.

8 **bits**, each of it with the value 0 or 1 (or cells in a **TURING Machine**) make a **byte**. There are thus 2<sup>8</sup>, i.e. 256 possible distinct combinations, which is quite sufficient for example for common **alphabets**, with punctuation and special **signs**.

0164

**ASILOMAR CONVERSATIONS**<sup>1)</sup>

The periodic meetings of a number of systemists in Asilomar, California.

The general goal of these meetings, originally inspired from the **Fuschl Group Conversations**, is to freely exchange views about specific human **issues** - as for ex. **education**, social **design**, social **organization**, social **awareness**, the future of societies, etc...

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

These conversations start with a general agenda, but develop in an open way through free debate in subgroups which define their specific agenda for the consideration of more precise aspects of the general agenda.

The conversations conclusions are not prescriptive, but could be called "inspirative".

0165

**ASSESSMENT (Collective reciprocal)**<sup>1) - 4)</sup>

A process of reciprocal **perception** and/or **information** leading to a shifting collective **behavior**.

D.M. GORDON showed that work in the anthill is a collective **distributed process** based on an also collective **perception** of the global needs, arising out of shifting **tasks allocation**, which in turn arise out of numerous **interactions** between individuals. (1995, p.50-7)

This type of **processes** obviously would deserve a general systemic research, because it is probably present in all kinds of **social systems**, from cells to **human systems**.

0166

**ASSESSMENT in systemic terms**<sup>1) - 4)</sup>

A. CASELLES proposes "a theoretical approach to all kinds of **forecasting** and **control** problems" considering "**General Systems Theory** ...specially adequate to the most difficult ones" (1993, p. 1285-89)

Applying his proposal to technology assessment, he suggests a **frame** "to begin the identification **process** of the **elements** and **connections** involved... in each technology assessment case", as well as a mathematical **model** taking in account the following factors:

- Required services depending on **population** implicated and on unitary demand respect to each service;
- **Population** implicated (based on a demographic **submodel**);
- Unitary demand (for example, all urban transport made by private cars makes the **unitary demand** of street surface higher than when public transport is used);
- Effective capacity to produce services;
- **Resources** to services; an **input variable** that enters the **resources** distribution among services, made by managers;
- **Resources** required by each technology;
- Offered services (producing an income);
- **Resources** consumption and **operation** (which produce a **cost**)"

R. PETRELLA (Director of the Program "Forecasting and Assessment in Science and Technology" of the European Union) writes: "... Technology Assessment is the **set** of procedures and **means** at the disposal of a society for the **understanding** of the nature and im-

port of scientific mutations, development and uses of technologies and for research about their usefulness, their economical feasibility, their social relevance and value" (1993)

This confirms that assessment, specially in technological matters, is much more than a simple study of technical and economical adequacy of some innovation, confirming the usefulness of CASELLES' proposed systemic **methodology**.

However, his list of technical **criteria** should be expanded in order to take in account some other important aspects, as for instance: **Costs** of **resources** renewal, or impact of their exhaustion; impact on **ecosystems**; social benefits and **costs**; probable duration of usefulness, etc...

To make this clearer, CASELLES' **criteria**, if applied for example to the realization of the Kazakhstan irrigation scheme - which ruined the whole Aral Sea **ecosystem** and the human system depending on it - would have passed it with flying colors. The purely technical and economical **criteria** applied where wholly insufficient to predict possible **side-effects** of different types.

0167

**ASSIMILATION**<sup>1)</sup>

Integration of external factors into a system's **structure**.

J.W. SUTHERLAND considers assimilation as the "complementary pole" of **acomodation**, which is merely a temporary or more or less lasting and reversible **adaptation** of the system to external variations.

The concept is somewhat difficult to conciliate with **autopoiesis** and **organizational closure**. Any system can assimilate only that which is compatible with its basic nature. Besides, assimilation seems possible only when the system still possess a high degree of **redundancy** (see **ageing**, **order from noise**).

Assimilation within the individual system, is *not* the mechanism, or at least the main mechanism, of **evolution**. This last comment commands however two caveats:

- The acquisition of new **habits** may well predispose in either a positive or negative way, the individuals of some species to the **transmission** of **dormant** or new traits.
- In the human species, mental assimilation of newly acquired **concepts**, **percepts** and symbolic associations seems to be directly transmissible through **communication**, something that KORZYBSKI called totalization through **time-binding** (1950b).

0168

**ASSOCIATION**<sup>2)</sup>

"The **relation** which is **commutative** and **connected**" (J. FEIBLEMAN & J.W. FRIEND, 1969, p.33)

Grains of sand which accumulate in a dune are related in an associative way, since this way is **commutative** (The **order** in which they accumulate is irrelevant), and **connective** (since no **element** needs of any intermediary one to be in contact)

Association is thus a simple, non-**structural** and non- **functional relation**, at least in the **meaning** proposed by FEIBLEMAN and FRIEND. It is here the most primitive and rudimentary form of **coordination** among **elements**.

It reflects however a **trend**, generally induced by common conditions imposed to the **elements** by the **environment**, as for example dominant winds on sand dunes.

The generally accepted sense in social psychology and sociology goes quite farther than this and includes the **results** of closeness, i.e. defined **interactions in groups** and **social systems**.

0169

**ASSOCIATION (Potential for functional)**<sup>1)2)</sup>

The existence of conditions in **elements** that could allow for the **emergence** of significant **relationships** among them.

Good examples are the combinatory potentials of chemical **elements** as a result of the different **states** of the electron shells of their atoms.

0170

**ASSOCIATIVITY**<sup>2)</sup>

The propensity of **elements** to form **links** and create **networks** or **structures**.

The most elemental forms of associativity are seen in **composite systems** and in **colonies**, where **subsystems** are not yet clearly differentiated. Such forms tend however in some cases to evolve toward much more strongly **integrative** types of **organization**. Any system is a more or less highly organized reunion of associated **elements**.

0171

**ASSOCIATOR**<sup>1)</sup>

"The **subsystem** which carries out the first stage of the **learning process**, forming enduring **associations** among items of **information** in the system"

This one of J. MILLER's 20 **critical subsystems** (1978, p.3)

0172

**ASSOCIAZIONE ITALIANA per la RICERCA sui SISTEMI (AIRS)**

→ **Italian Association for Research on Systems**

0173

**ASSUMPTIONAL ANALYSIS**<sup>2)</sup> - 4)

A **methodology** to reveal hidden assumptions of **stakeholders** in a **group** or **organization** confronted with some difficult **situation**.

This **methodology**, proposed by I.I. MITROFF and H.A. LINSTONE, is described by them in their 1993 book. Their general view is that it is "far better to debate a question without necessarily settling it than to settle a question without debating it" (p.146) Indeed, this last way is the best recipe to obtain an incomplete or false view of a **situation** or **problem**.

However, questions are settled without debate at least partly because their do not come out clearly and as a result, are easily ignored or jumbled. To make them appear clearly is specially important when they include conflicting views as held by the different **stakeholders**, because this is the only way to obtain a critical evaluation of the whole matter under consideration.

According to MITROFF and LINSTONE, the first step is to find out who are the **stakeholders**, that can affect or be affected by the **situation** as it is or as is could evolve. This they do by establishing a **graph** of all **stakeholders** (p.141). For example, in the case of a drug company, these are: the customers and patients; the physicians; the pharmacists; the suppliers; the salesmen; the competitors; government agencies; the holding company; the company management and the stockholders (not to be confused with the much more general **class** of the **stakeholders**!). In this way, it will become possible to obtain a most complete view of the **situation**.

The second step is to make the different **groups** of **stakeholders** expose their assumptions, which are mapped one by one into grids whose coordinates are "certainty-uncertainty" and "least to most important" (p.144)

In this way most hidden aspects can be brought to light and seriously debated. J. WARFIELD's **Generic Design** provides quite similar **methods** to avoid **underconceptualization** and incoherent debate (1994b).

Anyhow, assumptional analysis is by nature an open **process**. M. JACKSON considers that even after a synthetic list of assumptions has been established and a rating chart constructed (see hereafter), this is still a mere compromise among different- and possibly divergent- opinions. Thus "assumptions (should) continue to be negotiated and modified...for as long as progress is being made"(p. 228, 2000)

It is moreover obvious that the **issue** or **situation** may evolve. Accordingly assumptions may never be definitive, and corrective **iterations** of the analysis may be needed.

0174

**ASSUMPTIONS RATING CHART**<sup>2)4)</sup>

After due and as complete as possible tracking of the respective assumptions of all **stakeholders** about some **issue** they should be evaluated, ordered, and rated according to their relative certainty and importance.

This is best done by constructing a chart with two perpendicular axes; the one from most to least certain, and the other from most to least important (M. JACKSON, p. 228, 2000)

The known Eisenhower graph on respective importance and urgency of issues- as well constructed along two axes- is also about assumptions ratings

0175

**ASYMMETRICAL DEPENDENCE**<sup>2)</sup>

The dependence of systems on a lower **level** of **complexity** in relation to higher **level** ones in **organizations** or **ecosystems**.

This is a characteristic **relation** in **hierarchic systems**, where lower **levels** of **organization** depend on **regulations** and **controls** by higher **levels**.

More generally, any system or **subsystem** finds itself within a relation of asymmetrical dependence in relation to its **environment** or **suprasystem**. Even if and when it is able to modify its **environment** in a way more suitable to its necessities, such possibilities are limited by its **archetypical survival** needs.

It should be noted however that higher **levels** are also dependent of the lower ones, which provides them with the basic **inputs** they need in order to exert their **roles** as **regulators**, **controllers** and **deciders**.

0176

**ASYMMETRY**<sup>1) - 2)</sup>

1)"The differentiation of one half from the other" (G. BATESON, 1973, p.353)

2) "A union of unequal opposites, the coexistence of two different, opposite poles in a unity" (H. SABELLI & L. CARLSON-SABELLI - 1992, p.660).

The SABELLI's view asymmetry, the general result of **symmetry-breaking**, as the fundamental cosmic order in relation to the temporal **flow** of **energy**, as "Whereas mechanics (classical, statistical, relativistic, or quantum) postulates stationary and **reversible processes**, **thermodynamics** and **dynamics** postulate that **processes** asymmetrically tend to **attractors**" (p.661). Thus asymmetry is "imprinted in the **form** of every **object**" (Ibid.).

H. SABELLI observes that "this concept of cosmic asymmetry has been validated in our century, beginning with the discovery of the non-conservation of parity in beta decay, the optical rotation of atoms, the string theory of **matter**, the importance of highly asymmetric, **nonequilibrium states** in the **thermodynam-**

**ics** of **open processes**, the asymmetric preponderance of **matter** over anti-matter, the **time** asymmetric **collapse** of the wave function in quantum mechanics, the asymmetry of crystals of which rocks are made, the violation of gauge symmetry by superfluids, the lack of symmetry in magnets and fundamental biological asymmetries... Asymmetric **structures** lead to asymmetric **processes**, and in turn the asymmetry of **processes** becomes imprinted as **structural** asymmetry" (1991, 219-20)

G. BATESON writes about the step from bilateral **symmetry** to asymmetry.(in living beings): "... either the asymmetry must be achieved by a **random process** or it must be achieved by **information** received from the outside" (p.373).

In both cases, **positional value** of the receiving **element** becomes very significant.

Asymmetry acts as a factor of **organization** and **complexification** because it corresponds to **distinctions**, leads to **complementarities** and opens more possibilities for **differentiation**.

This had already been recognized in the 19th. century by L. PASTEUR and well explained in 1942 by Ch. LAVILLE, who constructed a theory of **fields** asymmetry.

Contemporary ecologists, as R. MARGALEF for instance (1982), also admit that asymmetric exchange between **living systems** (as in **commensalism** and **symbiosis**) leads to an increase of their global **complexity**.

M. HAAS established a typology of asymmetries. (1967). He distinguished:

temporal - spatial - kinetic - entropic and allocational asymmetries.

Within the **temporal** asymmetries he signaled (among others, which seem less significant): - **fluctuations** - **tides** - **discontinuities**

Within **spatial** asymmetries he mentions (also among others, more specific of social and political situations): - **segregation** - **centralization**

His description of **kinetic** asymmetries seems too restricted to these same social and political **situations**. It makes sense however to distinguish, for instance: - mobility at different **rates** - immobility

As to **kinetic** asymmetries, they seem quite basically related to different **levels** of **entropy** production in different **parts** of a system.

As to **allocational** asymmetries, HAAS' **classification**, as related to socio-political systems is difficult to transfer to other types of systems because it implies **values** of different kinds.

→ **Trend (Asymptotic)**

0177

**ASYNCHRONISM**<sup>2)</sup>

The existence of different **rates** of **propagation** of some **change**, or its **effects**, in **space-time**.

<sup>1)</sup>general information<sup>2)</sup>methodology or model<sup>3)</sup>epistemology, ontology and semantics<sup>4)</sup>human sciences<sup>5)</sup>discipline oriented

Asynchronism is closely related to **anisotropy**.

It can be observed within a system, or in the **environment** at large. It seems to be closely related to **chaotic behavior**, because of the growing interferences in **time** between the different sequences of **propagation**.

0178

**ATTENUATION**<sup>2)</sup>

The decrease in a **feedback cycle** resulting of a negative **amplification cycle**.

Attenuation corresponds to the progressive **damping** of the concerned **process** or **function**. When persisting, it may lead to their disappearance, by total loss of any capacity for regulating **fluctuations**.

(For the opposite, see "gain")

0179

**ATTRACTOR**<sup>1) - 2)</sup>

A limited **region** of the **phase space** (i.e. a point, or a **set** of points) towards which the **trajectory** of the system converges, tending to a **steady state** or **periodic** motion.

This is the concept of attractor according to classical **dynamics**.

There are two basic types of classical attractors (as opposed to strange, or **chaotic**, ones):  
1.-The attractor may be a single point (or **state**) towards which the system's **trajectory** converges in a monotonic way. This implies, for example, a tendency to **asymptotic stability**. This was the original mathematical **meaning** of the term.

2.- The attractor may be "a closed **loop**, corresponding to **periodic** motion" (I. STEWART - 1989, p.45)

This is a characteristic of systems which undergo a **cyclical** or **cyclomorphical activity**.

The first case corresponds to any system strictly submitted to the **2nd. principle of thermodynamics**, i.e. whose **entropy** grows steadily or, more precisely, to which a **trajectory** and the corresponding **energy function** is associated, such as its **value** constantly decreases with **time**.

The second case corresponds to systems which retain **dynamic stability** by maintaining their internal **structures** and **functions** within closely defined **limits**. Such systems tend to produce the minimum **flow** of **entropy** compatible with their absorption of **energy** obtained from the **environment** (cfr. PRIGOGINE's **irreversible systems** with small **fluctuations** as opposed to other **irreversible systems**, which undergo giant **fluctuations** throwing them out of their **stability limits**; and also his principle of **minimum entropy production**).

Attractors are **sinks**, which means that the attracted system is submitted to characteristic **constraints**, from which, in principle, it cannot escape using its own means.

In **chaotic dynamics** the motion becomes **quasi periodic** ("The geometrical picture for quasi **periodic** motion in quasi **space** is a curve that combines two or more different "circular" motions") (L. STEELS, 1990, p.45)

Hence, a **variety** of more and more complex attractors, which correspond to "the qualitative **diversity of dissipative systems**" (I. PRIGOGINE and I. STENGERS, 1992, p.69)

R. SWENSON characterizes the attractor as "The **time-independent (time-asymptotic) state**, or **limit set**, that attract **initial conditions** from some **region** around its "**basin of attraction**", during a **set** of **time-dependent processes (evolutionary behavior)** as  $t_y$ " (after D. RUELE, 1981) (SWENSON, 1989, p.189)

The **concept** of attractor is thus connected with the idea of dynamic **irreversible change**.

However, there seems to be two different kinds of these:

- **Adaptive change** in systems endowed with **organizational closure**, which cannot escape the necessity to reach a final destructive stable **state** ("Death is equifinal" says Stafford BEER)
- **Innovative change by emergence**. "Evolutionary **behavior**" corresponds to this kind of **transformations** (see "**attractor (emergent)**").

Francis HEYLIGHEN defines the attractor as "a region of **state space** invariant under the **dynamics** (each **state** in the attractor is sent upon a **state** of the same attractor) (1990, p.496), such that it does not contain subattractors. This means that there are no **fixed points** inside the attractor. Each point in the attractor is sent on another point of the attractor. This accounts for a **model** in which there is both conservation of the **distinctions** between different attractors and variation within each attractor". (Ibid).

Attractors may become multidimensional. M. FARGE defines the attractor's dimension as: "the **set** of the points of the **phases space**, i.e. of all possible positions and velocities that can be visited by the system, containing the set of all solutions within the **limits** of a very long **evolution in time**" (1992, p.214)

While any attractor controls a **basin** or area that converges to it, this area can be very narrow. In such a case quite small **disturbances** may push the system out of the **basin** and force it to **convergence** toward another attractor. These jumps from one attractor to another, very far to be a purely abstract **model**, are the gist of many **collapses** affecting real **structures**.

0180

**ATTRACTOR (Chaotic)**<sup>1) - 2)</sup>

Also called "strange attractors"

D. BROOMHEAD describes the chaotic attractor in these terms: "(It)... can be thought of as a bag in the abstract **phase space** defined by the **variables** of position and momentum; the bag contains an infinite number of **periodic states**, all of which are unstable. 'Unstable' in this sense means that if, at some **time**, the **behavior** of the system can be approximated by one of the **periodic states**, the approximation error grows exponentially with **time**. The interesting thing - and the resolution of the chaotic paradox - is that the bag, *as a whole*, is stable. Once the system is in the 'bag', it cannot leave; rather it wanders, moving close to one **periodic state** as it diverges from another" (1990, p.23)

It is thus quite clear that **randomness** in **chaotic systems** is *confined* within a global **determinism**.

I. PRIGOGINE and I. STENGERS observe: "Chaotic attractors are not characterized by whole **dimensions**, as a line or a surface, but by **fractionary dimensions**. They are what is called, since MANDELBROT, **fractal varieties**" (1992, p.73) (see: "**Fractal dimensions**")

J. CASTI makes this clearer as follows: "(in classical attractors) regardless of the **dimension** of the overall **state space**, the **fixed point** has **dimension 0**, while the **limit cycle**, being a simple closed curve, has **dimension 1** These numbers are the *geometric dimension* of the attractor. At the other end of the scale is the situation in which the system is truly **random**. In this case, every point of the **state space** is eventually visited, leading to the attractor's having the same **dimension** as the **state space** itself. **Chaotic systems** with their strange attractors lie somewhere in between. For such systems, the attractor is clearly not such a primitive geometrical object as a point or a simple curve. Yet it is still a proper **subset** of the overall **set of states**" (1994, p.101) (and, consequently has a fractionary, or **fractal dimension**)

0181

**ATTRACTOR (Dynamic)**<sup>1) - 2)</sup>

A stable **states cycle** in a **network**.

ST. KAUFFMAN, who applies this **model** to biological systems, states: "... once a **network's trajectory** carries it onto a **state cycle**, it stays there. The **set of states** that flow into a **cycle** or that lie on it constitutes the **basin of attraction** of the **state cycle**. Every **network** must have at least one **state cycle**; it may have more" (1991, p.66)

0182

**ATTRACTOR (Emergent)**<sup>1) - 2)</sup>

An **attractor** characterized by a progressive drive away from **equilibrium** (1989, p.189).

R. SWENSON states that emergent attractors result from interacting **processes** – that eventually **bifurcate** – and are more complex than the **processes** that formed them (Ibid)

S.J. GAO and F.J. CHARLWOOD distinguish four fundamental types of emergent attractors: **Fixed point** attractor, **periodic** attractor, **quasi-periodic** attractor and **chaotic** attractor. They state: "... they represent qualitatively different **states** of the system in different **environments**. The adapting and evolving **behavior** of the system can be defined as the quantitative **change** (changes of position in the **state space**) and qualitative **change** (changes of type) of these emergent attractors" (1993, p.62)

As examples of emergent attractors R. SWENSON cites: non **equilibrium** points, **limit cycles** and **chaotic attractors**.

He opposes the emergent attractors to **equilibrium attractors** or points, "by definition characterized by a drive towards it".

The emergent attractor is thus equivalent to a **dispersion** or radiating center, i.e. a **negative** attractor that we could call a "repulsor".

According to SWENSON: "Emergent attractors are **non-linearities**, and **nonlinearities** are **emergent** attractors. The spontaneous **transformation** of a **set** of atomisms (i.e. **elements** or **components**) from an infinitesimal **fluctuation** to a globally coherent dynamical **limit set** of **macroscopic scale** is, by definition, a **nonlinear**, viz **self-amplifying process**; the effects of the **attractor** (drive away from **equilibrium**) become its causes (the further away it goes, the faster it drives) until some **limit** is reached.

"When the **nonlinear relation** ceases to exist, so too does the "object" (**flow structure**), and its global **space-time correlation** vanishes into incoherence".(1989, p.189)

0183

**ATTRACTOR (Fractal)**<sup>2)</sup>

A discontinuous attractor which governs the **behavior** of a **complex system**

An attractor is said to be fractal if the **fractal dimension** is not an integer.

This subject is discussed under the headings: "**Basin of attraction**" and "**Fractal basin boundaries**"

0184

**ATTRACTOR (Quasi periodic)**→ **Attractor (Toric)**

0185

**ATTRACTOR (Stability of an)**<sup>2)</sup>

Capacity of an attractor to resist **perturbations**.

As stated By St. KAUFFMAN: "Attractors tend strongly to exhibit **homeostatic** return after **perturbation**" (1993, p.209). However "The **stability** of an attractor is proportional to its **basin size**, which is the number of **states** on **trajectories** that drain into the attractor. Big attractors are stable to many **perturbations**, and small ones are generally unstable" (1991, p.67)

This explains the **instability** in **chaotic systems**, where frequent jumps occur between smaller and smaller attractors that appear through **fractalizing bifurcations**.

For the concept of "basin size" see "**Basin of attraction**"

0186

**ATTRACTOR (Thematic)**→ **Thematic attractor**

0187

**ATTRACTOR (Toric)**<sup>2)</sup>

An attractor which "... describes motion made up of two independent **oscillations**" (J. CRUTCHFIELD et al., 1989, p.42)

Such a motion is "sometimes called quasi-**periodic**"(Ibid)

J. CRUTCHFIELD et al. point out that : " The important feature of **quasi-periodic motion** is that in spite of its **complexity** it is predictable. Even though the orbit may never exactly repeat, *if the frequencies that make up the motion have no common divisor*, the motion remains regular. Orbits that start on the **torus** near one another remain near one another, and long term **predictability** is guaranteed." (Ibid).

→ **Numbers (Prime)**

0188

**ATTRACTORS and BEHAVIOR MODES MODELING**<sup>2)</sup>

J. Aracil proposes an association of **attractors**, as **models** and **behavior modes**.

"It is well known that a **dynamical system** can show many **attractors**. With each **attractor** we associate a **behavior mode**. The attractors represent the **states** where the system is normally observed. The qualitative study of **dynamical systems** is concerned with the study of **attractors**. A very important question, that literature has not dealt with however, is to study how the variation of the theoretical framework along the **modeling process** can determine the possibility of **emergence** of new **behavior modes** (**new attractors**). This problem is linked to the **emergence** of **bifurcations** in the modeling **process** in the precise sense to be stated below. In this way the **modeling process** can be related to the concept of **structural stability** and with THOM's **catas-**

**trophe theory paradigm** considered in its widest sense, as a theory of **morphogenesis**: the **morphogenesis** of new **behavior modes** through the **modeling process**". (1986, p.244)

The lack of such a qualitative enquiry was one of the main shortcomings of FORRESTER's **Systems dynamics**

0189

**ATTRACTORS; A classification**<sup>1) - 2)</sup>

K.De GREENE proposes the following classification of attractors:

"1. Points, like the static **equilibrium** points of **catastrophe theory**. Points can apply to both **linear** and non-**linear** systems.

"2. Periodic attractors, like **limit cycles** that apply, say, to interacting **populations**

"3. **Strange, Lorenz or chaotic attractors**: A system **state** can be related to a **basin of attraction**, but how stable the system is and where the system resides relative to the **boundary** of the **basin** may be unknown and unknowable. Indeed, the very existence of an alternative **basin(s) of attraction** may be unknown".(1990, p.161)

Furthermore "...minuscule differences in **initial conditions** may lead to the exponential expansion of these differences" (Ibid.)

A slightly different classification is possible: **Fixed point**: The simplest attractor. It corresponds to a generally monotonous **trajectory** of a non disturbed system toward a final **state**, for example: a real pendulum, submitted to frictions.

→ ("**Fixed point**")

**Limit cycle**: Corresponds to a closed **loop** within the **phases space**. This implies that the system's **trajectory** involves a series of non-disturbed **periodic oscillations**.

**Toric attractor**: Characterizes the **behavior** of a system simultaneously submitted to two periodic **oscillations**, independent from each other. The **structure** of these **oscillations** remains always predictable and possible to carry out, even when the **periods** are incommensurable.

→ "**Numbers (Prime)**"

**Chaotic attractor**: Corresponds to the **behavior** of a system simultaneously submitted to, at least, three **periodic oscillations** independent from each others. The simplest corresponds to systems of simple differential equations where the **phases space** is three-dimensional.

Even in these cases the **transformations** of the system are generally not predictable. An early example was the famous astronomical **three bodies problem** studied by POINCARÉ.

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

0190

**ATTRIBUTE**<sup>1)</sup>

Any quantitative or qualitative property of a system, **subsystem** or any of their **elements** (Adapted from J.van GIGCH, 1978, p.14)

This author adds: "Qualitylike" attributes of greater difficulties of definition and of measuring than their counterpart – the "quantitylike" attributes" (Ibid)

0191

**AURA**<sup>1)</sup>

The **set** of the traces or **constraints** left over by a system after the end of its functional existence.

This stimulating systemic concept has been introduced by the French biologist H. PRAT. It can be applied to a fossil, or petrified wood, as well as to a sunken ship, or a destroyed empire, or the teachings of a great disappeared mystic or philosopher.(1971. p.92-5)

At any moment the system contains its history and, when it functionally ceases to exist, something may remain of it. In J. BRIGGS and F.D. PEAT's words "Time is inflexible, and however, the past is continuously recycled, somehow maintained eternally" (1991, p.145).

The aura corresponds to a kind of fossil **field**, i.e. a certain degree of **survival** of material and/or abstract **structures**. given the condition that there be no excessive disruptive **environmental activity** and that important **interconnections** between **elements** remain more or less intact, or correlatively transformed.

In some cases, the aura may even give birth to a new system. A curious example is the "Gustav Vasa", flagship of the Swedish navy, sunk in the 16th Century, forgotten for 300 years, then refloated in the 20th Century, and now a naval museum in Stockholm's harbor.

G. CHROUST gives a complementary **meaning** to the concept, asking how far the **effects** of teaching do extend in **space** and **time** and also, "what **size** can a **group** have such that one can still communicate effectively" (1999, p. 419).

These aspects can be mapped by using **graphs** and are also related to the **small world model**.

0192

**AUSTRIAN SOCIETY FOR CYBERNETIC STUDIES**<sup>1)</sup>

This Society is one of the oldest in Europe. Its original name in German is "Österreichische Studiengesellschaft für Kybernetik". It was created in Vienna by a group of Austrian cybernetists under the leadership of F.de PAUL HANIKA and Dr. R. TRAPPL, who is still its President.

It publishes technical reports, principally on A.I. and hosts the editorial office of the "Cybernetics and Systems" Journal, whose Editor-in-Chief is R. TRAPPL.

It organizes in Vienna every other year since 1972 a "European Meeting on Cybernetics and Systems", whose proceedings are published.

It has been one of the co-founders, with the **ISSS** and the **System Groep Nederland** of the **International Federation for Systems Research**.

0193

**AUTOCANALIZATION**<sup>2)5)</sup>

A **process** of self regulated **evolution** in the **biosphere** as a **whole**.

This concept has been introduced by V.F. Levchenko and Ya.I. Starobogatov.

In a more recent paper, Levchenko writes: "...canalizing factors include the **environment** which is not invariable with **time** but depends just on the **evolution** of both the **biosphere** itself and the **organisms** it is composed of"(1998, p. 106)

**Self-regulation** in natural systems was also suggested by François (1983), himself inspired by Ashby's "Principles of the **self-organizing system**"(1968)

Autocanalization is certainly significant for the understanding of Lovelock's GAIA (1979)

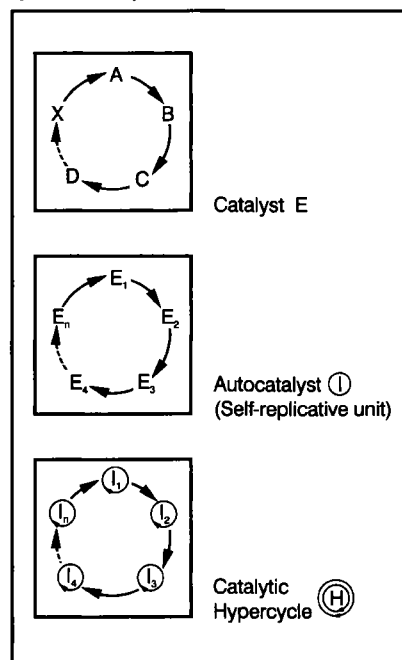
0194

**AUTOCATALYSIS**<sup>2)</sup>

A **process** in which the increase of an **element** in a system is enhanced by the concentration of the **element** itself.

The reaction's product is itself the **catalyzer**.

Figure: see entry **AUTOCATALYSIS**

**Autocatalysis**

From M. EIGEN and P. SCHUSTER: "The hypercycle" 1979 - p. 90

Autocatalysis is basically a **self-amplifying process**, but moved by a **cyclical positive feedback with relaxation phases**. It may however lead, in a limited **space**, either to a destructive supersaturation or, exceptionally to the **emergence** of a new **level of organization** of the **elements** reaching a **critical density**. K. KRIPPENDORFF observes that: "Autocatalysis is not to be confused with multiplication through **production**, including **self-reproduction** in which the **growth** of the **population** is an aggregate property of the productive capability of its individual members" (1986, p.5)

see figure left

0195

**AUTOCORRELATION**<sup>2)</sup>

"A statistical measure of the strength of association which exists between pairs of values of a **time series** as a **function** of the **time interval** which separates them". (T.F.H. ALLEN & T.B. STARR 1982, p. 262)

0196

**AUTOGENESIS**<sup>1)</sup>

The appearance of a new system by association of formerly unconnected **elements**. (C. FRANÇOIS, 1989, p.72)

"In some sense, autogenesis appears as a absolute beginning. "Before" there was "nothing" (i.e. only scattered, unconnected **elements**); "after", we suddenly have a new system, immediately **morphogenetic** and **autopoietic**. The **event** is, partly, a **random** one. This is interestingly paralleled in John H. CONWAY's **game of life**, where it is the player who defines an **algorithm** for general genesis conditions whose potential content he ignores. He does not know in which way the system will develop, or if and when it could become blocked or destroyed. However, the original **random decision** remains inserted within the most general conditions of the game: **elements, rules, a field, limited or unlimited**".

"In this sense, however, autogenesis appears as a relative beginning" (Ibid).

"Before", there were significant antecedents: **elements** and an **environmental situation**. "After", we have some new entity born with and within these antecedents. What is new is the combination. However, it takes place within an **archetypal algorithm**, which represents a kind of **autopoiesis** at a higher **level** in **space-time**.

Some examples will make this clearer:

- The autogenesis of a complex and original living being<sup>5)</sup>:

Can result only from the sexual pairing of two previous systems of the same kind. What is autogenetic is the fusion of two half genomes, and more precisely of *these* two half

genomes, while trillions of other combinations were possible. This is quite akin to an irreversible **decision**, but in this case its significance, if any, remains undecipherable for us.

The **autopoietic** aspect is that each of these half genomes must be of the same species, in order to be able to construct a new viable **autopoietic system**. This means that, even considering that the new system is an original and unique creation, it remains within the **limits** of a more general **algorithmic** and combinatory **model**: in this case, the species. Future genetic manipulations could possibly modify this general frame.

- Neural autogenesis <sup>5</sup>

According to V. CSANYI: "... in the course of **ontogenesis**, the human **brain** goes through phases of neural autogenesis, the phases of non-identical replication and identical **replication** and the **phenomena** of each phase (functional **differentiation**, rise of **hypercycles**, compartmentalization, **convergence**) can also be observed. The human **brain**, which consequently represents a **zero-system** capable of neural **evolution**, develops in the course of **embryogenesis**" (CSANYI, 1989, p.80)

- The autogenesis of a society <sup>4</sup>:

The autogenesis of a society, as an **emergence** into a higher **level of complexity**, offers the same characteristics, but more general. A cultural example will be used, but others, biological, political or economical could be given.

A human society in its phase of autogenesis entails the progressive **co-assimilation** of various **heterogeneous** groups, bearing different cultural inheritances and coming for the first time in contact in some defined area (by invasion, immigration, colonization, etc.). In this case, the fusion **event** seems, at our **time-scale**, a slow and hazardous **process**. However, at the historic **time-scale**, it is really be a very short one.

What is leading to **autopoiesis** here is the common pre-existence of a **variety** of cultural traits. While different, they are all somehow related to the unavoidable **constraints** of societal **organization** in general, as any society needs in order to survive some specific **environmental** conditions, as well as basic **values** and **norms**, transmittable from one generation to the next. (FRANÇOIS, 1989, p.72-73)

→ **Autopoiesis; Epigenesis; Equipotentiality**

0197

### AUTOGENESIS (From) to AUTOPOIESIS <sup>2)</sup>

This transition results of the appearance of **replication** within hitherto not functionally interconnected **sets** of compatible **components** (CSANYI's "**zero-system**")

This author writes: "A system may contain several different kinds of **components**, which are all **replicative** units with diverse fidelity. Among these, **interrelationships** develop and, as a result, their **replication** becomes coordi-

nated. Gradually the **whole** system will start **replicating** as a final **replicative** unity. In the autogenetic **process**, the **organization** of the system and of its **parts** changes due to the **functions** of the emerging new **components**. Thus autogenesis is possible only while the **state** of identical **replication** has not yet been achieved. In that **state**, the system becomes functionally **closed** and its **replication** in **time** continues as long as the **environment** does not change. There are no further organizational **changes** initiated by organizational causes because new **functions** cannot originate... This end **state** of an autogenetic system is equivalent to what VARELA calls **autopoiesis**" (CSANYI, 1993, p.264)"

There are **time limits** to **autopoiesis**, because the capacity of any system to generate **accomodating** or **adaptive** responses to **environmental stimuli**, while considerable, is however limited: systems are maturing and finally **ageing**.

0198

### AUTOGENETIC SYSTEM PRECURSOR (AGSP) <sup>2)</sup>

A minimal **set** of **components** in a system in its initial **phase** of **autogenesis (zero-system)**, which has the potential to start producing **processes**. (After V CSANYI, 1993, p.263)

CSANYI explains: "A precondition for starting a **self-organizing process** in a **zero-system** is the presence of a minimal **set** of **components** which is able to replicate and which fulfills the following criteria:

"1. It contains at least one **cycle** of **component-producing processes**;

"2. At least one of the **components** participating in this **cycle** can be excited by the **energy flux** flowing through the system" (Ibid)

This **model** seems apt to cover autogenesis in future artificial systems as well as in actual **living systems**

It also explains the "jump" from autogenesis to **autopoiesis**, as Csanyi describes it: "During autogenesis, as **time** advances, an increasing part of functional **information** becomes **replicative information**. This can appear only as an extension of AGSP, that is, additional **replicative cycles** appear which are interconnected with the AGSP" (Ibid)

0199

### AUTOGNOSIS <sup>3)</sup>

The study of the conditions of conscious **knowledge** (Adapted from W. DILTHEY: Gesamtelte Schriften, 1922-1935)

This is a step forward from SOCRATES "Gnoti seauton". His membership of the Athenian **culture** of his time was implicit for him and at the same time subtly preforming his way of being and thinking.

Such cultural and historical conditions are proper to any individual **observer**.

Being this observer inserted in his specific culture at a precise historical moment, he thus acquires peculiar **reference frames** in some well defined psychical and mental **environment**.

This setting has been considered by Dilthey in his "Critique of speculative systems and nature explanation starting from **consciousness** facts and the historical march of world thinking" (Note: spanish translation used: the german original could not be located). Dilthey describes the result as "reality for myself".

Accordingly, autognosis is (or should be!) a permanent **process**, but at the same time subordinated to what has already been acquired by **learning** and training through former **experience**. It is a sort of sedimentation in an **autopoietic** way. Dilthey uses Goethe's term "Protophenomena". He also quotes BENCKE and says: "thought as such...analyses experience"...of course within the already acquired mental and conceptual frame.

Autognosis is closely related to modern hermeneutics, as proposed by Dilthey in his 1900 book on the "Origins of Hermeneutics"

0200

### AUTOKINESIS <sup>1)</sup>

Capability for self-controlled (**autonomous**) movement.

This concept has been extensively elaborated by the French physiologist P. VENDRYES (1942)

It is exclusively proper to animals and up to a point to **artificial organisms** endowed with perceptive capabilities and **regulation** devices.

Throughout the scale of the animal reign, autokinesis grows with **complexity**. It will possibly be the same with intelligent **artificial organisms**.

Autokinesis would be impossible without **correlation** devices (senses, nervous system), empowering the system with possibilities to evaluate the **dynamics** of its displacement within its **environment**.

0201

### AUTOMATA: A Classification <sup>2)</sup>

According to M. BUNGE: "An automaton is a discrete and sequential system"

BUNGE distinguishes deterministic automata from probabilistic ones: "If lacking in spontaneity, i.e. acting only under external compulsion, the automaton is called **deterministic**. If **inputs** and internal **states** determine only **output** probabilities, the automaton is called **probabilistic**."

Deterministic automata are of interest mainly in technology, where highly reliable systems are desirable. Probabilistic automata are of greater scientific and philosophical interest, for

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

natural systems, such as **brains and communities**, are endowed with some spontaneity and seem to have strong stochastic **components**" (1979, p.263)

Some years after BUNGE wrote these lines, the development of the theory of **deterministic chaos** blurs somewhat the above **distinction**. But it also explains how an automaton, or system may function, being partly deterministic and partly stochastic.

G. KLIR proposed a different classification of automata, in accordance to their possible uses:

"1. **Decoder-combinatorial automata** which have the same **input and output variety** and in which the **mapping** between **stimuli** and **responses** is mutually unique.

"2. **Prospective automata – combinatorial automata** Prospective whose **output variety** is smaller than the **variety** at the **input**, and in which a single **response** is uniquely assigned to each **stimulus**, whereas the converse assignment is not unique.

"3. **Retrospective automata – sequential or complex random automata**, the **output variety** of which is larger than their **input variety** and where a single **stimulus** is assigned to each **response**.

"4. **Function generators – sequential or complex automata** which, as a result of at least one **stimulus**, produce in their **output** a **response** that is either a **determinate** or a **random function of time**.

"5. **Self-organizing automata – sequential or complex automata**, in which the **variety** of the **responses** produced by a given **stimulus** can change (as a **rule**, diminish) under certain circumstances." (1965, p.37)

This last class is very important as it corresponds to all natural and artificial **autopoietic** systems.

0202

### AUTOMATA (Initial Configuration in cellular)<sup>2) – 5)</sup>

A **set** of cells or **elements** arranged in some specific order which constitutes the initial **state** of the cellular automata.

Curiously, some initial **configurations** cannot be produced starting from any previous **configurations** (see **Garden of Eden**).

While some **configurations** can lead to **self-reproduction**, most cannot.

In some cases the **rules of transformation** of the cellular automata are embedded within its initial **configuration**.

0203

### AUTOMATA NET<sup>2)</sup>

A finite **net** of interconnected **elements** which operate on basis of an on-off logic.

This is a very general **model** that has been used in genetics (St. KAUFFMAN, 1969), in **models** of the cerebral cortex (D. DUBOIS, 1991), in **connexion machines** (T. TOFFOLI & N. MARGULIS, 1987) and quite recently in distributed **artificial intelligence** (R. BROOKS (1989); C. LANGTON; L. STEELS, 1990)

Automata nets present characteristic **emergent** properties and **behaviors**, which depend on the nature of their **interconnections** or "wiring".

The **net** must have **constraints**, i.e. some **connections** being permitted and other ones suppressed. **Flows** through the **connections** can be permanent or more or less **intermittent**. Furthermore, such **nets** tend to subdivide into local and specialized **subnets** and, as a result, simultaneous **events** in different **parts** of the **net** do not propagate their **effects** instantaneously and generate very complex **nonlinear** (and sometimes **chaotic**) **behavior**.

Automata nets present very numerous alternative possible **steady states** and in some cases, undergo giant **fluctuations** that may lead to **bifurcations** and **dissipative structuration**.

Once the **set** of internal **states** can be specified through a finite **state transition matrix**, the automata net becomes a **finite automaton** or, if it produces **outputs**, can be assimilated to a **sequential machine**. This does not however make it wholly predictable.

0204

### AUTOMATA (Reliability of)<sup>3) – 5)</sup>

H. ATLAN states as follows the problem of comparative reliability of natural and artificial **machines**:

"A reliability like the one of the **brain**, able to function continuously, while **cells** die every day without replacement, with unforeseen **changes** in the blood's **flow**, volume and pressure **fluctuations**, not to mention amputation of important **parts**, which perturbs only in a very limited fashion the whole **set's performance**, is not matched in any artificial automata. This fact had already struck J.von NEUMANN (1966), who was seeking to better the computer's reliability and could not imagine such a reactive difference to **random environmental** factors of aggression (**noise**), if not related to a basic difference in the organizational logic of the system. "Organisms, with their faculty to "swallow" **noise**, could not be understood as just only somewhat more reliable than the known artificial **machines**, but as systems whose reliability could be explained only by qualitatively different principles of **organization**" (1972, p.23)

"VON NEUMANN, WINOGRAD and COWAN's (COWAN, 1965) investigations aiming at the discovery of construction principles for automata whose reliability would be greater than their **components**'...led to the definition of nec-

essary (and sufficient) conditions of feasibility of such automata). Most of these conditions, (**redundancy of components, redundancy of functions, complexity of components, delocalization of functions**) lead to a kind of compromise between **determinism** and **indeterminism** in the build up of the automata, as if some measure of **indeterminacy** should be necessary, from a certain **level of complexity** on, to allow the system to adapt itself to a certain **level of noise**" (ATLAN, 1972, p.23).

0205

### AUTOMATA (Rules of transformation in cellular)<sup>2) – 5)</sup>

Those **rules** which prescribe the ways in which the **elements** of the automata will be created, maintained or destroyed at each **transition** from one to another **state**.

Different rules are possible, leading to:

- a seemingly **random transformation**
- **self-reproduction**
- blocage in some definitive **state**
- some **cyclical transformation** of the automata

→ **Game of Life**

0206

### AUTOMATA (Self-reproducing)<sup>3) – 5)</sup>

In L. LÖFGREN words: "... an automaton where the **behavior function F** is considered self-reproducing if, from some **stimulus**, it produces another automaton with the same **function F**. This leads to the question whether a **function** can contain itself in its **range**" (1978, p.247)

In view of **GÖDEL'S incompleteness theorem**, this does not seem to be a very promising proposition.

However ATLAN states: "...up to now the only self-reproducing automata known are the natural **machines**, i.e. the living **organisms**" (1972, p.22). But even this view should be qualified: reproduction by division is not the same **process** as sexual reproduction. Besides, self-reproduction has now a specific **autopoietic** meaning.

ATLAN also writes:

"a) Living **organisms'** specificity is related to (cybernetic) principles of **organization**, and not anymore to irreducible vital principles

"b) Once these principles are outlined, nothing should impede their application to artificial automata, whose performance could equalize those of living **organisms**" (p.22-23)

0207

### AUTOMATA (Self-reproductive cellular)<sup>2) – 5)</sup>

An automata able to reproduce itself, i.e. to produce a copy of itself after a number of **transformations**.

The project of a self-reproducing cellular automata was initially formed by J.von NEUMANN.

**Self-reproduction** in a cellular automata is clearly different from **self-reproduction** in the **autopoietic** sense, whose **models** were established later. However, both are obviously related

It is debatable if the appearance of a "copy" of the initial automata in some other **region** of the **substrate** is equivalent to the **endogenous self-reproduction** of a system endowed with **organizational closure**.

H. Maturana states: "Cells do not construct other cells, they just divide into two of the same kind, like in the fragmentation of a crystal" (1979, p.25)

A von Neumann automaton would be self-reproducing as a *whole* in a limited sense only if, after a number of **operations** (through a **process** akin to an **hypercycle**), it would regenerate *itself*. The automaton would then comprise the whole cycle.

Otherwise self-reproduction would mean production of another automata of the same type, and eventually of many other ones.

It is however possibly a matter of **levels**. **Self-reproduction** of the **elements** (in the sense of cellular automata) could conceivably lead to the **self-reproduction** of the **complex system** (in the sense of **autopoiesis**)

P. GREUSSAY comments: "von Neumann thought that, with a convenient **programming** of some cellular surface, some group of **cells** with proper characteristics would be able ...to produce a copy of itself in another zone of the cellular surface, this copy being able in turn to do the same" (1988, p.1321)

To achieve his goal, von Neumann selected a complex **repertory** of 29 possible **states** combined with an intricate **transition function**.

"In 1968 Edgar Codd... discovered a universal constructor **configuration** whose cells are limited to 8 different **states**.

"In 1984 Christopher Langton (University of Michigan)...showed that a self-reproductive cellular automata does not necessarily need the intervention of a **cell configuration** endowed with the property of a **universal constructor**" (Ibid, p.1322).

In von Neumann, Codd and Langton's cellular automata "the **self-reproduction process** is actively directed by the **initial configuration** itself, through a **transition function**. Take an **initial configuration at random** and there is no more any **self-reproduction**. Thus such a **self-reproduction mechanism** requires a quite complex and substantially precise construction. Indeed, to endow the parent **structure** with the capacity to actively direct its own duplication, transcription devices of the "genet-

ic material" of the **initial configuration** are needed, as well as **translation** devices acting on the **environmental** cellular surface" (p.1322)

We are coming thus very close to **organizational closure** in **autopoiesis**.

This research promises to be highly significant for the logic of future complex computers and probably also for genetics.

0208

AUTOMATION<sup>5)</sup>

The use in **production** and in **control processes** of **machines** having the capacity to adjust to changing conditions

"The **adjustments** require "sense **receptors**" (which take readings from the **environment**), **communication networks**, stored **memory** of standard **states**, correction devices, etc. All of these make for greater **complexity**, since the **state** of each device is an additional **variable** in the **state** of the system" (A. RAPOPORT, 1966)

Automated **machines** tend thus to become **open systems**, more **autonomous** and more similar to **living systems**.

They are normally **integrated** within still more **complex systems**.

0209

AUTOMATON (Cellular)<sup>2)</sup>

1. An abstract device able to transform itself.

The **concept** of a cellular automaton has been developed by A. Turing (1950) and John von Neumann (1956) and also somehow by W. McCulloch and W. Pitts (Their **formal neuron model**)

F. Heylighen describes cellular automata as "... mathematical **models** of **distributed dynamical processes** characterized by a **discrete space and time**" (F. Heylighen, 1997, p.33)

The conditions for the construction of a cellular automaton are as follows:

- an unlimited and uniform **substrate**, which constitutes a perfectly **isotropic environment**
- identical **elements** or cells, with defined properties
- an **initial configuration**, consisting of a number of **cells**
- definite **rules of transformation**

The basic characteristic of cellular automata is the **emergence** of complex **organization** obtained from simple **rules**.

Numerous varieties of cellular automata have been proposed. The best known are those in Conway's **Game of Life**. However Maruyama has used one as early as 1963 as an example of "**deviation-amplifying mutual causal processes**".

As to the **rules of transformation**, some are not deductible from any previous **configuration** ("**Garden of Eden**")

In some cases the **rules of transformation** are themselves embedded within the **initial configuration**.

2. A **network** composed of **elements (nodes)**, each of whom is an elemental device able to perform some elemental calculation.

Every **element** of the cellular automaton may be considered itself an automaton if its **operation rules** are included. According to A.G. Bar-Tal: "Cellular automata are **networks** of identical automata which are interconnected in a regular way with the automata having neighboring positions in the **network**" (1978, p.165)

B.R. Gaines and L.J. Kohout state: "...an automaton is a **discrete-time, discrete-state-space, state-determined machine**" (1976, p.192).

Each **element** processes a limited number of possible **binary states**.

The automaton evolves step by step, in a **discontinuous** way, according to the **rules** imposed to its **elements**, which determine at each step the **state** of each **node** according to its preceding **state** and the **states** of the neighbouring **nodes**.

Curiously, a very complex global **behavior** may emerge from the application of quite simple **rules** at local level.

Gaines and Kohout state: "... neither the actual current **state** of an automaton nor its current **input** are necessarily well-defined. For example, we may know only the *probability distribution* of possible current **states**, or of possible current **inputs**. In either case the next **state** of the automaton will not be necessarily a single **state** but will probably also be known only as a **distribution**" (Ibid)

Ashby has given interesting examples of such **ergodic systems**, whose **repertory** of all possible **states** is resumed in a **markovian matrix**. (1956)

According to Gaines and Kohout: "It is a convenient generalization of the **concept** of an automaton to consider **transitions** not just between **states** but between such **states distributions**, regarding **distributions** over **states and inputs** as generalized "states" and "inputs" respectively" (Ibid).

These authors propose the corresponding terminology of *hyperstates* and *hyperinputs*.

The automaton model is nowadays basic to the study of so-called **neural networks, connection machines** and **distributed artificial intelligence**.

It may even become very useful for the **description** of **social systems** in general.

0210

AUTOMATON (Finite)<sup>2)</sup>

A finite automaton is characterized by the following properties:

- an **initial state**
- a finite **set** of possible internal **states**

<sup>1)</sup>general information    <sup>2)</sup>methodology or model    <sup>3)</sup>epistemology, ontology and semantics    <sup>4)</sup>human sciences    <sup>5)</sup>discipline oriented

- a next-state **function** allowing for **transitions** from one internal **state** some other one
- a **subset** of the **set** of internal **states**, whose elements are **selectors of inputs** (accepting states)

An elemental automaton is open to any acceptable **input** and must necessarily function as a **sequential machine**. It can be represented by a **graph**. (After F. HARARY and S. LIP-SCHUTZ, 1967)

However, according to J.von NEUMANN, as quoted by L. LÖFGREN: "... when an automaton is not very complicated, the **description** of the **functions** of that automaton is simpler than a **description** on the automaton itself but ... the situation is reversed with respect to complicated automata" (1977, p.211)

This is a result of the **simultaneous** interplay of various **rules**, which leads to **ergodicity** or **chaos**.

0211

### AUTOMATON (Learning)<sup>1)5)</sup>

A type of automaton made of several **subroutines** able to interact

An interesting example is R.A. Brooks's "Allen" robot, described as follows by M. Pesche (2000): "Allen does not "think" about the room it occupies: it makes no effort to build a **model** of the room it occupies: or to understand the shapes of the objects inside"(p. 29)

"Allen is thus not programmed, i.e. no precise prescriptive instructions guide its **behavior**. It does not respond to the general characteristics of so-called "Artificial intelligence". Pesche writes: "Allen is built with a tight **connection** between its **sensors**, which detect the presence of nearby **objects**, and its affectors, which move the **machine**..."

"...Allen does not follow a **routine** sequence of **programming** steps to generate its moves. Several modular **subroutines**- such as drives to avoid moving objects and to explore uncharted **territories** run simultaneously and independently, which causes them to interact in unpredictable ways as they respond to the **environment**.

"Neither of these independent **modules** begin operating with any **knowledge** about their **environment**, nor about how their **activity** affects this **environment**. But as the **modules** execute, they compete to generate some aspect of Allen's overall **response** to its **environment**"(I-bid)

This is quite similar to Rumelhart and Mc Clelland **Parallel Distributed Processing** and it leads to a **bottom up** construction of a globally **coherent behavior**.

Interestingly, Pesche observes the similarity of Allen's **behavior**- as an automaton- with **learning** in children as was investigated by Jean Piaget, who described children's play as "...an advanced experiment in the ways the world works"(p. 30)

Both ways of learning lead to behavioral **autopoiesis**

0212

### AUTONOMY<sup>1) - 3) - 4)</sup>

The capacity of a system to select and decide, within **limits**, its own **behavior**.

This concept of autonomy was introduced by the French biologist P. VENDRYES (1942). It is quite different from MATURANA and VARELA's concept, introduced about 20 years later, but in no way incompatible. VENDRYES described a **hierarchy** of various **levels** of autonomy: trophic (or **metabolic**), kinetic (motor) and psychic and mental. This corresponds more or less with LABORIT's **hierarchic** concept of the **brain's organization**.(1954 and 1976). This concept of autonomy is essentially based on the relative possibility of the system to **control** its **relations** with its **environment**. It also implies a specific **concept of time**: present **time** is the **connection** between an already strictly determined past and a still more or less probabilistic future offering yet possibilities to select between various **choices**. Such **selection** converts one - and only one - of these options into reality, suppressing all the others. This **concept** thus implies a **limited** probabilistic view of the future, quite consonant with the more recent concept of **chaos**.

In the same vein, K. BERRIEN observed "1) **Choice** is the human equivalent of probabilistic **outputs** in the more general **systems theory**" and "2) Although some of the determining **parameters** (can be specified), their precise **measurement** is subject in principle to an **uncertainty** of the same general kind as originally indicated by HEISENBERG" (1968, p.97)

VENDRYES theory describes as follows the **goals**, **means** and **mechanisms** that characterize autonomous systems:

- **Counter-randomness**: The system uses regulating devices to compatibilize **random inputs** with its internal **determinism**;
- Internal **determinism**: The system is able to maintain the **fluctuations** of its internal **processes** within stable **limits**. This connects VENDRYES' views with CANNON's **homeostasis** and with MATURANA's **autopoiesis**;

- **Interrelation functions**: The system possesses mediating **functions** that coordinates its internal **states** with the **environmental** variations;

- Internal **medium** ("**invironment**"): This is the internal **space** of the system, where the **interrelations** between the **subsystems** take place. This concept comes from Cl. BERNARD and connects VENDRYES autonomy with J. MILLER's **living systems**, and again with CANNON's **homeostasis**, also inspired from Cl. BERNARD.

- **Perturbation**: Any **input** not yet controlled by the system. However, many **inputs** are needed by the system, and their **assimilation** is an essential aspect of the system's **symbiosis** with its **environment**.

- **Random** relation: Any not pre-defined **interrelation** of the system's **inputs** with its internal **states**. VENDRYES explains that the **relations** between two systems are **deterministic** when already functionally linked and **random** when not linked. The system may gain - up to a point and with **time** - predefined **controls** on critical **inputs**. This is another link with **autopoiesis**.

- **Articular relation**: A **mechanism** which permits the **selection** at any moment of a position, **state** or motion among various that are possible. The **model of articular relation** has been widely developed by VENDRYES. (see specific heading)

- **Reserve**: A potentially usable **store of energy** or **matter** within the system, that can be used at any moment by the corresponding **control** to offset in real **time** or within a **time lag**, a specific **perturbation**. This is a need in order to maintain the system distinct from its **environment**. **Controls** are efficient only if associated with specific **reserves**. (see specific heading)

Another viewpoint is given according to a subtle definition by R.H. HOWE: "Autonomy is the unity of computation and construction" (1975, p.5)

In this case, computation should be understood as that type of computation which occurs in concrete **neural networks** (i.e. any system with internal **communication** between numerous **elements** in an **organizational closure** way), and construction as **self-reproduction**.

In the last resort, it must however be emphasized that a system's autonomy depends always of its possibility to obtain sufficient **energy inputs** from its **environment**. In A.S. IBERALL words "... an autonomous system is a thermodynamic engine" (1973, p.4)

This basic condition, the existence of an **organizationally closed set of rules** being also provided for, allows for the autonomous existence of the system.

Still more generally, more autonomy also means more **interdependence** among more **components** and **subsystems** within the system and more extended and complex relations with a more precisely specified **environment**. Man for example, needs many more specific types of **inputs** than a tree.

0213

### AUTONOMY BY AUTOPOIESIS<sup>1) - 3)</sup>

"Attribute of an **organizationally closed system**, i.e. a system whose **organization** is self-explanatory and, by implication, circular" (K. KRIPPENDORFF, 1986, p.5)

Autonomy in MATURANA and VARELA's sense is self-generated through an **organizational closure process**. In R.N. ADAMS words: "...control over relations of production is wholly internal" (1988, p.63).

This is a property of **living systems**. H.von FOERSTER writes: "By autonomy we mean that all **decisions** regarding an **organism's action** are made within its skin. A living **organism** is a **universe** in itself". von FOERSTER proceeds, giving the following example:

"1. The **interpretations** of an **organism's** sensations determine its **activity**;

"2. An **organism's activity** determines the interpretations of its sensations" (1981, p.215)

He resumed his stand in these terms: "A living **organism** is an independent, autonomous and **organizationally closed** being" (1992, p. 42). By "independent" (in the German text "selbständig", i.e. "existing by itself"), one should understand "**entificated**" in R. GERARD sense.

von FOERSTER also stated that autonomy is "**self-regulation**" or "**regulation of regulation**" (1981, p.306), which locates him quite close to VENDRYES.

P. GOMEZ and G.J.B. PROBST, in turn, write:

"1. The development and **viability** of a system depend much more on internal **coherences** than on **environmental inputs**. What is important is what the system does, how it acts, and finally, how it reacts to **noise** from the **environment**

"2. An autonomous system produces its **limits** and the **limits** define the system. Research should emphasize the search for **sources** and **rules** of the internal **transformations** of **coherences**" (1989, p.314)

The first statement could be somewhat misleading. No system can emerge, develop and maintain itself if the necessary **inputs** are not available in the **environment**. Only the *pre-adapted* systems are viable. Of course, **pre-adaptation** is a result of **autopoietic transmission** of formerly **emerged** conditions. As an example, an astronaut is viable in space only if the basic **environment** he/she imperatively needs for **survival** is artificially recreated and maintained.

Autonomy itself is obtained only within the specifications of an inherited or formerly **emerged template**.

→ **Archetype**

0214

### AUTONOMY: the 3 basic levels <sup>1)</sup>

J. LORIGNY writes: "According to P. VENDRYES three levels of autonomy should be distinguished: metabolic autonomy, motor autonomy and mental autonomy..."

"VENDRYES's three autonomies correspond to three successive stages in **evolution**. Each developed at a definite stage of life's history and does not emerge formerly, at least in a visible fashion... The more recent ones are imbricated into the former ones, each using them after incorporating them..."

"Thus, **motor** autonomy uses **metabolic** autonomy... and in the same way, mental autonomy uses **motor** autonomy... (Furthermore) each autonomy feeds and reinforces the former ones, having them **embedded** in a systemic **hierarchy**" (1992, p.13).

Strikingly enough, when compared with MATURANA and VARELA's concept of **autonomy** and **organizational closure**, VENDRYES himself wrote as early as 1942: "The living being is to itself its own **reference system**" (1942, p.290).

0215

### AUTOPOIESIS <sup>1) - 2)</sup>

The condition of a system able to regenerate itself by **self-reproduction** of its own **elements** and of the **network** of their characteristic interactions.

This notion has been introduced by H. MATURANA, who writes: "... there are systems that are defined as unities as **networks** of production of **components** that 1) **recursively**, through their **interactions**, generate and realize the **network** that produces them; and 2) constitute, in the **space** in which they exist, the **boundaries** of this **network** as **components** that participate in the realization of the **network**" (1981, p.21).

The main characteristic of autopoietic systems is **organizational closure**.

Autopoiesis has very important bearings on the theories of **perception** and of **cognition**. As stated by W.R. WINBURN: "The perspective of autopoiesis, in which **organisms** are described "from the inside out", proposes a basic shift in the **observer-object relationship** behind traditional scientific **observation**. **Living systems** are explained only by **reference** to features within the possible **domain of interactions** specified by their **organization**" (1991, p.565).

One wonders however what WINBURN really means when he writes: "But autopoiesis defines biological **autonomy** in terms of **self-referential organization** of **living systems**. From this vantage point, **organisms** are necessarily **input-less** and **closed**" (ibid). This seems to be unfortunate semantics (more than once to be found in autopoietic literature): any **living system** depends on **inputs**, a lot of them. That these **inputs** be assimilated by **organisms** in a way non-contradictory to their internal **self-referential organization** is a different point, related to that kind of systemic stabilized **identity** obtained through autopoiesis.

R. ROSEN's formulation seems better: "... a non-empty **environment** can only affect **autonomous system behavior**, never its **autonomous dynamics** or **identity**" (1993, p.27). Even so, any system can be destroyed by its **environment**.

From another viewpoint, autopoiesis seems to be constructed in a **hierarchical** way. Biological and even possibly biochemical autopoiesis in individuals and species alike, must have preceded physiological, psychological, mental and social autopoiesis. Each of these successive **levels** is a kind of stepping-stone for the next **emergent** more complex one. This could be the connection between higher **level order**, **emergence** by **dissipative structuration** and, most importantly, **nucleation** from one side, and successive **levels** of **organizational closure**, from the other.

F. CAPRA gives the following wide embracing significance of autopoiesis: "...the **pattern** of life (that is the **pattern of organization of living systems**, **dissipative structure**, as defined by Prigogine, as the structure of living systems; and **cognition** as defined initially by G. BATESON (1904-1980) and more fully by MATURANA and VARELA (1946-2001), as the process of life (1977, p. 160)

→ **Autogenesis; Epigenesis; Equipotentiality; Santiago theory; Zero-system**

0216

### AUTOPOIESIS: About LUHMANN's view <sup>4)</sup>

O. THYSSEN (1995, P. 13) characterizes as follows the way LUHMANN (1927-1998) extends the concept of autopoiesis: "LUHMANN generalizes the concept to cover not only **living systems**, but also mental and **social systems**. Whereas **living systems** operate in the medium "life", mental systems operate in the medium "**consciousness**" and **social systems** in the medium "**communication**". According to LUHMANN, a **social system** does not consist of human beings or **artifacts**. It consists of an ongoing stream of **communication**". THYSSEN has some problems with these views: "An **autopoietic system** is closed"(Note: i.e. *organizationally closed*) "It has no contact with the **environment**"(Note: it is however *structurally coupled* with it. Is that not a "contact"?) THYSSEN adds: "A disturbing consequence is that mental and **social systems** are totally distinct. No analysis of **consciousness** will ever reveal anything about **brain processes**, which are the domain of **living systems**"

One wonder if it is not the reverse: could not **brain processes** reveal something about **consciousness**. And: "Another disturbing consequence is that LUHMANN has no place for the individual. This point is methodological, not normative or "antihumanistic".(ibid)

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

MAN is a very diffuse idea allowing references to many different systems which do not have MAN as an **element** and which do not form a unity: no **supersystem** encompasses living, mental and **social systems**. So what is MAN depends on who is observing and how. KORZYBSKI (1879-1950) could have said it: MAN is a high level abstract "label" that should be used very carefully.

The hinge of the problem is obviously that any **social system** depends on *individual observers* in two complementary ways:

- 1- In any **activity** the **structural coupling** with the **environment** of the **social system** is through individuals (which make a kind of porous frontier with the **environment**)
- 2- The internal **autopoietic behavior** of the system as a **whole** depends on myriads of interindividual **structural couplings** as **observers** of each others

0217

### AUTOPOIESIS and EVOLUTION<sup>1) - 4)</sup>

The concepts of **autopoiesis** and **evolution** are difficult to connect in a satisfactory way. Various critical angles must be considered.

1) **The autopoiesis of individuals: Autopoiesis** seems to preclude any acquisition of new characters by individuals, as it implies **organizational closure**. Such is at least the case *immediately after the creation of a new individual*. However, impacts from the **environment** may still be received, which will potentially modify some characters, in very exceptional cases transmissible to the descendants. If otherwise, no **evolution** (nor genetic engineering) should be possible.

2) **Variability of a population:** Genetic recombination allows **populations variability**, but then only within the **limits** of the global genetic stock in existence. However, this stock may have been potentially impoverished or, on the contrary increased by the effects of inheritance by some individuals of mutations undergone under impacts from the **environment**, received by individuals of a former generation.

3) **Effects of mutations:** Lethal mutations are those which destroy the **viability** of new individuals for not being compatible with their basic **control subsystem**. Acceptable ones are those compatible with the **constraints** proper to the species and, as such, "written" in the **control subsystem** of the individuals (See the concept of "Stellar system" of A. MALINOWSKY).

4) **Radiative evolution:** If acceptable mutations are to become registered within the **control subsystem** and in accordance with the already existing **constraints** proper to the species, then every species may become the origin of a wide variety of new species. However, as the species **control subsystem** (partially represented in every individual) is **autopoietic** (i.e. **organizationally closed**), it will never – at

least in natural conditions – be possible, starting from the present type, to regress to former types.

5) **Mega-innovation by association:** It seems that, at some very infrequent times in the **process of evolution**, the **association** of numerous similar individuals, grouped within different functional units, produced the **emergence of heterogeneous systems** of a higher degree of **complexity**. In such systems a higher order central **control subsystem** is needed and it seems to surge spontaneously (i.e., through a **process** still not yet quite well understood). The present global **transformation** of mankind into a hypercomplex global system is, possibly, an example.

0218

### AUTOPOIESIS and the "IMMANENT QUESTION"<sup>3)</sup>

The concept of "immanent question" has been introduced by G. BATESON in "Steps to an Ecology of Mind". (1973, p.371)

However the first example given by him comes from biology: "Consider the case of the unfertilized frog's egg for which the entry point of the spermatozoon defines the plan of bilateral **symmetry** of the future embryo.... The prick of a hair from a camel's-hair brush can be substituted and still carry the same **message**... But the internal **context** into which the **message** comes must be exceedingly complex. The fertilized egg, then, embodies an immanent question to which the entry point of spermatozoon provides an answer" (Ibid).

This implies that the egg, the seed or, probably, the **brain** and even possibly the first germ of a culture, contains (in BATESON's words) an appropriate **structure**, i.e. the implicit **time-to-talized order** created from former **adaptation** and **evolution**. (see "order from noise", for a critique of the well known von FOERSTER's experience with magnets).

Autopoiesis seems thus to be the result of a **process** of progressive **emergence of order**, as the source of BATESON's "immanent question".

Remains to find out which is the prime mover of this **emergence**.

→ **Autogenetic system precursor; Zero-system**

0219

### AUTOPOIESIS (S. BEER on levels of)<sup>1) - 2) - 4)</sup>

In his paper on "Suprahuman Autopoietic Systems", F. ROBB explains in the following way BEER's views on **emergent levels of autopoiesis**

"Beer (1975) in specifying the conditions of **viability** of systems, conceptualizes the social world as containing "esoteric boxes" which, when strung together, form larger **organiza-**

tions. These esoteric boxes are not **closed systems** but they are more often than not **ultrastable**, resistant to **change**, and are "designed for **survival**". The **connections** between these **subsystems** are complex beyond **understanding**, transient, and **unstable**. It is the **networks of connections** that are dubbed "metasystems", and effective **control** over the assemblage can be achieved only if these **metasystems** can be defined and formalized, or as Beer puts it, "institutionalized". The design of a **metasystem** required to ensure an **organization's viability** entails that it should be capable of absorbing the **variety** generated by its lower-order systems and by the **environment of the whole**.

"The **metasystem** uses a higher-level logic and higher-order values than used by the **object systems** and these are the means of containing **variety** and of realigning the **objectives** of the esoteric boxes so that they serve higher-order **objectives**. Left to themselves, the **subsystems** will **suboptimize** and will not contribute to anything but their own **survival**. In any social **organization** there may be many **levels of recursion**.

"Beer's esoteric boxes appear to have all the properties of **autopoietic** systems. They are **processors** of self-production. They appear to be, before intervention **organizationally closed**. The institutionalization of their **metasystems**, which Beer calls for, may be seen as the attempt to open them so that their **autopoiesis** is destroyed and their **processes** directed toward the **autopoiesis** of the greater **whole**.

"To Beer, the intervention is made in order to understand internal **structure** and **behavior** and to redesign the **metasystemic** relations required if the **autopoiesis** of the **whole** is to be sustained. In this way, the "designed" **metasystem** is seen as a necessary artefact required to ensure that the **whole** satisfies the needs as expressed by the **objectives** of the highest (in logical order) **level**. Without this intervention the lower-order needs may be satisfied temporarily but at the very great risk that the **metasystemic** interconnections will be severed or dissolve as the **whole** disintegrates" (1989, p.59)

It should be pointed out that:

1- **Subsystems' autopoiesis** is probably not "destroyed", but more or less **embedded** and modified according to the autopoietic needs of the **whole**.

2- The **autopoiesis in levels** concept could likely be applied to all **levels of complexity**, starting possibly with the atom and the molecule.

3- Referring to "Suprahuman Autopoietic Systems", Robb himself emphasized that it is in no way obvious that social **metasystems** can be widely controlled by individuals. The opposite is quite more probable.

4- Beer's well known attempts to create global **monitoring** systems at the national **level** in various latin-american countries (Chile, Uruguay, Venezuela) may even seem somewhat paradoxical, knowing his own skepticism about the "surrogate worlds we manage" (1973).

0220

### AUTOPOIETIC RELATIONS OF PRODUCTION<sup>1) - 2)</sup>

In MATURANA and VARELA view, autopoietic systems count with an inherent **set of relations of self-reproduction**, i.e.

1. "The **relations** of constitution "that determine the **components** produced, constitute the **topology** in which the autopoiesis is realized"
2. The **relations of specificity** "that determine that the **components** produced be specific ones defined by their participation in the autopoiesis"
3. The **relations of order** "that determine that the concatenation of the **components** in the **relation** of specification, constitution and **order** be the ones specified by the autopoiesis" (1980, p.88 – as quoted by R.N. ADAMS, 1988, p.82).

0221

### AUTOPOIETIC SYSTEM<sup>2) - 3) - 4)</sup>

"A unity realized through a closed **organization** of production **processes** such that (a) The same **organization of processes** is generated through the **interaction** of their own products (**components**) and (b) a **topological boundary** emerges as a result of the same constitutive **process**" (M. ZELNY, 1981, p.6).

ZELNY comments his definition as follows: "... the **organization of components and component-producing processes** is maintained **invariant** through the **interactions** and **flux of components**" (ibid.).

F. ROBB thus resumes MATURANA's basic **concept**: "Autopoietic systems are characterized by circular **relations** which give rise to and maintain their autopoiesis. They define themselves, they are irreducible **objects** in nature, not defined by **observers**, they are self-producing and self-maintaining, they emerge from **instabilities**, and they have properties not possessed by their **components**" (1990, p.394).

The comment about "irreducible **objects** of nature" is intriguing: it could possibly be considered as a base for a systemic **ontology**.

However, when H. MATURANA and F. VARELA write: "**Living systems**, as physical autopoietic **machines**, are purposeless systems" (1980, p.86), one wonders if there may be a danger that some could interpret autopoietic **machines** as solipsistic (or autistic!) **machines**.

Seemingly, an autopoietic **observer**, for instance, must, to begin with, **construct** his/her internal **organizational closure**, even if this **process** begins before birth, in the guise of physiological **organizational closure** through genetic and **generative** heredity.

As conjectured by ZELNY, any autopoietic system would need to be a society, whether of **cells** in a **living system**, ants in an anthill, neurons in the **brain**, human beings in an **organization**, and even possibly in a near future elemental **robots** in systems of **distributed artificial intelligence**.

It has also be argued, by F. ROBB, that: "... there are strong reasons to believe that ever-higher order social **processes** can **emerge**" (1990, p.394).

**Biotopes** as well may be considered up to a point as autopoietic systems, when not seriously disturbed by outside **perturbations**.

Amanda GREGORY states: "The autopoietic system is structurally coupled to its **environment**: it responds to environmental **perturbations** by producing a feasible **set of responses**, in such a way to maintain its autopoietic **state**, from which the **environment** selects" (1996, p.571)

Thus the autopoietic system is equipped to oppose a strong resistance to **change**.

Accordingly, A. GREGORY examines in her paper the difficult relation between external evaluators and the (internal) managers of human **organizations**, which autopoietic character at times leads them to be highly resistant to **change**.

0222

### AVAILABILITY<sup>1)</sup>

Existence in the **environment** of the **resources** needed by the system.

Availability must be permanent or, at least, exist at any moment the system is seeking the **resources** it needs.

This is a condition of **survival** for any system, even if the normal **input source** can be in some cases replaced, at least temporary, by an alternative more or less equivalent **source**, or by **reserves** stored within the system itself.

Availability can be affected by variations in the **environment**, spontaneous or provoked by the system's own **action** or by **competition** between various systems.

0223

### AVALANCHE<sup>2)</sup>

A very quick succession of **changes** triggered by a minimal **perturbation**, in a **network** or a **composite system** in a **critical state**.

An avalanche is a **percolation phenomenon** and is submitted to a **power law distribution**.

According to P. BAK and K. CHEN: "An avalanche is a type of chain reaction or **branching process**" (1991, p.28). Good examples are the propagation of an earthquake, of a forest fire or of a mud or snow slide.

In **composite systems**, the possibilities that such avalanches could propagate, depend on the characteristics of the **network** and, particularly on the existence of more or less extended stable "islands". (Blocks of **frozen elements** as described by St. KAUFFMAN, 1993, p.67)

Avalanches imply the existence of **conditional interactions** between **elements** in a more or less loose **network**.

P. BAK writes: "Large avalanches, not gradual **change**, make the link between quantitative and qualitative **behavior**, and form the basis for **emergent phenomena**" (1996, p. 32)

This is significant not only for physical **phenomena**, but also for economic and sociological ones: "If this picture is correct for the real world, then we must accept **instability** and **catastrophes** as inevitable in biology, **history** and **economics**" (Ibid).

**History** here covers political and social upheavals.

And: "Because the outcome is **contingent** upon specific minor **events** in the past, we must also abandon any idea of detailed long-term **determinism** or **predictability**" (Ibid).

This does not however seems to be **absolute**: "detailed" defines the basic meaning of this sentence. We still have a kind of overall **long-term stochastic determinism**, related to **self-organized criticality**. Earthquakes for instance are frequent along some known geological fracture lines, and rare elsewhere. In **time**, their **frequency** is relatively defined by a specific **power law** (Gutenberg- Richter Law) (Ibid, p.13)

0224

### AWARE OF<sup>1)5)</sup>

It is significant that the word "aware" is generally used with "of".

Obviously awareness is always the result of some relation between a percipient **observer** and some **event** or **situation** in his **environment**.

The crux of the matter is finding out how exactly such **interactions** take place, which consequences they produce and which more precise **meaning** we can give them after a cautious critical evaluation

0225

### AWARENESS<sup>1)5)</sup>

The awakening of alertness and attention triggered by any specific **perception**.

Awareness is frequently used as a synonym for **consciousness**. This seems to be rather unfortunate, as **consciousness** is the ultimate state of awareness, if used in the **meaning** of a capacity to reflect on one's own **perceptions**, as integrated and more or less clearly formulated by a human **brain**.

However, as expressed by F. Capra, this is "a key character of human **consciousness**". Thus "for a thorough understanding of the general **process of cognition in living systems** it is thus important to understand how human **consciousness**, with its abstract thought and symbolic concepts, arises out of the **cognitive process** that is common to all living **organisms**" (1997, p. 286)

In fact, awareness in its first state, can be only minimally distant from non-awareness. An example could be the passage from a merely dim **perception** of cold weather to a much clearer perception of what it means for the **observer**: 1) "It feels very cold. 2) Let me have a look on the thermometer for a more precise **evaluation**"

Awareness leads to focused attention and normally to a more selective orientation of **perception**, that may in last resort become clearly **intentional**. This sequence can already be observed in animals like dogs or chimpanzees

In many cases it leads to specific **action** and is thus a prime mover of selective **behavior**.

0226

### AWARENESS (Critical) <sup>1)2)3)</sup>

Awareness is a very ambiguous notion. Everybody believes being "aware". But the fact is that there are many different forms and qualities of awareness. Critical awareness is widely discussed by M. JACKSON in his most recent book (2000, p. 356), as a basic foundation for **systems thinking** in general.

JACKSON basically distinguishes a hard **approach** and a soft one to complex **situations** and **issues**. He quotes CHECKLAND's opinion that "hard systems thinking is guided by functionalist **assumptions**: the world is seen as made of systems that can be studied objectively and that have identifiable **purposes**" (Ibid).

Leaving aside the "observing systems" problem (von FOERSTER, 1981), the most favored tool of hard system thinking will be **linear causality** or, at most, a kind of cybernetical **mechanicism**. In short, the quality of awareness depends on the **range** and quality of **perception** and on the limits of our conceptual **frame of references**.

JACKSON commends a wider sociological approach to the awareness problem: "with CHURCHMAN, ACKOFF and CHECKLAND, systems thinking becomes much more subjective, and the emphasis shifts from attempting to model systems "out there" in the world toward using **systems models** to capture possible

**perceptions** of the world". Furthermore this leads to "structure and enhance debate among **stakeholders**" so that an **accomodation** about **action** to be taken can emerge" (Ibid)

In short, critical awareness should be kind of stereoscopic or **holographic**. This view should meet JACKSON's conclusion: "Critical awareness, incorporating social awareness, became one of the central principles of critical systems thinking and remains so to this day. The main problem, of course, is that the apparent strengths and weaknesses of any particular systems approach will vary dramatically depending upon the **paradigm** from which it is observed and judged" (Ibid., p. 357). And moreover: "Critical awareness involves... criticizing the theoretical underpinnings, strengths and weaknesses of available systems **methodologies** and the usefulness of the **variety** of systems models, **methods, tools** and techniques in the service of different methodologies" (Ibid, p. 375)

0227

### AWARENESS (Levels of) <sup>1)5)</sup>

**Levels** of awareness seem to be depending on the growing **levels of complexity** of the **nervous system** and the **brain** all along the evolutive lines of animal species

It has much to do with the **activity** chain that starts with **perception**, follows with **perception** interpreted as a **signal**, and ends with some **behavior** triggered by the **signal**

The following **levels of awareness** should be tentatively considered:

- **perception** (in all cases the basic condition for any awareness)
- inner **interpretation** of perception as a "**signal**" (this already supposes a previous training)

The capacity of **interpretation** broadens, widens and deepens until it reaches the aptitude for finer and finer **distinctions in categorization** and, finally, more and more capacity for complex **abstraction** and self reflecting **representation**.

- enhanced individual awareness obtained through reciprocal signaling within social **frames**. Such frames also become ever more complex from social amoeba to human societies
- the possibly questionable level of collective awareness in societies and **cultures**

Archaic forms of such collective awareness can be observed in beehives, termites mounds and ants nests.

0228

### AWARENESS (Self) <sup>1)5)</sup>

The capacity to clearly perceive oneself as a separate entity

As noted by F. Capra, self-awareness, as far as we know, is manifest only in higher animals and fully unfolds in the human mind" (1997, p. 287)

He adds: "As humans we are not only aware of our **environment**, we are also aware of ourselves and our inner world. In other words, we are aware that we are aware. We not only know; we also know that we know. It is this special faculty of self-awareness that I refer to when I use the term "**consciousness**" (Ibid)

It can also easily be observed that the degree of self-awareness varies widely among human individuals, from about non-existent to acute **consciousness** in the case of mystics, "illuminated" or "awakened" (in the Buddhist sense) Capra also observes that "In the **Santiago theory**, self-awareness is viewed as being tied closely to **language** and the **understanding of language** (as) approached through a careful analysis of **communication**"...and "**Communication**, according to Maturana, is not a **transmission of information**, but rather a **coordination of behavior** among living **organisms** through mutual **structural coupling**. Such mutual **coordination of behavior** is the key characteristic of **communication** for all living **organisms**, with or without **nervous system**, and it becomes more and more subtle and elaborate with **nervous system** of increased **complexity**" (Ibid)

→ **Brain (Triune)**

0229

### AWARENESS vs. CONSCIOUSNESS <sup>3)4)</sup>

According to Susan Blakemore, awareness is a moment-to-moment **phenomenon** (2002, p. 26).

It is the result of instantaneous **perception**, that can be repetitive, but in a **discontinuous** manner.

Moreover awareness is always awareness of "something". It necessarily supposes an **experience** of some **event** "there outside". But the experience is "inside" as it is basically a complex **computation process** in a **neural network**.

It is also automatic. We do not need to decide that we are going to perceive: we just do.

As our **nervous system** possesses somehow the faculty of remembering former **experiences** we easily gain the impression of a **continuity of consciousness**. In fact it seems that this is also a construction in our **nervous system** which somehow throws bridges between these **discontinuous** moments of awareness.

The nature of the bridges is probably related to the continuous existence of a neuronal net in our **brain**, which becomes repeatedly reorganized after each **experience**. This is the gist of Maturana and Varela concept of **Autopoiesis**. (- see J. Gran, 2002, p. 46-49)

→ **Hippocampus**

0230

**AXIOLOGICAL HYPOTHESES versus AXIOMS**<sup>3)</sup>

J.W. SUTHERLAND says that the negation of POPPER's caveat about embracing creeds, "transforms axiological hypotheses into axioms" ... in which case "...the role of the scientist is displaced by that of the rethorician" (1973, p.107).

Since most, if not all of the **General Systems models**, are patently axiological hypotheses, **generalists** should be careful not to fall in the trap signaled by POPPER.

0231

**AXIOLOGY**<sup>3)</sup>

The discipline that studies the nature of **values**.

Systemics has an impact of axiology mainly for the following reasons:

- As it instates a **hierarchy** of **embedded** and **interdependent** systems, it should lead to a re-examination of the **rights, responsibilities** or reciprocal **needs** of each system and **co-system** within the corresponding **supra- and infrasystems**. This subject embraces a wide range of disciplines, from ecology to psychology and sociology.
- As it introduces a strong **time-dimension, needs, rights** and **responsibilities** must be considered within a future perspective, corresponding to different **time scales**.
- As it proposes a specific way to understand the relation of the **observer** with the observed, and peculiarly, the relations among various **observers**, systemic axiology needs to focus on **consensus** and **co-participative decision making**.
- As systemics introduces a new **understanding** of the nature of cultural differences, systemic axiology must also strive to find satisfactory transcultural **values**.

**B**

0232

**BABEL TOWER EFFECT**<sup>1)</sup>

The growing incommunication between specialists of all trade resulting from increasingly partialized specialization.

While specialization is the condition of **efficiency** and genuine well founded **knowledge** in every specific trade, it also provokes a growing disconnection between specialists, as a result of the **emergence** of specialized jargons.

Systemics tries to create **meta-concepts** and a **metalanguage** of **isomorphic** or **homomorphic models** whose **validity** should cover as wide specialized areas as possible. It does not intend in any way to replace or reinvent specialized **knowledge**. Its real main aim is to

reestablish a higher degree of reciprocal **understanding**, in particular when numerous specialists must collaborate in the **management** of a complex **situation** or the **co-participative design** of some project.

0233

**BACKGROUND**<sup>1)</sup>

The significant **environment**, past and/or present, of a **percept, representation** or **concept**.

The background is not taken into account until, for some reason, it becomes modified in a way that affects the **observer**. This is the case, for instance, of normal gravitation... until there is an earthquake, or for an astronaut floating in outer space.

However, a unperceived part of the background can be significant: nuclear irradiation can kill without being perceived.

The background can also silently accumulate slow **changes** that may suddenly **trigger** some **catastrophic effect**.

From a systemic viewpoint, an unobstrusive **monitoring** of the background can thus be very useful.

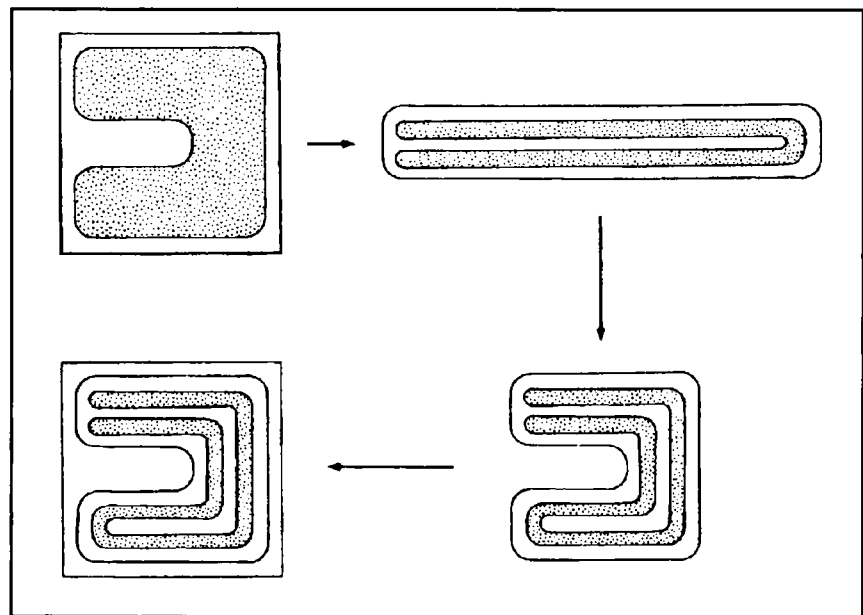
→ Invisibility

0234

**BACKSIDE BALANCE**<sup>4)</sup>

A kind of **behavioral feedback** that tends to restore dynamic **equilibrium** in a distorted economic or social relation.

Figure: see entry **BAKER'S TRANSFORMATION**



The Baker's transformation as applied to Smale's "horseshoe"  
From I. EKELAND: 1984, p. 90.

The notion has been introduced by M. MARUYAMA (1994, p.35), who calls it "backside system". It seems better here to avoid the use of the word system, because the backside **reaction** is not in itself a system, but a device or **process** within a system.

MARUYAMA gives various examples of this kind of **adaptive regulation** in distorted systems. "The combination of low wage and off-the-job income in South America, and low wage and multiple employment in Hungary until 1992, are also examples..." (Ibid)

MARUYAMA makes this very important observation: "Quite often, the backside system is invisible to outsiders" (Ibid)

0235

**BAKER'S TRANSFORMATION**<sup>2)</sup>

A **topological** transformation which helps to visualize the **chaotic fractalization** of **processes trajectories** in **complex systems**.

I. PRIGOGINE and Y. ELSKENS describe the Baker transformation of a unit square as "a piecewise **linear area-preserving mapping**" (1986, p.211)

PRIGOGINE describes it as follows: "(it) owes its name to the association with the kneading of dough... Beginning with a square, we first flatten it into a rectangle. Then we fold one half of the rectangle on top of the other half to form a square again. This set of **operations**... may be repeated as many times as one likes. Each time the surface of the square is broken up and redistributed. The square here corresponds to the **phase space**. The baker transformation takes each point from its original positions to a new, but perfectly well defined position... AI-

though the series of points obtained in this way is "**deterministic**", the system displays in addition some irreducibly statistical aspects" (1980, p.77).

As explained by J. CASTI: "The stretching and folding operations are complementary, in the sense that the first separates points, while the second tries to bring them back together again – but with new neighbors" (1994, p.91).

He adds: "There are two directions in which the points can move: up/down and left/right. So there are two rates of separation, one in the vertical direction, the other in the horizontal" (p.100).

The baker's transformation is a **model** of how a **deterministic process** can produce a **chaotic behavior**.

see figure page before

0236

**BALDWIN Effect**<sup>2)</sup>

D. DEPEW writes: "The general idea of the Baldwin effect is that learned **behaviors** can affect both the direction and the speed of evolutionary **change**. If an **organism** changes during its lifetime to acquire **habits** or exhibit behaviors which permit more effective **interaction** with its **environment**...it will probably leave more offspring" (2000, p. 7)

In this way a connection is established between **ethology** (and even **ecology**) and **evolution**. The idea reminds also somehow of LA-MARCK's view about "heredity of acquired characteristics". In relation to DARWIN's view of evolution, it adds sense to the concept of **selection**.

Baldwin's idea, according to DEPEW is in need of "the articulation of new theoretical **frameworks** in which it may make sense"(Ibid)

More generally, it is obviously related to the ways adaptive or evolutive change in **elements** or individuals affects the group of the **social system**. In **modeling** terms, it would be the reconstruction of the "**metasystem**" from **bottom up**, or the subtle contradictions and complementarities between **autopoiesis** (Maturana), **homeostasis** (Cannon), **emergence** (Priogine), **autogenesis**(Csanyi) and **variety** (Ashby).

No doubt: the debate is far from concluded. But the collection of papers published by "Cybernetics and Human Knowing" is a quite significant step. (7(1), 2000)

→ **Renormalization group; Somatic ecology**

0237

**BASE RATE**<sup>1)2)</sup>

The general **probability** of an **event** to occur.

Such a rate is more easy to determine for frequent **events**, as for example the occurrence of rainy or snowy days in New York, than for rare **events** as for example hurricanes in Miami.

0238

**BASE RATE EFFECT**<sup>2)</sup>

"The effect that the **chances** of an **event** occurring at all - its base rate - have on our ability to predict it" (R. MATTHEWS, 1997, p.25)

The more infrequent an **event**, the less we can predict its occurrence.

This has practical consequences. MATTHEWS states: "Its central lesson - that rare **events** are hard to predict - could... save us from spending millions on what may well be scientific wild goose chase". As a possible example, the author gives the prediction of earthquakes, a costly research until now "without a single unequivocal success" (p.31).

**Criticality** theory helps to understand the deeper reasons of such failures.

0239

**BASELINE**<sup>1)</sup>

Existing conditions and **trends** in the **activity** of a system before any modifying **action** occurs.

It constitutes a bench mark **state** from which **knowledge** is needed for the **evaluation** of any natural or projected purposeful **change**.

It is also useful for consideration of non-action alternative

0240

**BASIN BOUNDARY**<sup>1) - 2)</sup>

The **set** of points that defines the outer **limit** of a **basin of attraction**.

The crossing of this boundary due to some **perturbation** knocks the system out of the basin and either sends it into some other basin corresponding to another **attractor** or readily destroys it.

However, according to R. THOM, the basins relative to two **attractors** can penetrate each other in a **topologically** complicated way, with a quite undeterminate outcome (1972).

See **Basin erosion**

0241

**BASIN BOUNDARY (Fractal)**<sup>2)</sup>

The boundary of a **fractal basin of attraction**.

**Nonlinear** systems have in many cases **trajectories** submitted to **chaotic attractors**, which can be very complex, i.e. they may have a very wispy micro **self-similar structure** (homoclinic tangles; SMALE's horseshoe, etc...).

Such systems are very difficult to describe, to monitor and to control.

0242

**BASIN EROSION**<sup>2)</sup>

The progressive invasion of a stable **basin of attraction** by **instabilities** generated by a **chaotic attractor**.

During this **process** the basin is progressively divided into layers of smaller and smaller **regions of stability** and of **instability**, i.e. becomes **fractalized**.

In such a case, the basin may become "... so thin or wispy that small **disturbances** can knock the system out of the basin to **converge** somewhere else" (A. McROBIE & M. THOMPSON, 1990, p.45).

These authors add: "To be safe any engineering system must have its **attractor** at a prudent distance from its **basin boundary**. Structural engineers refer to failure as "exceedance of the ultimate **limit stage**". Once a **structure** passes this condition, it will **collapse**" (Ibid.)

This quite insidious **process** of loss of **stability** is responsible for numerous structural disasters in buildings, ships, airplanes, bridges, etc. submitted to external **disturbances** like winds, **overload**, collisions, small seismic movements, etc...

It is also present in celestial mechanics, where H. POINCARÉ first met it in the study of Saturn rings.

0243

**BASIN OF ATTRACTION**<sup>1) - 2)</sup>

The **region** that includes all the **trajectories** corresponding to an **attractor** in a system's **dynamics**.

A specific basin corresponds to each **attractor**.

The global **state space** consists of a **set** of **basins**, that are isolated from each other by **separatrixes**. In the neighborhood of a **saddle**, basins **limits** become **unstable**, and a **trajectory** can jump from one basin to another (A **catastrophe event**).

This abstract concept can be intuitively visualized through the example of a river basin, in which **flows** circulate in a structured **space**. The general character of a basin implies, in K. KRIPPENDORFF's words: "... that no **state** in one basin succeeds or is succeeded by **states** in another basin and any two **states** in one basin share at least one preceeding **state** or successor" (1986, p.5-6). Every basin thus defines some specific **dynamics**, and inhibits any other.

To different kinds of **attractors** correspond different types of basins.

0244

**BAYESIAN PROBABILITIES**

→ **Probabilities (Bayesian)**

0245

**BAYESIAN SYLLOGISM**<sup>1)3)</sup>

The Bayesian syllogism has been introduced by V.V. NALIMOV and is based on Bayes probabilistic logic (1982, p. 284).

In NALIMOV's own terms: "It becomes possible to speak of the Bayesian syllogism. It may be regarded as a generalization of ARISTOTLE's syllogism (i.e. the categorical syllogism in which two initial categoric assertions linked by the common middle term yield the third judgement called the **inference**..., an assertion of absolute **value**, independent of any conditions).

"Whereas in the Aristotelian syllogism the inference is a logically clear assertion, in the Bayesian syllogism the inference is the redistribution of weights in the system of initial value **concepts**, determining the trend of thought on the logically structured **level**" (Ibid)

In a later work, NALIMOV adds: "In my interpretation, the Bayesian formula well known in statistics acquires a new **meaning**. From an auxiliary computational formula, broadly used in mathematical statistics, it turns into one setting the logic of propositions" (1985, p. 28)

→ **Bayes theorem; Bayesian probabilities; Parallel distributed processing**

0246

**BAYES's Theorem**<sup>2)</sup>

R. MATTHEWS (1997, p.38) explains Bayes's theorem as follows: "(The) theorem shows how to update your belief in a particular theory in the light of new **data**. Mathematically, it states:

**Odds (Theory, given observed data) = LR x Odds (Theory)**

where Odds (Theory, given observed data) are the odds on the correctness of the theory, given the new **data**, and Odds (Theory) are the so-called prior odds that the theory is correct - that is, a measure of the plausibility of the theory before the new **data** emerged. Precisely how that new **data** changes your beliefs is captured by the so-called "**Likelihood Ratio**" (LR), which is made up of two factors:

**LR = Prob (getting the data, given theory is correct)**

**Prob (getting the data, given theory is wrong)"**

BAYES's Theorem helps dealing with statements "that lie somewhere between absolute truth and falsity" (R. MATTHEWS, 2000, p.45). This is crucial for the **evaluation** of the soundness of any scientific result (and any belief in general), because, as **observers**, we have no way to appreciate "absolute" truth or falsity.

MATTHEWS explains: "... as you accumulate more **information**, BAYES's theorem shows that your original thoughts - flaky or well founded, right or wrong - become progressively less important... The scientific process contains

an ineluctable amount of **subjectivity** at the onset, but... it gives way to **objectivity** as the **information** accumulates. In other words, scientific **objectivity** is "emergent" (p.45).

It would be possibly better to say that it is "asymptotically emergent", because it is impossible to totally eliminate **subjectivity**. This **process** is closely related to POPPER'S **false-ability**. It is also obvious that asymptotic **objectivity** is better reached by recurrent debate and **consensus**.

→ **also: Epistemo-praxeological closure; Observability (Constraints on); Observation process; Probability (Bayesian)**

0247

**BEHAVIOR**<sup>1) - 4)</sup>

1. "The system of interconnected and expedient **actions** carried out by an **organism**" (UNESCO-UNEP, 1983, p.6)

2. A repetitive sequence or **pattern of actions** or **operations**, and resulting **states**, characteristic of a specific system.

The second definition is more general than the first, since it can apply to non-**living systems**, as well as to societies of **organisms**.

The concept of behavior, when referring to a **complex system**, may be associated with an interconnected **network of actions**.

G. PASK gives the following examples: "The behavior of a steam engine is a recurrent **cycle** of steam injection and piston movements that remains invariant. The behavior of a cat is made of **performances** like eating and sleeping and, once again it is an **invariant** form selected from the multitude of things a cat might possibly do" (1961, p.18).

**Models** of numerous different behaviors can be constructed, but one **model** may be used to modelize analogous behavior of different systems, as for example cyclical **oscillations** in **homeostatic systems**, or **dissipative structuration in systems far from equilibrium**.

Behavior is thus a systemic-cybernetic concept of very ample significance and does not exclusively and necessarily have psychological overtones.

However, as stated by R. ESPEJO: "The greater the number of distinct behaviors that are recognized in a **situation**, the more complex it appears to be" (1988, p.140)

From a somewhat different **viewpoint** G. KLIR defines behavior as: "A particular **set of time-invariant relations** between certain quantities". He then proceeds to define three basic kinds of behavior:

Table: see entry **Behavior**

Type of system	Behavior of system	Outcome of behavior
<b>State</b> maintaining	Variable but determined (reactive)	Fixed
<b>Goal-seeking</b>	Variable and chosen (responsive)	Fixed
<b>Multi-goal-seeking and purposive</b>	Variable and chosen	Variable but determined
<b>Purposeful</b>	Variable and chosen	Variable and chosen

"1. **Permanent (real) behavior** - the **set** of all absolute **relations**;

"2. **Relatively permanent (known) behavior** - the **set** of all relative **relations** of a particular **activity**;

"3. **Temporary behavior** - the **set** of local **relations** within a distinct section of a particular **activity**". (1965, p.30)

He adds: "It should be remembered that permanent behavior is known only in some cases, e.g., when it is directly given in some engineering system" (Ibid)

Still from another perspective, A. ROSENBLUETH, N WIENER and J. BIGELOW (1943, p.22) proposed a **classification** of orders of behavior.

In turn, R.L. ACKOFF establishes the following behavioral **classification** of systems (1971):

see table below

0248

**BEHAVIOR (Active)**<sup>2)</sup>

"A system's **behavior** is determined not only by the **state** and influence of the **environment**, but also by the system's own **goals** presupposing the **transformation** of the **environment**, its subjection to the system's need" (I.V. BLAUBERG, V.N. SADOVSKY & E.G. YUDIN, 1977, p.120).

According to these authors: "...in a system with active **behavior**, a crucial role is played by the **teleological** characteristics of the system itself and of its separate (i.e. distinct) **subsystems**, and by the **interaction** of these characteristics" (p.130).

Active behavior is possible only for a system endowed with **regulation** and **control mechanisms**, which must include a **knowledge** of its own **state** and that of its **environment**, including some **knowledge of past states**.

This concept makes sense particularly in connection with **autonomous** (= **autopoietic**) **systems**.

0249

**BEHAVIOR (Adaptive)**<sup>\*</sup>

→ **Adaptive behavior**

0250

**BEHAVIOR (Anticipatory)**<sup>1) - 2)</sup>

The activity of a system that constructs a predictive **model** of itself, its **environment**, or both, in order to adapt itself to probable future **change**.

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

R. ROSEN found that such behavior is quite general in **living systems** of all kinds, even if at very different **levels** of systems **complexity**.

The notion of anticipatory behavior should be handled in a discerning way, in order to avoid logical contradictions: future **events** cannot of course exert influence on present ones, but what is *now correlatively* perceived or believed about what will probably or possibly happen, can. ROSEN gives the following example: "Many primitive **organisms** are negatively phototropic: they move toward darkness. Now, darkness in itself has no physiological **significance**; in itself it is biologically neutral. However darkness can be *correlated* to characteristics which are not physiologically neutral, e.g., with moisture or with the absence of sighted predators. The relation between darkness and such positive features composes a *model* through which the **organism** predicts that by moving toward darkness, it will gain an advantage" (1979, p.15).

This action of a *present prediction* upon the *present* behavior acts as a **regulation** or **control** and is called **forward activation**, the result of a **feedforward**.

ROSEN adds: "Of course this is not a conscious **decision** on the **organism's** part; the **organism** has no real option, because the **model** is, in effect "wired in" (p.544).

In animals with complex brains, however, particularly man, the **model** becomes much more complex and can evolve, becomes reflexive and self-corrective, and leads to changing **goal-directness**.

An obvious conclusion, stated by ROSEN (p.557), is the need for ever-perfected predictive **models**, in order to improve anticipatory behavior. This field should urgently be researched upon as to the anticipatory behavior of **social systems**.

→ **Club of Rome, Feedforward, System (Anticipatory) and Systems Dynamics**

0251

**BEHAVIOR (Chaotic)**<sup>2)</sup>

I. PRIGOGINE and I. STENGERS write: "A behavior is chaotic if **trajectories** outcoming from points as close as possible in the **phases space**, stray from each other in **time** in an *exponential way*". (1992, p.77)

This implies that, after a sufficiently long span of **time**, it becomes impossible to predict future behavior relying solely on the **initial conditions**. The authors explain that only a more accurate **knowledge** of these may better the **predictability** of behavior, but that such **knowledge** will rapidly become prohibitive in **costs** and in **time**.

While this is an abstract view, it corresponds to our practical **situation** in front of **complex systems** and it strongly limits our possibilities to govern them.

→ **Lyapounov exponent**

0252

**BEHAVIOR (Coherent)**<sup>1)</sup>

The behavior of numerous **elements** or individuals which start to exhibit coordinated **interactions**.

This **phenomenon** can already be traced in physical effects (**BÉNARD's instability**) and chemical reactions (the **BELOUZOV-ZHABO-TINSKY reaction**). It heralds the **emergence** of higher **order structures** and, in living beings, of social **organization**.

0253

**BEHAVIOR (Determinate)**<sup>2)</sup>

G. KLIR thus characterizes determinate behavior (in **automata**): "The instantaneous **response** can be uniquely derived from the instantaneous **stimulus** and sometimes from past **stimuli** and **responses**; this is accordingly subdivided in:

1. **combinatorial** – the instantaneous **response** depends solely on the instantaneous **stimulus**;
2. **sequential** – there exists at least one **response** that depends not only on the instantaneous **stimulus** but also on the past **values** of some of the quantities" (1965, p.37).

KLIR opposes determinate behavior to **random** behavior

0254

**BEHAVIOR (Eco-)**<sup>1) - 4)</sup>

The behavior of elementary units in a **network** as it becomes organized through their repeated **interactions**.

This **concept** has been promoted by J. ERCEAU and J. FERBER whose "... objective is to construct a society of **agents**... (true non-anthropomorphic micro-robots), capable of work within a hostile **environment**, and to improve their individual and collective **performances** through **mechanisms** akin to **learning**" (1991).

These authors include in their "society" reactive **agents**, communicating **agents**, rational ones and intentional ones. (See "**Multi-agents systems**").

In natural **ecosystems**, different types of behavior are distributed among different species or among various individuals of the same species. There appear to be a kind of spontaneous and distributed **control mechanism** peculiar to these systems.

Strikingly, eco-behavior could be used as a **model** for any type of **social systems**.

0255

**BEHAVIOR (Eigen)**

→ **Eigen**

0256

**BEHAVIOR (Emerging)**<sup>2)</sup>

Innovative behavior of a system or **network** that does not exist in any of its **elements** or **parts**.

Emerging behavior results from the combined **interactions** of some or many **elements**. Some of the **interactions** are simultaneous in different **parts** of the **network** or system, while others are sequential. This situation may lead either to what St. KAUFFMAN (1991) calls **anti-chaos**, i.e. **organization** at a higher level of **complexity**, or **deterministic chaos**.

In **multi-agent systems** global behavior emerges from the **interactions** of numerous "**agents**", whose abilities are more or less elementary and specific. This is a typical social **network situation**. It also seems to promise complex societies of simple **robots** in the future.

0257

**BEHAVIOR (Functional)**<sup>1)</sup>

In order to be considered functional, any **behavior** must be **adaptive**, i.e. allow for a suitable **reaction** of the system to some **stimuli**.

However, functional behavior is more than a **functional reflex**, which is only a **response** to a **command**. A **functional reflex** may indeed endanger the system in some cases.

Functional behavior, even though its progress ceased at the reflex **levels**, involves the previous incorporation of a **variety** of possible reflexes into a **subsystem**:

1. which will be able to produce a considerable **choice** of distinct **sequences**, according to the general conditions (and not only to the specific **stimulus**)
2. which will be **integrated**, i.e. able to select the appropriate **response**.

0258

**BEHAVIOR (Isopraxic)**

→ **Isopraxic behavior**

0259

**BEHAVIOR (Line of)**<sup>2)</sup>

"A succession of **states** and **time-intervals** between them" (W.R. ASHBY, 1960, p.20).

AHSBY adds: "The first **state** in a line of behavior will be called the **initial state**. Two lines of behavior are equal if all the corresponding pairs of **states** are equal, and if all the corresponding pairs of **time-intervals** are equal" (p.243)

This is of course the basic condition for **homomorphisms** and **isomorphisms** between functional **models**.

0260

**BEHAVIOR ( Operative)** <sup>1)4)</sup>

The behavior of a **decision** maker or **operator** when trying to manage a system or correct some **disturbance** in a **function** of the same.

The following types of operative behavior have been identified:

- **skill-based behavior**: it is similar to an automatic behavior, practically without mental **activity**. The **operator** only reproduces behavioral **models** acquired by intensive **training**. Any alarm functions as a **trigger** for a kind of **conditioned reflex**
- **rule based behavior**: this behavior supposes a conscious mental **activity** and is characterized by the sequential **performance** of coordinated **tasks**, according to learned or written well assimilated **rules**
- **knowledge-based behavior**: the **operator**, in a more complex and not very common **situation**, must understand the problem, plan adequate **responses** and execute the corresponding **decisions**. This behavior generally includes reasoned **choices** made in due time on the base of a proper **understanding** of systemic **complexity**. A high level of personal **responsibility** can be achieved in this way.

A frequent and very dangerous error is to give **responsibilities** of this last level to people trained only for **rule- or skill- based behavior**.

Human behavior in operative **situations** and in relation to mental **activity** seems to respond to the three following basic types:

- **Skill-based behavior**: a practically automated behavior generally produced by a long **training**. Such behavior allows a very quick and efficient operative **response**, but then only in situations similar to those met during the **training process**. The skill acquired by a pianist for example is rigorously related to the universal standard board of pianos
- **rule-based behavior**: a less automated behavior, in which a measure of mental **activity** is needed in order to select the correct behavior in different specific cases. Such behavior is not over-complex when the number of possible different cases is limited and corresponds to more or less similar or well known **situations**
- **Knowledge-based behavior**: an intelligent mental behavior needed to tackle quite complex and/or unusual **situations** wherein automated skills or **rule** application are wanting. In such cases an **operator** must be able to discover adequate procedures in **decision making** or in **design processes**.

→ **Christmas tree effect; Complexity; Decision tree**

0261

**BEHAVIOR (Purposive)** <sup>1) - 4)</sup>

A. RAPOPORT observes that: "...mathematical analysis shows that the apparently purposeful behavior of the system is a consequence strictly deduced from the fact that it is **open, not closed**" (1966, p.8).

In effect, the need to process *specific inputs* of **energy, matter** or **information** in accordance with the internal nature of the system implies a behavior oriented toward the maintenance of defined internal **parameters**. This does not necessarily impose **consciousness**, and even less so, **teleology**.

We would probably have to distinguish between two types of purposive behaviors. The first one is, in animals, non-conscious *purposive* behavior (another semantic trap!) and the second is man's, based on **symbolic** capability (cf. L.von BERTALANFFY, 1967), that should be called *purposeful*.

Evolutionary **differentiation** seems to bear on a steadily growing capability to *create* new behavior within the **reference frame** of an already globally installed **understanding** of **environment** as well as **invironment**.

Such a capacity could be a result of the growing **variety** of effective and of potential neural **interconnections** in the **brain**, which provide the possibility of practically unlimited recombinations.

0262

**BEHAVIOR (Random)** <sup>2)</sup>

G. KLIR characterizes random behavior (in **automata**) as the one in which: "... the **response** depends statistically on the instantaneous **stimulus** and sometimes also on past **stimuli** and **responses**, accordingly subdivided into:

1. simple, where the instantaneous **response** depends (statistically) solely on the instantaneous **stimulus**;
2. complex – there exists at least one **response** that depends (statistically) not only on the instantaneous **stimulus**. but also on the past **values** of some of the quantities" (1965, p.37). Complex random behavior thus seems to be a characteristic of **ergodic** or **markovian systems** in general terms.

0263

**BEHAVIOR (Reactive)** <sup>1)</sup>

A system's behavior "determined by **environmental input** in all essential points" (I.V. BLAUBERG, V.N. SADOVSKY & E.G. YUDIN, 1977, p.130).

0264

**BEHAVIOR SCHEDULE** <sup>1)</sup>

A. LOTKA introduces this interesting **concept** as follows: "We may say ... that the **organism** goes through a certain **routine** of motions or

**activities** which are rendered possible by its **structure**, and which, in turn, are a necessary condition for the continued existence of that **structure**. These **activities** in general involve the expenditure of certain quantities of free **energy**, and a part of the **energy** so expended, is spent necessarily in collecting (earning) a "replacement" amount equal to the total expenditure, to balance the account, to cover the *cost of living*" (1956, p.346).

By connecting behavior with **structure** (in a reciprocal way), this **concept** bridges a gap between those of **dynamic stability, organizational closure, hypercycle** and **behavior** in general.

It is possible to describe behavior schedules in a quantitative way, for example, as shown by LOTKA, by an estimation of the normal use of earned calories.

Behavior schedules can be modified, for instance by adaptive ethological **changes** in **habits**.

0265

**BEHAVIOR (Self-organizing)** <sup>1)</sup>

E. JANTSCH distinguishes "the following three basic types of internal self-organizing behavior:

- " - *Mechanistic* systems do not change their internal **organization**;
- " - *Adaptive* (or **organismic**) systems adapt to **changes** in the **environment** through **changes** in their internal **structure** in accordance with **pre-programmed information** (e.g., engineered or genetic **templates**);
- " - *Inventive* (or human action) systems change their **structure** through internal generation of **information** (invention) in accordance with their intentions to change the **environment**" (1975, p.66).

This latter type corresponds to Singerian **adaptation**.

In JANTSCH's opinion, it could very well derail into unforeseen and dangerous developments (p.64-66). In effect, short term ill-conceived **changes** may become harmful later on.

0266

**BEHAVIOR SPACE** <sup>2)</sup>

"The collection of behaviors a system can follow, the **set of paths** a system is capable of taking" (K. KRIPPENDORFF, 1986,p.6)

This concept is interesting in that the observed behavior during a **time** lapse is not necessarily the only possible kind, but merely a special one, corresponding to certain internal and/or external **conditions**. What "always" happens is no sure-fire guarantee of the future of the system or of one of its **processes**.

0267

**BEHAVIOR (Specific action)** <sup>5)</sup>

A type of **action** standardised in accordance with a specific task.

A specific **action** pertaining to a **pattern** of behavior can be repeated without any adaptive **variations** as many times as needed.

Only **machines** – mainly so-called **robots** – can be programmed for specific action behavior.

**Living systems**, particularly human beings, are not efficient specific behavior actors, precisely because they are good at adaptive **variations**.

H. COLLINS observes: "We can replace workers on **production** lines with **machines**, but only after we have organised the factory so that the tasks can be accomplished through standardised behavior, rather than varying **actions**" (1992, p.39).

Specific action behavior thus introduced as **algorithms** and **routines**, become completely stabilized and **context** independent.

COLLINS adds: "The theory of the specific action behavior... gives us a simple test which highlights most of the difficulties of making **machines** that mimic human **action**" (p.39).

This is true at least for **machines** guided by **algorithms**, but could become less so for **machines** trained by **learning**.

0268

### BEHAVIOR (State-determined)<sup>2)</sup>

"A behavior is state determined if an **observer**, knowing the **state** at  $t$ , is able to predict the **state** at  $t+1$  with certainty" (G. PASK, 1961, p.28).

G. PASK rephrases the concept in a still more precise way: "A behavior is state determined if  $X(t+1)$  depends in a *unique* fashion upon  $X(t)$  and, in the **phase space**, this means that the **path** describing a state determined behavior *does not bifurcate*" (Ibid).

As stated by G. PASK, a state determined behavior "must either converge... to a fixed **state**, called the **equilibrium** point, or enter a behavioral **cycle**" (p.29).

The **equilibrium** point is also called a punctual **attractor** and the behavioral **cycle** is inscribed in a **confluent** or **basin of attraction**.

0269

### BEHAVIOR SYSTEM<sup>2)</sup>

A **model** of a **data** system assuming that the **relationships** among **variables** are invariant.

This **model** is introduced by G. KLIR who says that these **invariances** are so "with respect to the supporting **medium** involved" (1993, p.32). The **invariances** can be in **time**, **space**, **space-time**, **population**, etc... Furthermore: "The **relationship** may involve not only **variables** contained in the experimental **frame**, but also additional **variables** defined in terms of the former by specific **translation rules** in the supporting **medium**. When the supporting medium is **time**, for example, we obtain **lagged variables**" (Ibid).

And: "We say that a **data** system is represented by a behavior system if, under appropriate **initial** or **boundary conditions**, the support-invariant **relation** of the latter can be utilized for generating **data** of the former" (Ibid).

→ **Reconstructability analysis**

0270

### BEHAVIORAL ALGORITHM<sup>2) - 5)</sup>

A genetically inherited or learned behavioral **pattern** that became stabilized.

J. CORBARA and A. DROGOU give the example of the three basic **patterns** of behavior of some ants: taking care of the brood, seeking fodder or being inactive. The different **patterns** are in that case activated or deactivated through social **triggers** (1993, p.835).

Behavioral algorithms seem very basic for carrying out in an economical way many **routine** tasks. Training, a more channeled way of **learning**, leads in many cases to the acquisition of such algorithms (e.g. swimming, using a **language**, driving a car).

0271

### BEHAVIORAL CHAINS

→ **Action Chain**

0272

### BEHAVIORAL PROPERTIES<sup>1)</sup>

J.W. SUTHERLAND states: "...behavioral properties of any real significance are generally dependent upon a **context** for their **viability**" (1973, p.37).

This should be understood in two different senses:

1. Behavioral properties are basically "constructed" by the system in accordance with its genetic characteristics (corresponding to its **archetype**, as well as its proper, more specific ones), which reflects the historical adaptive **evolution** of the **archetype**.

2. More specific behavioral properties are variations on the basic ones, learned in accordance with the special **situations** encountered by the system in its **environment**.

0273

### BEHAVIORAL SPACE<sup>2)</sup>

"The **set** of **paths** a system is capable of taking" (K. KRIPPENDORFF, 1986, p.6)

According to this author: "A behavioral space represents, sometimes graphically, and/or abstractly,... just what a system can do, so that what it actually does can be seen as a special case determined by **initial conditions**, circumstances, **purposes**, etc" (Ibid).

Behavioral space is to **processes** what **states space** is to possible **states** of the system.

0274

### BEHAVIORAL UNCERTAINTY<sup>5)</sup>

A certain **level** of leeway in behavior.

While behavior must be more or less narrowly channelled by mental and psychological **algorithms** in order to respond efficiently to a wide **range** of variations in the **environment**, a degree of leeway is also necessary for **adaptation**.

Behavioral uncertainty is especially developed in man and gives him an increased power to select alternative **responses** when faced with hitherto unknown or unforecasted **changes**.

It tends however to decrease with **ageing**.

**Cognitive maps**, which are necessarily normative, tend to reduce behavioral uncertainty, but at the same time allow for it, at least in some measure.

0275

### BEHAVIORISM<sup>3) - 4)</sup>

The school of psychology that considers that it is objectively possible to observe and describe animal and human **behavior**, stresses the role of **environmental constraints** upon such **behavior** in terms of **inputs (stimuli)** and **outputs (responses)**, and admits that it is possible to modify **habits** by appropriate conditioning.

While it offers some systemic aspects, it is not really possible to admit behaviorism as a systemic theory because:

- with its over-emphasis on **habits** to explain **behavior**, it tends to trivialize the **relationship** of the acting animal onto its world *as it perceives it*.
- it reduces **relationships** between the animal and its **environment** to over-simplified **feedbacks** (a kind of simple and very **deterministic mechanicism**).
- it gives little consideration to the internal **organizational closure** of the animal, considering it only as apt to be conditioned and thus denying it any measure of **autonomy** (at least in B.F. SKINNER's version of behaviorism).

There is a strong antinomy between behaviorism and **constructivism** or **autopoiesis**.

0276

### BEING, DOING, BECOMING<sup>1) - 3)</sup>

According to J.L. LEMOIGNE, "An **object's** definition is made by triangulation: it includes

- a functional definition (what the **object** does)
- an **ontological** definition ( what the **object** is)
- a genetic definition (what the **object** becomes)" (1977, p.39)

LEMOIGNE adds that this "Triadectics of being, doing and becoming is probably the key of **representation**, if not even of **knowledge**" (Ibid).

This important insight reminds us that none of the three definitions corresponds to an absolute **knowledge**:

- What the system actually does may be quite different of what we believe it does, or of our specific viewpoint in relation to our research;
- We do not know if the "real **object**" corresponds perfectly to the **model** we did construct (see "**Ontological skepticism**");
- It is not secure that our **forecasts** in connection with the future of the **object** are valid, nor even that it would be possible to make any valid **forecast**.

The trialectic concept of LEMOIGNE's is basic for the whole of his "**Système General**" Theory (p.40).

W. PANKOW writes on the same topic: "Being is becoming. Self-transcendent systems are **time** generating systems. Being and **time** are complementary aspects of **gestalt**. **Gestalt** has no origin: it is its own origin" (1976, p.21).

0277

**BELIEF**<sup>1)4)</sup>

"Mental acceptance or conviction in the **truth** or actuality of something"(Am.Heritage dict., p. 121, 1978)

Beliefs are very significant in individuals and in social systems. It is debatable if "acceptance" is "mental". It seems generally to be rather emotional.

In any case, for an individual, beliefs are a pre-ordering factor of **reference frames**, whether rational, esthetic, philosophical or religious. But a rational belief may lead one to question a religious belief, or conversely. Different kinds of beliefs lead naturally to different **decision making and behavior**.

In any human group, as for example a business, or a political party, common beliefs are the indispensable common ground without which **cohesiveness** cannot be maintained and **coherent behavior** be sustained.

This remains true even if these beliefs are implicit and never overtly proclaimed.

Similarly, different **cultures** are different precisely because the basic beliefs shared by individuals in any specific culture are at variance with the beliefs of other ones.

In any culture, the **set** of beliefs acts as a general behavioral **control**, because it compatibilizes and coordinates individual behaviors (in German: Gleichschaltung)

Moreover, its beliefs set endows a culture with a kind of **immunity** to encroachments from other cultures. Unfortunately this derives frequently into intolerance and reciprocal hostility between individuals or groups alien to each other.

→ **Clanthink; Community; Communities (types of human); Compatibility; Groupthink; Human Systems; Language and Culture; Semantics (General); Systems (Cultures as)**

0278

**BELOUSOV – ZHABOTINSKII REACTION**<sup>2)-5)</sup>

"A complex chemical reaction involving the cerium-catalyzed bromination and oxidation of malonic acid by bromate ions" (J.S. TURNER, 1982, p.48).

A now famous chemical reaction, whose relation to **nonlinear systemic processes** studies is thus described by TURNER: "The great interest of the Belousov-Zhabotinskii (BZ) reaction lies in its unique ability to exhibit a wide variety of characteristic **nonlinear behavior**. Ranging from **homogeneous** chemical **oscillations** in stirred reactors to travelling chemical **waves** and stationary spatial **structures** in unstirred mixtures, the **phenomena** observed in this system include all the types of **nonequilibrium** coherent **structures** that have been studied theoretically in the past decades. In the last few years, besides, new experiments have suggested that the same chemical **processes** which give rise to coherent **phenomena** may also yield incoherent or **chaotic behavior** as well" (p.48).

The BZ reaction is an example of a **reaction-diffusion system**, resulting from the competition of a force that tends to produce **dissipative structures** and another that tends to dampen them out.

0279

**BÉNARD's INSTABILITY**<sup>2) - 5)</sup>

A **phenomenon** of **structuration of forms** through **energy dissipation**.

This **phenomenon** was discovered by the French physicist BÉNARD at the beginning of the 20th century, but its **general systemic meaning** was not understood until PRIGOGINE's discoveries in **thermodynamics of far from equilibrium systems**.

F. DAVID PEAT describes this kind of instability as follows: "It occurs when a pan of water is heated on a stove or when hot air in the desert lifts tiny particles of sand into the air. If the pan of water is heated slowly, heat at first moves upward into the cooler water by conduction. Since no part of the liquid is far from thermal **equilibrium**, the surface is smooth and undisturbed. However, as the water at the bottom becomes hotter, and therefore less dense, it tries to rise while, at the same time, cooler water falls from the top. Under these competing **flows** the water is now **far from equilibrium** and it contains a mixture of **flows**, eddies and whorls... In fact, **chaos** has set in.

"As the rate of heating continues to rise, however, a **critical point** is reached at which the whole system moves from **disorder to order**. This occurs when heat can no longer be dispersed fast enough through **random** movements alone and the tiny eddies suddenly become magnified into large-scale **flows**. Almost

magically, movement in the liquid shifts from **chance** into a series of stable convection currents which have the effect of producing a regularly ordered **lattice of hexagonal** currents.

"... millions upon millions of molecules suddenly move coherently rather than in a **random** way – a **phenomenon** that recalls the convergent movements of **cells** in the slime mold (Note: see *Dictyostelium discoideum*) or electrons in plasma." (1988, p.78-9)

→ **Hexagonal space filling; Structure (Dissipative)**

0280

**BENEFIT per unit cost**<sup>2)5)</sup>

The relation between a system's **input** and the **resources** that it must spend in order to obtain them.

This relation must remain positive, i.e. it should yield a better than average return, at least as a general mean.

This is a very general relation, that can be observed from Biology and Animal Ecology to Business and Economics

In Economics for example, it is expressed through marginal utility.

It obviously governs **behavior** in any system in its relations with its **environment**.

When the **costs** of obtaining needed **inputs** cross a specific **threshold**, the system is losing its balance. If this **situation** is not corrected, the system could be on its way toward **collapse** of bankruptcy.

→ **Foraging theory; Stability (Dynamic)**

0281

**BIFURCATION**<sup>2)</sup>

The splitting of a **trajectory** into two or more new **trajectories**.

Bifurcations characterize states of **uncertainty**.

They occur in the "**region of the parameter space** where a **state** of a system becomes **unstable** and gives way to a pair of **states** in which a new **order parameter** has a finite **value**" (R. FIVAZ, 1991, p.31).

According to this comment by FIVAZ, a bifurcation is thus characterized by the **emergence** of a qualitative change in the nature of an **attractor**. According to I. PRIGOGINE and G. NICOLIS; "... (a) bifurcation is basically a "**decision making**" **process**. But because of the multiplicity of **choices** at the "decision" point, a **selection mechanism** is necessarily involved. Now all physical systems possess such a mechanism, in the form of **random fluctuations** that are generated spontaneously around the **deterministic evolution**" (1985, p.6)

Of course, "**decision making**" in physical systems does not imply any human willfully **meaning**

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

PRIGOGINE also adds: "... the **phenomenon** of bifurcation is extremely general and ... there is a **wide variety** of solutions that can bifurcate: multiple **steady states**, **oscillating** solutions, propagating **waves**, etc. Also there could occur higher-order bifurcations" (1984, p.50).

It is by crossing a **critical value** in the **parameter space** that the **trajectory** becomes divided into two possible **trajectories**, corresponding to two different qualitative **behaviors**.

According to R.N. ADAMS "... a number of alternative further **paths**" is even possible (1988, p.66) and, at such "crossroads" any small **random effect** may lead to **nucleation** of new **structures**.

It thus becomes impossible to predict with perfect accuracy the future **behavior** of the system.

The **domain** of possible **behaviors** becomes discrete, and sudden **transitions** (i.e. "**catastrophes**") may occur from one **state** to another quite different one.

The first **bifurcation** signals the onset of **chaotic behavior**, proper of **non-conservative**, or **non-Hamiltonian systems**, also called **dissipative**.

The concept of bifurcation is a significant link between:

- the theory of **irreversible systems far from equilibrium** (i.e. **dissipative**)
- the mathematical theory of **catastrophes**
- the theory of **chaos**, or **topological dynamics**

According to S. WIGGINS such a **change** is a result of "qualitative **changes** that occur in the orbit **structure** of a dynamical system as the **parameters** on which the **dynamical system** depends are varied" (1988, p.62).

K.DE GREENE states: "A bifurcation is most generally the appearance of a new solution to reaction-diffusion equations at some **critical value**. Systems moving toward bifurcations reflect both **deterministic** and probabilistic features. These systems behave deterministically between bifurcation points; however, near bifurcation points, **fluctuations** are essential to **selection** of the **path** the system will follow. Such systems may be structurally **unstable** if arbitrary small **fluctuations** alter the mechanisms of **interaction** between system **elements**. Evolving **complex systems** show successive **instabilities** associated with successive bifurcations that produce increasing **coherence**" (1988, p.290).

0282

### BIFURCATION AS AN IRREVERSIBLE PHENOMENON<sup>2)</sup>

I. PRIGOGINE and P.M. ALLEN write: "When bifurcation occurs, then **stability** of the existing **state** of the system breaks down, allowing the **amplification** of some small **random fluctuation** to occur and to carry the system off to one of the possible, new branches of solution".

And "... **nonlinear interactions** can give rise to bifurcating solutions of the phenomenological equations, such as those of chemical kinetics, for example, and this gives rise to new dynamic, coherent **structures**, which have been called **dissipative \*structures**. However, even in **equilibrium systems**, bifurcating solutions can occur, but in such cases they correspond to the occurrence of an **equilibrium phase transition**" (1982, p.7).

According to F. HEYLIGHEN when a bifurcation takes place, pushing the system into one of several new **regimes**: "...the **process** is no longer predictable. We do not know which of the available **trajectories** the system will choose at the bifurcation point. The **process** becomes **stochastic**". (1989, p.366).

At a point of bifurcation the **process** becomes **divergent**. Thus bifurcations are anti-nomic to **equifinality**.

0283

### BIFURCATION (Symmetry-breaking)<sup>2)</sup>

A bifurcation leading to the non-symmetric splitting of a rotating fluid as it solidifies.

The subject was introduced by H. POINCARÉ (1892, 1901) in relation to the study of rotating gravitating fluid masses in celestial mechanics. It seems that these were the very first examples of an incipient **chaotic behavior**

0284

### BIFURCATIONS (Social)<sup>4)</sup>

E. LASZLO has proposed the following applications of the bifurcations **model** to societies. He makes a distinction among:

- **T bifurcations** "due to the destabilizing **effects** of technological innovations";
- **C bifurcations** "due to **instabilities** introduced by **conflicts** and conquests";
- **E bifurcations** "triggered by the internal **collapse** of the dominant institutions owing to mushrooming economic and social crises" (1987, p. 150).

LASZLO gives interesting examples of all of these bifurcation types, showing that the **model** is much more than a **metaphor**, or even an **analogy**, in social sciences.

0285

### BIJECTIVE RELATION<sup>2)</sup>

A relation between two **sets** of **elements** such as any **element** of the first one corresponds to one and only one **element** of the second one.

Bijective relations are important in order to establish and verify a satisfactory relation between a **concrete system** and its **model**, or between general **models** derived from various **concrete systems**.

0286

### BINARY CODE<sup>5)</sup>

A **code** which is used to express numbers on base 2, using 0's and 1's only.

Such a **code** permits the reduction of complex sequences of **decisions** to a succession of "yes/no" ones. It is based on **Boolean** logics and is perfectly fit for use in **digital computers**. It can be used in any type of **operations** corresponding to the third excluded logic.

0287

### BINARY LOGIC

→ **LOGIC (Binary)**

0288

### BINARY RELATIONS<sup>2)</sup>

Binary relations appear in **graphs** and **matrices**.

There are different types of binary relations, as follows:

- **reflexive**, by which a **node** is connected to itself through a **loop**
- **symmetric**, by which two **nodes** are connected by two opposite **arcs** of the same value
- **transitive**, by which a third or nth **node** is connected to the previous ones by an unbroken **path**
- **antisymmetric**, where two **nodes** are connected by opposite **arcs** of unequal value
- **equivalent**, if the connection is simultaneously reflexive, symmetric and transitive
- **similar**, if the connection is simultaneously reflexive and symmetric
- **ordered**, if the connection is simultaneously reflexive and transitive (After A. KAUFMANN, 1970, p.21-26).

This classification is helpful in order to distinguish more clearly different types of relations. The binary character of these relations is very convenient for computer **modeling**

0289

### BINARY SIGNAL

→ **SIGNAL (Binary)**

0290

### BIO-AMPLIFICATION<sup>1) - 5)</sup>

The progressive concentration of chemical products through the pyramid of **living systems**.

A good example is the primary absorption of DDT or other toxic chemicals by the phytoplankton and their further concentration through the oceanic trophic sequence: small fishes, big fishes or penguins and other marine birds, and finally carnivorous marine mammals.

The possible effects for animal life in general are still ill known.

0291

**BIOCENOSE**<sup>5)</sup>

The living **community** of plants and animals in a **biotope**

0292

**BIOCHEMICAL EVOLUTION**<sup>5)</sup>

This subject was tackled by the belgian biochemist M. FLORKIN (1944)

While this technical work seems rather specialized, it has been important in showing the "unity in diversity" in the general **organization** of life in animals.

Florkin also considered, in his former "Introduction a la Biochimie Générale", biochemistry's relations with **biosphere** and the consequent **interrelations** of living beings to the biospherical **cycles**.

This research is probably still more significant today, after the deep alterations of the biosphere by man's activities.

0293

**BIOCOMPUTATION**<sup>5)</sup>

von FOERSTER biocomputation, in the words of W.R. WINBURN "... reveals how the **structure** of the nervous system and the **recursive** nature of **neural events** determine an **organizationally closed process of cognitive development**...

von FOERSTER explains how **autopoiesis** and **cognition** may operate in accordance with the mathematics of **recursive function** theory, in which an infinite series of **recursive operations** in a closed algebraic system develops stable **values** that produce themselves (i.e., **eigen values**, the German term for self-values) (1991, p.565).

0294

**BIOCYBERNETICS: Its eight basic rules**<sup>2) - 5)</sup>

F. VESTER thus defines and comments the basic **rules** of biocybernetics:

"1. **Negative feedbacks** must predominate over positive ones.

... **Positive feedbacks** provoke **reinforcements**. Negative ones protect **stability** against **perturbations** and avoid **thresholds** over-crossings.

"2. Systems **functions** must be independent from **growth**.

... Energetic and material **flows** become constant in the long run. This limits the influence of **irreversibility** and uncontrolled crossings of **values limits**.

"3. The system should be **function** oriented, not product oriented.

... Resulting **variability** enhances **flexibility** and **accomodation**. The system becomes able to survive variable requirements.

"4. Use of available forces, according to the Jiu-Jitsu principle instead of boxing method.

... Outside **energy** is better used (**energy** cascades and chains), while internal **energy** is mainly used for steering. This enhances **self-regulation**.

"5. Multiple use of **functions**, organizational **structures** and products.

... This reduces **flows**, increases **integration** and reduces **energy**, **matter** and **information** expenditures.

"6. **Recycling**. Re-use through cyclical **processes** of **waste** and residual heat.

... Amalgamates **outputs**. When **flows** become **cyclically** organized, **irreversibilities** and **dependences** are restricted.

"7. **Symbiosis**. Reciprocal use through exchange and harmonious **coupling**.

... Favours limited runoffs and shorter transport lines. Diminishes **flows** and external **dependence**, while increasing internal **dependence**. Limits **energy** use.

"8. Biological **design** of products, **processes** and organizational **structures** through **feedbacks** planning with the **environment**.

... Takes **endogenous** and **exogenous rhythms** into account, as well as useful functional matches. Harmonizes the **system's dynamics**. Allows for the **integration** of new **elements**, in accordance with the eight basic **rules**" (Adapted from F. VESTER – 1983, p.82).

These basic **rules** could seemingly be extend to **groups** and social systems, as a groundwork for **sociocybernetics**.

0295

**BIOLOGICS**<sup>2) - 5)</sup>

"A field of research intended... to establish super-additive **nonlinear** composition **rules** for the **elements of living systems**" (I.V. BLAUBERG, V.N. SADOVSKY & E.G. YUDIN, 1977, p.160).

This field was introduced by H.von FOERSTER (1958, p.240-255), who spoke of "biological computers" and established the differences between the ways of internal **organization** of electronic computers and **living systems**.

In these, "...as the general case, the **function** "phi" of the **whole** exceeds the sum of the **functions** of the **parts**:

$$\Phi(x,y) > \Phi(x) + \Phi(y)$$

(BLAUBERG et al, p.160).

The subsequent development of biologics led to the concepts of **autopoiesis**, **self-reference**, **eigen-values** and **organizational closure**, and to a better **understanding** of **neural networks**.

More recently, it seems to open the way toward a still more general **understanding** of social **nets** and kinds of "social robotics" and highly **parallel** computing (**connection machines**).

0296

**BIOLOGY (Relational)**<sup>1)5)</sup>

**Organismic biology**, as developed by Bertalanffy, Needham, Weiss, Woodger and others was one of the roots of systems theory, as a more general **transdisciplinary worldview**.

It was however not the only one. D. Gernert writes: "In the late 1920's. a pioneer of mathematical biology, Nicholas Rashevsky, set up mathematical **models** of specific biological **processes**, such as nerve excitation, cytokinesis, cardiovascular dynamics, central nervous **functions**, and many others. This was done with **mathematics** of that time...

"Later on, however, Rashevsky himself was more and more worried by doubts about the reach of his **models**, and looked for "a successful mathematical theory which would treat the integrated activities of the **organism** as a **whole**" (Rosen, 1994, p. 421). His endeavours led to what he called relational biology, as distinct from quantitative or metric biology. What really counts is no longer one or another **variable**, accessible to physical measurement, like blood pressure or electric potential at a certain spot, but the overall **structure**, which can be expressed, e.g., by a set of **organs** and the set of the relations between the **organs** (see e.g. Rashevsky, 1967) (quoted from D. Gernert, 2000, p. 157-58) Gernert adds: "Molecular biology, developmental biology and other fields require fundamental **patterns**-related **operations**: **pattern generation**, **pattern transfer**, **pattern recognition**, **pattern interpretation** and **patterns application** (Ibid.)

The same aspects became also apparent in **ecology** and in animal **ethology** and **zoo-semiotics**, as for example in the **interpretation** of biological molecules (pheromones, etc) as **signs** carrying **meanings** between animals, and even between plants and animals.

0297

**BIOMATRIX**<sup>5)</sup>

The global **network** of living beings (After G.G. JAROS, 1994, p.5-6)

The biomatrix is a **hierarchy** of many **levels**, all interconnected. JAROS considers the isolated study of any **part** (in his vocabulary: "**tel-eons**") of the **network** as quite difficult, in view that his theory corresponds mainly to the study of **processes**.

0298

**BIOMORPHS**<sup>2)</sup>

Graphical **structures** that represent, in a very simplified way, **processes** of **evolutive transformations**.

R. DAWKINS (1986) introduced these curious **models** that, through **processes** of splitting and growing according to some **rules** prescribing the **behavior** of different "genes", can proceed from very simple to quite complex **forms**.

0299

**BIONICS**<sup>5)</sup>

The science of **artifacts** or artificial systems whose **structure** and/or **operation** is imitated from natural systems.

It also includes the study of the natural **design of living systems** or their **parts**.

Bionics started with the **design** of architectural **structures** and, later on, of artificial limbs, for example. It is now progressing apace through the study of natural **processes of organization and regulation**. A. GIORDAN proposes the name of **physionics** for this extension of bionics (1996, p.81-6).

0300

**BIOS**<sup>1)5)</sup>

A natural **process** mainly in **living systems** that continually creates novel and transient **patterns** (H. Sabelli, pers. comm.)

Sabelli develops the concept as follows:

"As unpredictability defines **chaos**, novelty defines bios" "Biotic patterns have been identified in time series of:

- heartbeat intervals
- economic indexes
- series generated by the process equation that formulates **process theory**

"Bios resembles natural processes and human **language** in continually generating new patterns. In contrast, an **attractor**, including **chaotic** attractors, is changeless-the more it changes, the more it stays the same. Bios is also characterized by:1)**asymmetric** rather than symmetric statistical **distribution**, 2) multiple **fixed points**, 3)high self-correlation (PEARSON's **correlation**), 4) anti-persistence (Hurst exponent <0.5), 5) patterned wavelet and **recurrence** plots resembling those obtained with 1/f **noise**, and 6) ring patterns in complement plots. In contrast to **random** series, bios is characterized by determined novelty and determined **recurrences** rather than abundant recurrence and low **determination**."

Around this basic concept, Sabelli and his collaborators have developed important applications in medicine and psychiatry, establishing a much closer connection between physiological and psychological disorders.

Sabelli is attached to the Rush Hospital in Chicago.

0301

**BIOSEMIOTICS**<sup>1)3)5)</sup>

The study of the origins of **meanings** as a problem of biology (K. Kull, 2000, p. 91)

"A new **field** which concerns itself with **signs** in biological systems, ranging from **communication** among animals to the individual **cells'** genetic **code** as a **sign** system of its own" (Cl. EMMECHE, 1994, p.126)

The field is also known as **Semiotic Biology**

The beginnings of Biosemiotics can be traced back to J.von ÜEXKULL (1928, 1934)

However, the subject lay dormant for many years. It is now reviving, specially with G. WITZANY in Austria (2000), M. BARBIERI, University of Ferrara, Italy, K. KULL, University of Tartu, Estonia and the "Cybernetics and Human knowing group" of S. BRIER, in Denmark.

The following statement by WITZANY, quoted by Kull (2000, p. 92) seems to clearly define the central idea of Biosemiotics: "...living nature is structured and organized in a **language-like** and communicative manner, i.e. that all **organisms**, including humans, are members of a global **community of communication**... Evolutionary **history** could then be understood as a developmental history of **interaction** semi-oses"

→ **Biosphere; Colony; Ecosphere; Ecosystem; Ecosystems dynamics; Ecosystemic relation; Evolution(Co); Gaia hypothesis; Information transmission; Stigmergy; Swarm; World Engine**

0302

**BIOSOMA**<sup>4)5)</sup>

The indissoluble **combination** resulting from the **interactions** between **biology**, society and **machines** (G. BUGLIARELLO, 1998, p.230)

BUGLIARELLO, who introduces this interesting concept, comments: "**Technology**, the **process** that human societies devised to produce and use **machines**, is in itself the quintessential biosoma" and "Despite the prevalence of such bio-socio-**machine** complexes, we rarely consider their broad implications. Nevertheless, our future depends on understanding the different characteristics, potentials and **pathologies** of the three **elements** of a biosoma and the opportunities that a well-guided **synergism** can offer".

The author adds: "Problems arise in a biosoma when there are imbalances among its **elements**... The social **element** of a biosoma responds slowly to innovations in the **machine element**. These frequently require new organizational **patterns**, new laws, the development of new **perceptions** or the evolution of new customs"

Moreover: "The human **element** of a biosoma is bound to commit **random** errors in **performance**, and it is powerfully affected by psychological factors" (p. 229-31)

0303

**BIOSPHERE**<sup>1)</sup>

The global **space** occupied on our planet by **living systems** within their total **environment**.

The term "Biosphere" was introduced by the Russian geochemist Vladimir VERNADSKY (1863-1945) in 1926 (see 1929)

In 1935, A.G. TANSLEY introduced the closely related concept of "Ecosystem"

The biosphere is merely a "... thin covering of the planet that contains and sustains life" (UNESCO-UNEP, 1983, p.6)

The existence of the biosphere is the result of the ability of living beings to construct and maintain complex **structures** by **dissipating** electromagnetic **energy**, at the high cost of major global **entropy production**. However, it seems that globally, through what LOTKA called the **world engine**, this **process** tends to respect PRIGOGINE's **theorem of minimum entropy production**... save the puzzling fact that, at present, mankind seems to be violating this principle on a massive scale.

According to J. LOVELOCK, the biosphere is an **integrated system** wherein **energy**, mineral **elements** – gaseous, liquid and solid – and living beings find themselves enmeshed in a global **symbiosis** in continuous **evolution** through **time**. This is the so-called **GAIA hypothesis** (1979).

A deeper **understanding** of the numerous **symbiotic** exchanges within the biosphere seems to be an urgent condition of **survival** for mankind.

Recently, E. ODUM proposed a **parasitic model** of the **relation** of mankind with the biosphere (1997).

Such a **model** seems indeed close to the actual and present ways of man's **relations** with our planet. Possibly our challenge is now to shift from a **parasitic relation** at least to a **commensalist** one and, hopefully to a **symbiotic** one. In fact, the idea is not new: It was proposed (in 1935!) under the guise of an "**Interdependence** declaration" (between plants and animals - among them, men of course) and an "Ecological Constitution", by W.P. TAYLOR, at the time President of the American Society of Ecology.

...So many significant ideas lost in the mists of the past!

0304

**BIOTOPE**<sup>5)</sup>

"A small geographic unit occupied by a **community** of plants and/or animals and characterized by a high degree of uniformity in its main climate, soil and biotic conditions" (UNESCO-UNEP, 1983, p.7).

A sand desert, or a small island, or a lake are examples of biotopes as defined by UNESCO-UNEP lexikon.

As a rule the plant-animal **community** entertains **symbiotic relations** and fluctuates in relation to the **environmental** conditions.

0305

**BISOCIATION**<sup>3)</sup>

The supposed interlocking of two **matrixes**, or **frames** of thought, leading to creative ideas.

This concept was proposed by A. KOESTLER, as the sudden **association** of "two self-consistent, but habitually unconnected **frames of reference**". KOESTLER explains: "I have coined the term "bisociation" in order to make a **distinction** between the routine skills of thinking on a single "plane", as it were, and the creative act, which... always operates on more than one plane" (1964, p.35).

Bisociation is generally sudden and unexpected. Numerous examples are known in sciences and the arts.

Bisociation, as a **model**, is in fact an attempt to explain the way **analogies** (or even significant **metaphors**) suddenly crop up.

The concept seems also related to K. STEINBUCH's **learning matrixes**.

0306

**BIT (= Binary digit)**<sup>5)</sup>

"The unit of selective **information**-content... which determines a single **choice** between equiprobable alternatives" (D. MCKAY, 1969, p.172).

This unit of quantity of **information** is also sometimes called the HARTLEY, as this author studied **transmission of information** as early as 1928.

A bit represents a single yes/no **decision** and is the basic unit in **digital computers**.

The bit capacity of a **channel** is the number of bits transmissible per second (p.175).

0307

**BLACK BOARD**<sup>5)</sup>

A zone of common access in a **distributed artificial intelligence network** where **information** can be traded between autonomous **modules**.

E. BUCHBERGER describes it as the: "Global **data structure** which stores all the intermediate and final results in an **expert system**" He adds: "The blackboard is mostly **hierarchically** organized. Any **data** exchange between **programs** (or **knowledge** sources) ensues on the blackboard" (1987, p.29).

Another possible **communication** mode is by reciprocal sending of **messages** between the **modules**. In this case **criteria** of **channel availability** and **periodicity** must be established.

This, interestingly, seems a good **model** for the exchange of **information** in **human systems**: an example could be the electronic trade boards in stock markets, which **information**, furthermore, can be transmitted over electronic **networks**.

0308

**BLACK BOX**<sup>2)</sup>

"A box to which **inputs** are observed to lead and from which **outputs** are observed to emerge" (St. BEER, 1968, p.293).

The "black box" **model** has been - according to ASHBY - introduced by J.C. MAXWELL to "justify the building of functioning **descriptions** (in his case equations) that accounted for the observed **behavior** of some **phenomenon** when the workings of the **phenomenon** were not clearly visible" (R. GLANVILLE, 1982, p.1)

And "Briefly, a black box can be characterized as:

- a) being believed to be distinct
- b) having observable (and relatable) **inputs** and **outputs**
- c) being black (that is, opaque to the **observer**") (Ibid., p.1)

Of course, any black box is black for some specific observer, i.e. becomes a **construct** of the observer through his peculiar way of **observation**.

GLANVILLE, who discusses widely the black box model, adds that, after experimenting with the box, "what the observer has is a functional **description** that has worked in the past. That it will continue to do so is a pure article of faith: The black box regularity is an **assumption**" (Ibid, p.2).

However, when repeated **observations** produce similar results, this assumption is reinforced and "it is said that the black box has become white. The whiteness (as WIENER, 1948, asserts) is not a property of the box, but of the observer's **interaction** with it" (Ibid, p.4).

Viewed possibly from outside (by another observer), the interaction between the black box and the observer is, in fact, between two black boxes, and the whole system is thus a higher level black box.

In order to reach some **consensus** about a (tentative) conclusion we should thus clearly state our own observation level.

The black box can be either a concrete experimental **artifact**, or a conceptual **model**.

R. ESPEJO writes: "The black-box **construct** is a shorthand for the real world, that is, for the **transformations** actually taking place in it" (1988, p.140).

It however should never be forgotten that different **observers** may interpret the same black-box **behavior** in different ways (W. KARGL, 1991, p.577). The internal **organization** of this box is at the start of the experiment totally unknown. It must be conjectured by making hypotheses about the links between **inputs** and **outputs** and modifying these hypotheses as the experience is furthered.

St. BEER comments: "The reason why we contemplate a box having such odd properties, is that the more familiar box in which something is known about the internal **connectivity**, has its **variety** (already) **constrained**... Even if an arrangement having fairly high **variety** were chosen, the potential **variety** of all the other arrangements which could have been built in is

suppressed. But a black box is assumed to be able to take on any internal arrangement of **input-output connectivity** at all; it can therefore proliferate maximal **variety**" (Ibid.).

→ **Grey box**.

0309

**BLACK BOX METHOD**<sup>2) - 3)</sup>

"A **strategy** for investigating a complex object without **knowledge** or assumptions about its internal make-up, **structure** or **parts**" (K. KRIPPENDORFF, 1986, p.7)

The general idea of this **method** is to send **inputs** into the system and to monitor the resulting **outputs**, making conjectures about the internal **processes** within the system that can explain how a specified **input** produces a specific **output**. In general, systems are "grey" boxes, i.e. **entities** about which at least something is known.

The black box method is widely applied in engineering, biology and other sciences, because of its **heuristic** value.

However, as stated by KRIPPENDORFF: "The **isomorphism** between the black box and its **model**, which the **method** aims to establish, does not imply **structural** correspondences between the two" (Ibid). One should thus be careful and not extract unwarranted conclusions from experiments that could be incomplete or ill interpreted.

0310

**BLACK BOX OR BLACK ENGINE**<sup>3)</sup>

J.L. LEMOIGNE proposed to dynamize the **black box model** (1977, p.99).

From the systemic viewpoint the **black box** does not merely possess one determined **state**. On the contrary it develops a series of successive **states**, as it possess a **diachronic structure**. Only by registering large series of **behaviors**, resulting from a great **variety** of **stimuli**, corresponding to very varied global **situations**, could we discover part or the **whole** of its internal **organization**.

This is why LEMOIGNE puts forth the concept of "black engine", which is of course implied in the **understanding** of the **black box model** by most cyberneticians and systemists.

0311

**BLINDSPOTS**<sup>3)</sup>

The non-**perception** of some aspects of **problem situations**.

H.von FOERSTER uses the example of the ocular blindspot as a **metaphor** for psychological and mental selective blindness. P. LEDINGTON has given a remarkable example of this anti-systemic disease (1992, p.57), but many others are well-known. The basic causes are the difficulties for specialists to **see** aspects of a **situa-**

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

tion outside their own field, their feeling of righteousness about their own way to tackle a problem and their tendency to mere technical patching up.

LEDINGTON observes that there is also a kind of communities blindness – through **subsumption** of individual and **groups** blindness – which does not allow them to face their problems in a coherent way.

G.de ZEEUW's "invisibility" and R.S. ACK-OFF's fables and parables are closely related to the blindspots problem.

The elimination – or at least, **reduction**- of blindspots can be obtained through **conversation** among various **observers** who observe the same **situation**. In effect, each one observes or can observe the blindspots of the other observers and thus contribute to their detection

0312

**BLOCKING MECHANISM**<sup>1)</sup>

In relation to the existence of **functional cycles**, J.von UEXKÜLL, as early as 1928, showed the presence in systems of mechanisms able to block functional **processes** when they could cross a **threshold of instability**.

He added that the blockage is absolute in the case of a critical **threshold** whose crossing would provoke the systems destruction. However, when the **process** leads to **fluctuations** within acceptable **limits**, the mechanism merely acts as a guideline (1979, p.164).

von UEXKÜLL's concept may be generalized, considering that any **function** in a **complex system** appears to be controlled by a **pyramid** of hierarchical blocking **mechanisms** at different **levels**.

→ **Slaving Principle**

0313

**BOIDS**<sup>2)5)</sup>

Computer **models** of birds used to study **flocking behavior** in real birds.

These "computer birds", designed by C.W. REYNOLDS, are assigned the following individual **rules of behavior**:

"1. Maintain a minimum distance to other **objects** (including other boids) in the **environment**.

"2. Seek to adjust speed according to the other boids in the immediate **vicinity**.

"3. Maintain the position in the **vicinity** of that **location** considered by the boid to be the center of the flock (the "center of gravity" of the other boids nearby)

"A migratory urge is built into the **model** and specified in terms of a global direction, ...to make sure that the flock does not remain in the **location** but continues forward"

These **rules** are sufficient to elicit collective **behavior** of the boids, as for instance avoid by suitable dispersal, obstacles introduced in the modeling **space** and thereafter reconstruct an ordered **flocking**. (C. EMMECHE, 1994, "Schools, Shoals, Swarms", p.89-90)

0314

**BONDING MECHANISM (Inchoate)**<sup>2)</sup>

The incipient or not yet perfected establishment of bonds between **elements**.

This concept is discussed by J. BRYANT (1991), p. 113-120) in relation with the progressively organizing **linkages** among **neurons** in the **brain**. He writes, about synaptic **links** between neurons: "We shall assume that (such) transient electrochemical states actually do occur when neurons fire; and we shall call them inchoate bonds, since they function in a matter similar to, and as prior conditions for the **growth** of a synaptic bond"(p.114)

Analogous **mechanisms** are probably active in any system developing the internal relational **organization** among its **elements**. It should be useful to discover their existence and characteristics in all **complex systems** in their formative **process**

The study of **globalization** processes in these terms could be useful

→ **Autogenetic system precursors; Engram; Memory;Parallel distributed Processing; Zero system**

0315

**BOOLEAN ALGEBRA**<sup>2)</sup>

The algebra corresponding to discrete (or finite) mathematics.

This algebra was introduced by the British mathematician and logician G. BOOLE in his book "An Investigation in the Laws of Thought" (1854)

J. WARFIELD resumes: "There are precisely two **constants** in Boolean algebra. They are 0 and 1. A Boolean **variable**  $x$  is an unknown that may take only the values of the constants, that is 0 or 1.

"The complement of 0 is 1, and the complement of 1 is 0. The complement of a Boolean **variable**  $x$  is written  $\bar{x}$ . It is also called the "negation of  $x$ " or may be read simply as "not  $x$ " (1989, p.208).

The parts of Boolean algebra which are relevant for systemics are "... **sets** and partitions, **orders** and partial orders, **binary relations** and **lattices**..., vectors, **matrices** and **digraphs**" (Ibid)

WARFIELD develops these aspects and gives references (p.208-84). He developed his theory in notably systemic terms.

0316

**BOOLEAN formulation of a network**<sup>2)</sup>

Let us suppose  $N$  Boolean **automata** (able to transmit only the values 0 or 1) that are connected in a network. At any moment  $t$ , each automaton has a value 0 or 1, which is function of the value of a number of other automata in the network at the instant  $t-1$ . In such a network there are  $2^N$  possible **configurations** (i.e.  $10^{30}$  for a network of 10 automata with all their potential connections) (adapted from H. ZWIRN, 2002, p. 54)

As it is not possible to consider simultaneously the behavior of many automata (as it depends from the others and that **communication** is neither **isochronic**, nor isospatial, the behavior of the network is difficult (practically impossible) to forecast. However"...as the number of possible configurations is limited, the network's global behavior must be cyclical... However, the **cycle** is necessarily very long and the network's dynamics will seem chaotic" (Ibid)

0317

**BOOLEAN FUNCTION**<sup>2)</sup>

"A logical switching **rule** which specifies the **activity** of a **variable** in response to all the possible combinations of **activities** in the **input variables**" (St. KAUFFMAN, 1993, p.65).

St. KAUFFMAN writes: "The Boolean function specifies for each possible combination of current **activities** of the **input variables**, the **activity** of the regulated **variable** at the next moment. For example, an **element** with two **inputs** might be active at the next moment if either one or the other or both **inputs** are active at the current moment" (1993, p.188).

There are two Boolean functions:

- The **OR function**, "which says that a **variable** will be active if any of its **inputs variables** is active" (Ibid).
- The **AND function**, which "declares that a **variable** will become active only if all its **inputs** are currently active" (Ibid.).

These very simple **rules** were enounced originally by George BOOLE and are of cardinal importance for any study of **networks**.

0318

**BOOLEAN NETWORK**<sup>2)</sup>

"A system of **binary variables**, each with two possible **states of activity** (on and off), coupled to one another such that the **activity** of each **element** is governed by the prior activity of some **elements** according to a **Boolean switching function**" (St. KAUFFMAN, 1993, p.182).

St. KAUFFMAN writes: "In a Boolean network, each **variable** is regulated by others that serve as **inputs**. The dynamic **behavior** of each **variable** – that is, whether it will be on or off at the next moment – is governed by a logical

switching **rule** called a **Boolean function**" (see above) "The **function** specifies the **activity** of a **variable** in response to all possible combinations of **activities** in the **input variables**... One can calculate how many **Boolean functions** could conceivably apply to any **binary element** in a **network**. If a **binary element** has  $K$  **inputs**, then there are  $2^K$  possible combinations of **inputs** it could receive. For each combination, either an active or inactive result must be specified. Therefore, there are  $2$  to the  $2^K$  power possible **Boolean switching rules** for that **element**" (1991, p.67)

Many, if not all social **interrelations** in the most general sense seem to be amenable to **network modelling** in the Boolean sense as for example: neural **nets** in the **brain**, **nets** in **connection machines**, social interactions in **groups** and, possibly in the future **networks of robots** (see for example R. BROOKS, 1991)

0319

### BOOLEAN NK NETWORK (Autonomous random)<sup>2)</sup>

A Boolean network whose **inputs** are all of **endogenous** origin.

Such networks are used by St. KAUFFMAN for the study of biological systems (1991), but have obviously a potentially wider field of applications, as for example in **languages** and in natural or artificial social systems.

The concept also seems to be related to **autopoiesis**, **organizational closure** and **autocatalytic hypercycles**. In KAUFFMAN's words: "A critical feature of random Boolean networks is that they have a finite number of **states**. A system must therefore eventually reenter a **state** that it has previously encountered... It will consequently **cycle** repeatedly through the same **states**" (p.66)

For a full development of the NK model, see reference.

0320

### BOTTOM UP<sup>1)</sup>

The progressive **self organizing mode** of a system or **model** composed of numerous **elements** each of which endowed with limited elementary capabilities and able to interact in a not absolutely determined way.

This notion has been described as follows by J. ERCEAU and J. FERBER in their study on **Distributed Artificial Intelligence**:

"**Agents** endowed with an elementary **behavior** potential, of the type **stimulus-action** (for example: to be attracted by a **signal**) are able to interact. From these local **interactions**, **structures** arise, which appear as globally organized. "Intelligence" thus emerges from the **interactions** of a great number of **agents**, individually devoid of "intelligence". An **analogy** sometimes used here is the anthill, the termite-hill or the beehive" (1991, p.755)

Furthermore: "The elementary units have thus specific **behaviors**, which do not necessarily coincide with **subfunctions** of the wanted global **function**. This will emerge from the **interactions** among elementary units.

"...In the bottom-up approach, the system organizes itself to react in an adequate fashion in every case, from which its **flexibility** results. Furthermore, a breakdown in some unit does not impair the global working of the **whole**, thus conferring its robustness to the system" (Ibid).

This **description** seems to fit even very complex **social systems** (i.e. systems including a very great number of **elements** capable of undergoing a very considerable number of **interactions**). As well as to societies of insects, it can probably be extended to societies of **automata**, to human societies and, possibly to societies of neurons in the **brain**.

As to **models**, for instance in **systems dynamics**, the bottom up procedure insists on starting with complete **models** of all the separate subsectors. D. MEADOWS et al state that these "should be carefully estimated, tested, elaborated and explored, so that one understands and has confidence in each part of the **model** before they are fitted together" (1982, p.274)

Still, in the case of the **Systems Dynamics model**, the **process** of fitting together, far from spontaneous, is decided by the modelizer and thus more or less depends on her/his subjective views.

The "bottom up" approach should not be exclusive of the "**top-down**" one. Both are in fact complementary, as expressed by Cl. PAHL-WOSTL (1993): "...the **dichotomy** between **top-down** and bottom-up **control** converges to a mutual and inseparable **dependence** on both factors. Neither a purely **reductionist** approach nor a merely **holistic** perspective is sufficient to encompass the intrinsic nature of the systems **behavior**"

0321

### BOUNDARIES of a PROBLEM<sup>1) - 3)</sup>

According to St. BEER, determining the boundaries of a problem "is the most difficult problem in **operational research**". He adds: "In practice the scientist needs to enlarge the scope of his study in every dimension until the factors he is bringing in seem to make no tangible difference to the answers he is getting" (1968, p.53)

BEER's comment could very well be extended to the whole research on **complex systems**.

Furthermore, we should never forget that the accuracy of the definitions of boundaries depends on the perceptive competence of the **observer**: what is tangible? to whom?

See "cognitive **blindspot**", "**invisibility**", "**underconceptualization**"

0322

### BOUNDARY<sup>1) - 3)</sup>

"The **subsystem** at the perimeter of a system that holds together the **components** which make up the system, protects them from **environmental stresses**, and excludes or permits admission to various sorts of **matter-energy** and **information**"

This is J. MILLER's definition in his list of the **20 critical subsystems** of any system (1978, p.3)

In B. BANATHY's words: "The boundaries of a system delimit the system **space** and set aside from the **environment** all those entities that make up the system" (1973, p.85)

K. BAUSCH describes boundaries as the "**parametric** conditions that delimits and define a system and set it apart from its **environment**" (Glossary - Personal communication)

The concept of boundary is basically ambiguous, in two different ways.

First, the boundary separates the system from its **environment** by defining what is inside and what is outside the system. In some cases however, it is difficult to distinguish precisely if some **elements** of the boundary belong to the system or to its **environment**... or to both.

Besides, the boundary does not define an absolute enclosure. It allows some specific **inputs** and **outputs** and bars others. It is selectively permeable.

In L. CARLSON-SABELLI and H. SABELLI's words: "Boundaries, when they exist, are **interphases** where **opposites** coexist, neither sharply delimited as in logic, nor simply gradual **transitions**, but actual areas of interchange and/or **conflict**, as illustrated by cellular **membranes**, and by national boundaries. The **basins** relative to two **attractors**, for instance, can penetrate each other in a manner which is **topologically** very complicated, rendering the outcome undetermined" (1992, p.681).

Furthermore, the boundary may be open or closed, in relation to the circumstances which affect the system and its **environment**.

T.F.H. ALLEN and T.B. STARR (1982, p.262) define the boundary as "a **distinction** made by an **observer**" and add: "Artificial boundaries are drawn arbitrarily and haphazardly. Natural boundaries are still arbitrary, but tend to be robust under **transformation**. That is, natural boundaries coincide for many distinct **criteria**".

Quoting G.H. GOODE and R.E. MACALL, G. P. SHCHEDROVITZKY writes "... boundaries pass over broad vague territories and the search for their precise position would elicit large but fruitless controversies" (1966, p.35)

These difficulties move G. WEINBERG to write: "**Interface**" is a more useful word than "boundary", for it reminds us to pay attention to the **connection** and not just the separation between system and **environment**" (1975, p.147)

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

Boundaries of physical systems are at the atomic or molecular **level**. In **living systems** they become organized as permeable **membranes**. In an **organization** they can be material enclosures as well as the **behavioral** result of abstract **criteria** of membership.

0323

**BOUNDARY CONDITIONS**<sup>2) - 4)</sup>

"...a **set** of supplementary **constraints** that the solutions of differential equations must satisfy at all times" (T.F. ALLEN and T.B. STARR, 1982, p.262).

It appears from the context that these authors understand that each **set** of boundary conditions corresponds to a typical **hierarchical level** (p.44).

As stated by H. HAKEN, boundary conditions can be **periodic** (1983, p.269). Consequently, there are specific boundary **variables** which affect boundary conditions.

J. PLATT writes: "The surface may be taken as passing through a family of points where some **parameter** such as "**interaction-density**" has a maximum **gradient**" (1969, p.201-214).

Furthermore... "The boundary-surface for one property (such as heat-**flows**) will tend to coincide with the boundary surfaces for many other properties (such as blood **flow**, **sensors** endings, physical **density**, and so on) because the surfaces are mutually-reinforcing".

And... "All **gradients** and **flows** in the **region** very near the boundary will tend to be either parallel or perpendicular to the boundary... Evidently in the **region** close to a boundary the strong-**coupling interactions** within the systems are parallel to the boundary while the weaker-**coupling interactions** between the system and the larger **super-system** flow in and cut perpendicular to the boundary" (ibid).

All this obviously applies to boundary conditions in **social systems**, as for example beehives, anthills, business companies or nations.

A very important observation by I. PRIGOGINE et al. is that: "A sufficiently small system will always be dominated by the boundary conditions – the conditions imposed at the walls of the vessel (note: the authors are referring in this specific case to a chemical reaction. Similar effects are however present whenever boundaries are proportionally very important in relation to surface and volume)." In order for the **non-linearities** to be able to lead to a **choice** between various possible solutions, it is necessary to go beyond some **critical spatial dimensions**. Only then can the system acquire a degree of **autonomy** with respect to the outside world" (1975, p.31). This is because: "In the case of small-size **fluctuations**, boundary effects will dominate and **fluctuations** will regress" (ibid, p.43).

This aspect is probably the most basic explanation of the universal tendency of systems – natural or artificial – to grow in **size**, at least up to some critical **limit** where the effects of big **size** become preponderantly negative.

Boundary conditions are not necessarily constant. A.S. IBERALL states: "... if boundary conditions of a nonconstant nature are maintained, the system may find a **process** which is either in **steady state** or which is dynamically fluctuating... It has begun to be realized that **fluctuations** and turnover are necessary conditions for the maintenance of **form** (See e.g. the work of PRIGOGINE, KATCHALSKY, MOROWITZ, PATTEE, IBERALL, ZHABOTINSKY)" (1973, p.5).

Such **concepts** were developed as early as 1942 by the French engineer Ch LAVILLE in his theory of **vortexes**.

0324

**BOUNDARY (Elusive)**<sup>2)</sup>

**Fractal** boundaries are infinitely complex and seem to dissolve as we try to pin them down more precisely.

This is undoubtedly a feature of existing **complex systems**, but then only up to the point where the **elements** of the boundary dissolve at a lower **scale** in some other type of lesser **elements**.

However, the mathematical **models**, especially their graphic representations, are quite useful to visualize the elusiveness of boundaries, which means that any boundary **element** is simultaneously within the system and within its **environment** (or within neither).

**WEIERSTRASS function** expresses this characteristic through the impossibility to differentiate for any **value** of the **function** (i.e. to draw a tangent to any part of the curve).

The same principle applies to every **fractal**.

0325

**BOUNDARY OF EQUAL ADVANTAGE**<sup>1) - 2) - 4)</sup>

In K. BOULDING's words: "... any **organization** in competition with others will find that its advantage in the **interaction** diminishes as it goes away from some kind of "home base", so that at some point the advantages of any further expansion fall to zero".

BOULDING adds: "... the concept could easily be generalized. It is these boundaries of equal advantage which really define the **niches** of an **ecological system**" (1972, p.69-70).

The respective boundary of equal advantage tends to be more or less geometrically regular for competing or **cooperating** systems, as shown by W. CHRISTALLER and A. LÖSCH (see **hexagonal space filling**).

This seems to be a rather general result of **structuration by dissipation**.

It is also probably related to a problem of length of **lines of communication**, as the distance from the center of the system increases: the possible expansion of political or economic systems must submit to BOULDING's boundaries of equal advantage.

0326

**BOUNDARY REGULATION**<sup>1) - 2)</sup>

No boundary is ever absolutely closed, nor completely open. It depends on the **energy flow**, as noted by R.N. ADAMS, in accordance with LOTKA's **Principle of maximum energy flow**: "The distinctiveness and **stability** of the boundaries of a **dissipative process** vary directly with the tendency of that **process** to seek a minimum **dissipation rate**, inversely with its tendency to maximize **energy flux**" (1988, p.149).

As to the **autonomy** of the system it depends at least partly on its ability to close or open its boundary for the purpose of maintaining its **dynamic stability** by regulating its **inputs and outputs of energy**.

The study of a variety of systems shows that boundary regulation is partly automatic (by **reflexes**) and partly voluntary. Furthermore the deliberate part of **regulation** grows steadily with the **complexity** through the evolutive **scale** of systems.

As **dynamic stability** results generally from the **cyclical** or **hypercyclical** succession of **states**, boundary regulation depends on the **knowledge** the system has of its own **states**, past, present and possible futures. The heightened **predictability** aptitude in highly **complex systems** goes matched with the increase of the **feedforward** (i.e. willful) capacity for **regulation** of their boundary conditions.

0327

**BRAIN**<sup>3) - 5)</sup>

St. BEER described the brain in cybernetic terms as follows: "We have in the cranium a slightly alkaline three-pound electrochemical computer running on glucose at about 25 watts. This computer contains some ten thousand million (that's  $10^{10}$ ) logical **elements** called **neurons**, operating on a basic **scanning rhythm** of ten **cycles** per second. Then this is a **high-variety dynamic system** all right; but it really *is* finite. It follows from ASHBY's law that we can recognize **patterns** up to a certain **limit**, and not beyond. Thus if something is going on that involves a higher **variety** than the brain commands, we shall not recognize what it is. This is the old **constraint of requisite variety**" (1974, p.58).

BEER adds the following: "About a quart of blood (about one seventh of the circulation) flows through the brain every minute, and is heated about one degree Fahrenheit. That takes about 25 watts.

"The resting **state** of the brain, called the **alpha state**, is characterized by the **alpha rhythm**, which tends to be **stable** at around **ten cycles**" (p.67).

Of course, in 1974, research on **networks** and **connection machines** was just starting. The **analogies** between the brain and the computer (**digital** or **parallel**, or both?) surely needs still more careful scrutiny.

From another angle, related to the general **organization** of the brain, it would seem that it is at the same time localized (with specific perceptive and active areas), distributed (even a seemingly global **function**, as for instance sight, is the global result of a **synchronic synthesis** of distinct **perceptions** of **limits**, **position**, shape, motion, depth, colors, etc.)... and **hierarchical**, in the sense that, admitting the **modular** character of brain **organization**, brain works in a coordinated way (Philippe LAMBERT on Xavier SERON's cognitive neuropsychology - 1999. p.39-43 - Hemai PARTHASARATHY, 1999, p.29-31).

However "**hierarchical**" does not imply an all powerful and precisely localized organizer. It seems to respond to a kind of **chaotic determinism** through multiple **simultaneous** neuronal **interactions**, within diffuse **limits**, leading to **autopoiesis**

This could better explain **creativity**, **learning**, and also partial readaptation after some disability (as a stroke, for example).

→ **Algorithm (Back propagation); Algorithm (Framing); Algorithm (Iterative refinement); Algorithmization by selection; Information; Nervous system and brain, Memory (Distributed); Taxon memory**

0328

### BRAIN and ENVIRONMENT<sup>1) - 3)</sup>

... or the macrocosm within the microcosm.

According to V.I. KREMYANSKIY: "The brain first developed mainly as an organ of internal **interconnexion**, and then primarily as an organ of **interconnexion** with the **environment**" (1969, 125-46).

In fact, it seems probable that both developments have been simultaneous and complementary all along **evolution**, by a kind of alternating **process of reinforcement**, in relation to ASHBY's **Law of Requisite Variety**.

KREMYANSKIY adds: "This augmented the **dependence** of the **organism** on far more distant and complex **events** in the **environment** (with the development of the **organs** of **perception** and systems of **receptors**) (p.141).

Man has been speeding up this movement during the last centuries, with the **emergence** of more numerous and complex artificial **means** of **perception** and interpretation.

However, admitting that the enhanced presence of the **environment** under the guise of **representations** within the brain increases **dependence** it also increases the capacity to handle it, which of course brings forth new hazards.

0329

### BRAIN CIRCUITS<sup>1)5)</sup>

C. KOCH and G. LAURENT write: "Brain **circuits** are not **Boolean networks**, where **connectivity** is everything. They are not made of static, **linear neurons**, **isotropic nets**, or constant **connection weights**.... A more realistic accounting of the dynamic nature of neuronal ensembles and their nonrandom, inhomogeneous **connectivity topologies** has been incorporated by TONONI and his colleagues into a formal definition of "neuronal complexity" using concepts drawn from **information theory**. These concepts express the degree of **interactions** between **elements** of a neuronal **population**... **Complexity** will be high if a large number of subassemblies of varied sizes can be formed within the population" (1999, p.97).

Further on they add: "The standard **von NEUMANN** computer **architecture** enforces a strict separation between **memory** and **computation**. **Software** and **hardware**, which can be easily separated in a **computer**, are completely interwoven in brains... Furthermore, brains wire themselves up during **development** as well as during adult life, by modifying, updating, replacing **connections**, and even in some circuits by generating new **neurons**. While brains do indeed perform something akin to **information processing**, they differ profoundly from any existing computer in the scale of their intrinsic structural and dynamic **complexity**" (Ibid, p.98)

As stated by the authors, much work will still be needed to reach a better understanding of brain circuits.

→ **Synaptic weights**

0330

### BRAIN - EYE LAW<sup>3)</sup>

This law has been proposed by G. WEINBERG in the following complementary form:

"To a certain extent, mental power can compensate for observational weakness;

"To a certain extent, observational power can compensate for mental weakness" (1975, p.96).

The first leg of this law is a result of the existence of conceptual **paradigms** and tested **models** and **methods**, accumulated through **learning**. **Observation** conversely, lead to a renewal of **viewpoints**, eventually conducive to a renewal of abstract **frames**.

0331

### BRAIN: its organization<sup>1)5)</sup>

The main parts of the brain are the following (for locations see fig.)

The definitions are from J. ECCLES (J.E.)(1977), or from the American Heritage Dictionary (AHD), (1978 ed.)

- Archicortex: the ancient part of the cerebral cortex; it includes the **hippocampus** (J.E. p. 234)
  - Cerebellum: the brain structure responsible for **regulation** and **coordination** of complex voluntary movements (AHD, p. 219)
  - Cerebral cortex: the extensive outer layer of gray tissue of the cerebral hemispheres, largely responsible for higher nervous functions
  - Cerebro-cerebellar pathways: the complex pathways linking the cerebral cortex and the cerebellum in both directions (J.E. p. 234)
  - Cerebrum: the main **structure** of the brain occupying most of the cranial cavity and divided into two cerebral hemispheres (AHD, p. 219)
  - Corpus callosum: the tract of nerve fibers connecting the cerebral hemispheres (J.E. p. 235)
  - Hippocampus: one of two ridges along each lateral ventricle of the brain (AHD, p. 624)
  - Hypothalamus: a deep laying part of the cerebral cortex, concerned in visceral control, f. ex. in relation to temperature, salt, water, food, endocrines, and mood (J.E. p. 238)
  - Medulla oblongata: the nervous tissue at the bottom of the brain that controls respiration, circulation and certain other bodily functions (AHD, p. 816)
  - Neo-cortex: the most recently developed part of the cerebral cortex, composing the cerebral hemispheres (J.E., p. 236) The neo-cortex includes an enormous array of interconnected neurons
  - Thalamus: the massive collection of nerve cells deep to the cerebral cortex, in part concerned with transmission of cutaneous sense to the cerebrum.
  - Ventricle: a small anatomical cavity in the brain (AHD, p.1421)
- A part of the thalamus (called ventrolateral) is specially concerned by the transmission from the cerebrum to the cerebellum (J.E. p. 243)
- This is of course a very simplified and sketchy description of the brain's structures.
- For much better **information** see f. ex. J. ECCLES ( 1978), J.Z. YOUNG (1978) here also used, or some more recent work, as for ex. R. CARTER (1998)

0332

### BRAIN METAPHOR<sup>3)</sup>

As the **hypercomplex system** that it is, the brain is not yet fully understood. This is probably why it has been extensively used as a meta-

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented

phor for different concepts of **regulating** and **deciding** devices. The **hierarchical** brain metaphor extols the brain as the all powerful chief **controller** and **commander**, who should know and decide about everything.

Another and newer metaphor is the brain as a **learning** and adaptable **network of elements**. This seems to be a more adequate **analogy**, but the unifying and regulating powers of **networks** should not be forgotten. It is quite possible that future research into brain physiology could lead us to a still different metaphor or **analogy**, not necessarily incompatible with the existing ones.

Our metaphors should not blind us to some other important facts, as for instance the necessary **connections** of the brain (and other **learning-regulating-deciding** devices) with other critical **subsystems** and their significance.

0333

**BRAIN (Triune)**<sup>5)</sup>

A three levels model of the brain.

This **concept** of a multilevel **organization** of the brain as a **complex system** was developed by P. Mac LEAN, as quoted by A.S. IBERALL: "At its base lies the reptilian brain, in which one might say the **routines** or rituals of higher forms of life are governed and programmed. Surrounding that **structure** is the paleomammalian brain, the limbic **structure**, sometimes referred to as the older "smell" brain. Out of this the governing of the world originating from smell, the worlds of food and sex and aggression are intermingled (and sometimes confused). Finally, at the top emerges the neomammalian brain, the brain of sight, the primate brain, the brain of **cognition** and **language**, and coordination of **language**... What is characteristic of the neocortex is its rapid **response**, particularly to sensory **signals**. It programs at the millisecond **level**. It devotes a considerable part of its capacity to handling optical **signals**" (1975, p.21).

This **model** of the globally integrated brain has also been considerably developed by the French physiologist H. LABORIT (1954 and 1970).

0334

**BRAIN-COMPUTER ANALOGY**<sup>3)</sup>

It could be said that the superficial analogy between brain and computer which filled the pages of so many popular magazines has considerably obscured the issue of comparison of **artificial** as compared to natural **intelligence**.

Only the introduction of some "deus ex machina" would permit us to sustain such superficial analogy as for example in this statement by N.A. COULTER Jr. "Intelligence may be

defined as the **set of software programs** which enable the Supervisor (or Ego) (sic) to acquire, create, and execute application **programs**" (!) (1976, p.36).

Curiously enough COULTER himself adds: "... the self-**determinism** of brains is one fundamental difference between brains and computers"... but he immediately relapses again into the idea that these self-**determined** brains depend on "the consent of its Supervisor - Ego" to be "programmed" Where could such a "Supervisor" be located?

More recently, M. BODEN makes, from a different standpoint, the following criticism of the **analogy**: "... current **neural-network models**, for all their likeness to the brain, are significantly unlike brains too. For instance, nearly all involve two-way **connections**, whereas brain-cells send **messages** in one direction only. Any one unit is directly connected to only a few others, whereas the lacy branches of a given neuron usually abut to many hundred of **cells**. **Computer models** contain no **analogue** of the neurochemicals that diffuse widely through the brain. Further, neuro-scientists still know very little in detail about what computations are carried-out by brain-cells, and how" (1990, p.131). BODEN admits however that: "Certainly, the brain is a **connectionist** system" (Ibid).

Somehow, the brain is probably working simultaneously in **parallel** and sequentially, a "trick" that computers have just started to learn.

0335

**BRAINSTORMING**<sup>4) - 5)</sup>

A mental exploration technique seeking new ideas through **unconstrained** conceptual **associations**.

Brainstorming tends to break rigid **reference frames** and, using coincidence, open the way to **serendipity** and discovery. It is a collective technique, used by groups interested in considering a **situation** and aiming at producing as many as possible new and creative ideas. It avoids critical stances as inhibitory to **creativity**. On the contrary, it encourages free-wheeling imagination, unfettered by inhibiting, authoritative or logical **constraints**. Its nature is systemic, since it helps to discover and explore hidden **interrelations** in **complex situations**.

The technique, quite popular during the fifties, is now nearly forgotten. It should possibly be reconsidered in more systemic terms, as it can be very useful in **decision making** on a wider **understanding** basis. See for example J. WARFIELD (1994b).

0336

**BRANCHING**<sup>2)</sup>

A graphical way to represent **hierarchical organization** in **space** or **bifurcating evolution** in **time**.

Branching as a **model** started from the "tree" **metaphor**. But a real tree is no **metaphor** and its main and secondary branches represent stages in its **growth**. Besides, its roots are also branching.

Of course, **organizations** where one commander or manager has **control** over 10 executive officers, each of whom in his turn commands and/or oversees a large group of people do exist, and can be represented by a branching **diagram**. So is a sequence of various simultaneous **operations**, modelled in a **flow graph** in **time**.

Branching thus corresponds to a well specified type of **order** within systems and/or **processes**. It is now formally incorporated in **theory of graphs**

0337

**BRANE**<sup>1)</sup>

This shortened neologism for "membrane" has been introduced recently by some authors. Its usefulness remains to be established, specially as an intended generalization.

→ **Membrane**

0338

**BREAKDOWN**<sup>1)</sup>

The structural disintegration or functional disruption of a system or **subsystem**.

M. BUNGE distinguishes: "If **integration** fails the system undergoes *structural breakdown*. On the other hand **coordination** concerns the **relation** among either **components of functions** resulting in functional **maintenance**. If **coordination** fails the system undergoes *functional breakdown*. There can be **integration** without **coordination** but not conversely. A complex **machine** out of kilter is integrated but not coordinated. On the other hand **organisms** are coordinated and *a fortiori* integrated as long as they live (1979, p.38).

While **machines** can be sometimes repaired, **breakdown** in **organisms** and **sociosystems** is generally **irreversible**.

0339

**BREAKDOWN TIME**<sup>2)</sup>

The **time limit** after which a system submitted to **wear** finally gets out of order or is destroyed.

The subject has been reconsidered recently by P. WINIWARTER and C. CEMPEL (1992, p.9-34), according to whom: "...the breakdown time is determined by the internal **structure** of the system and the way of **energy dissipation** inside the system" (p.25). Furthermore: "Every type of **symptoms of wear** approaches infinite **value** asymptotically at the **vicinity** of the breakdown time" (p.27).

**Living systems**, as well as artificially constructed ones have each a more or less characteristic breakdown time.

0340

**BREMERMANN's LIMIT**<sup>3) - 5)</sup>

"No **data** processing system, whether artificial or living can compute more than  $2 \times 10^{47}$  **bits** per second and per gram of its mass" (as stated by K. KRIPPENDORFF, 1986, p.8).

G. KLIR writes: "Using the limit of **information processing** obtained for one gram of mass and one second of **processing time**, BREMERMANN then calculates the total number of **bits** processed by an hypothetical computer the size of the Earth within a **time period** equal to the estimated age of the Earth... This imaginary computer would not be able to **process** more than  $2.56 \times 10^{92}$  bits, or when rounding up  $10^{93}$  bits. This last number  $10^{93}$  is usually referred to as BREMERMANN's limit and **problems** that require processing more than  $10^{93}$  bits of **information** are called transcomputational **problems**" (1993, p.44-5)

KLIR adds: "The problem of transcomputationality arises in various **contexts**. One of them is **pattern recognition**... Another **context**... is the area of testing large-scale integrated **digital circuits**". As a result, we need a "science of simplification" to reduce the **problems** of **complex systems** to a manageable size. This is one of the basic aims of **systemics**."

K. KRIPPENDORFF writes that the limit "refers to a self-contained system where the power supply is included in the total mass and where computation is defined as the **transmission of information** over one or more **channels** within the system. Recognizing that computation requires **energy** for changing physical **markers** and for recognizing such **changes** in subsequent steps, the limit is obtained from EINSTEIN's relation between **energy** and **matter**,  $E=mc^2$ , and HEISENBERG's **uncertainty principle**, which specifies the inaccuracy or **noise** in the **measurement of energy**" (1986, p.8).

For a suggestive development about "Everything material stops at  $10^{100}$ " see W. ROSS ASHBY (1974, 166-9).

0341

**BROWNIAN MOTION**<sup>3) - 5)</sup>

The **random** motion at microscopic **level** of particles suspended in a liquid or a gas.

As stated by P. DAVIES: "Brownian motion is the archetypical, **random** unpredictable **process**. Yet, so the argument ran, if we could follow in detail the **activities** of all the individual molecules involved, Brownian motion would be every bit as predictable and **deterministic** as clockwork. The apparent **random** motion of the Brownian particle is attributed solely to the lack of **information** about the myriads of participat-

ing molecules, arising from the fact that our senses are too coarse to permit detailed **observation** at the molecular **level**" (1990, p.49).

However: "Two major developments of the 20th century have... put paid to the idea of a clockwork universe" (Ibid).

The first was quantum mechanics which introduced **indeterminacy** at the physical micro-level as well as in relation to our possibility of **observation**. And the second one is **chaos** which, while still somehow **deterministic**, rapidly makes even very simple systems fairly **unpredictable**.

Thus, **determinism** cannot be polarly opposed to **randomness**, nor is **unpredictability** simply a result of our imperfect **perceptions**.

0342

**BROWNOID MOTION**<sup>2)</sup>

A **Brownian motion** affected by some **constraints**, not sufficient to bring about full **deterministic behavior**.

This **concept** has been introduced by the French biologist P. VENDRYES (1942).

This author gives various examples. One is the register - by himself - of a Parisian taxi driver, who showed the following absolute or relative - **constraints** upon passengers instructions, or whims:

- remain within the **limits** of Paris municipality
- respect one way traffic **signs** and traffic lights
- follow some obliged routes for public transport
- occasional or more or less permanent diversions due to public works
- existence of some focal and thus more frequently asked for destinations: museums, famous monuments, railway stations, hospitals, etc.

A similar **model** was introduced by W.R. ASHBY in 1956 under the guise of **Markov chains** and **transitions probabilities matrixes** - with some quite entertaining examples (1956, Ch.9).

0343

**BRUSSELATOR**<sup>2) - 5)</sup>

A general **model** for **cross-catalytic reaction cycles**.

The Brusselator **model** has been created by I. PRIGOGINE's **thermodynamics** study group in Brussels, "as a perfectly acceptable model for the study of cooperative **processes** in chemical kinetics. It plays somewhat the same role as such models as the harmonic **oscillator**..." (G. NICOLIS & I. PRIGOGINE, 1977, p.94). It consists of the following (very simplified) steps:

1.  $A = X$
2.  $B + X = Y + D$
3.  $2X + Y = 3X$
4.  $X = E$

X and Y are intermediate molecules in a global sequence through which A and B become D and E. The Brusselator is thus a very fundamental **transformation cycle**. For accurate description and insights, see reference.

0344

**BUFFER**<sup>5)</sup>

A device introduced into a **communication** system to allow asynchronous **communication**.

L. BRIM comments: "A buffer preserves **message** sequences. The buffer discipline is as follows:

- The **sender** may always send a **message**
- The **receiver** may always receive a **message**, provided the **medium** is not empty
- The order of receiving **messages** is equal to the order of sending **messages**" (1992, p.135).

Buffers allow for serialized and ordered **communication**, avoids bottlenecks and, to some extent, **overloads** in **communication channels**.

0345

**BUFFER COMPARTMENT**<sup>1)</sup>

"A **part** of a system which acts as a reservoir for incoming **energy**, **matter**, or **information** such that the **inputs** enter the rest of the system with smoothed and averaged characteristics" (T.F.H. ALLEN & T.B. STARR, 1982, p. 263).

The quantities of **energy**, **matter**, or **information** stored in the buffer compartment are at the free disposal of the system. They can be used by **regulatory subsystems** when needed. This permits a **range** of differential **responses** in a changing **environment**, an adaptive **mechanism** sometimes called buffering, and it also opposes wide structural destruction.

0346

**BUTTERFLY (LORENZ')**<sup>1) - 2)</sup>

A **chaotic attractor** whose graphical **representation** is similar to butterfly wings.

This **attractor** was discovered by the American meteorologist E. LORENZ. It graphicates the **turbulent sequences** of meteorological variations, submitted to the **stochastic determinism** proper to very **complex systems**. The same type of **attractors** appears in many other **situations** dependent from the **sequence of interactions** between various **initial conditions**. More generally, this is a **chaotic attractor**, for which, as stated by R. MAY "arbitrary close **initial conditions** can lead to **trajectories** which, after a sufficiently long **time**, **diverge** widely. This means that, even if we have a simple **model** in which all the **parameters** are determined exactly, long term **prediction** is nevertheless impossible" (1976, p.466).

In a **metaphorical** – but not at all rigorous – way, the so-called “butterfly effect” in weather forecasts says that, if a butterfly flaps its wings somewhere in the States today, it may produce a typhoon in the Eastern Pacific one month later, i.e. a small local initial **effect** may trigger a **snowball effect** eventually leading to a gigantic accumulative **event**, possibly faraway in **space and time**.

0347

**BY-PRODUCT**<sup>1)</sup>

A secondary product or **side-effect** of the **activity of a system**.

By-products or **side-effects** are mainly results of the **activities** of artificial **systems**. Save (very significant) exceptions, they are generally damped by the **environment**. However various problems may become serious.

First, while slight **side-effects** or limited quantities of by-products can be absorbed by the **environment**, massive quantities may suffocate it.

Secondly, there is a specific **critical time** lapse for **assimilation** of by-products by the **environment**. A quite obvious case is half-life at a scale of millenia for radioactive **waste** produced by nuclear **energy** utilities.

Thirdly, some synthetic by-products (or even products) are unassimilable by the **environment**, which offers no known **process** to recycle them.

The by-products and **side-effects** problems are typically systemic, because they affect or may affect the whole natural setting, or a large part of it, during very long **periods**.

0348

**BYSTANDER EFFECT**<sup>1)</sup>

The effect on other **elements** of some **input** into one **element** in a system.

This effect has been observed in human biological systems where “**cells** that suffer a direct hit from radiation alter the level of gene activity in neighbouring cells” (Jack LITTLE, quoted by R. EDWARDS, p. 22, 1998).

This implies some **communication** between these cells, probably “through chemical messengers” (ibid.)

Conversely, where there is a **communication link**, a bystander effect is probably possible. A search for **bystander effects** in societies should eventually be rewarding.

0349

**BYTE**<sup>5)</sup>

A set of various **bits**.

The most common is the octet, which permits the identification of one possibility among 256 ( $2^8 = 256$ ). A kilobyte equals to 1024 bytes and a megabyte is one million bytes.

**C**

0350

**CALCULUS FOR SELF-REFERENCE**<sup>2)</sup>

This logical calculus has been introduced by F. VARELA as an extension of G. SPENCER BROWN's **calculus of indications** aiming “... to encompass all occurrences of self-referential **situations**” (VARELA, 1975, p.5).

VARELA explains: “This is done through the introduction of a third state in the form of **indication**, a state seen to arise **autonomously** by self-**indication**” (ibid.).

This third state represents the unavoidable **organizational closure** of the **observer**. In VARELA's words: “... a third, not so obvious but distinct **domain**, of a self-referential **autonomous** state which other laws govern and which *cannot* be reduced by the laws of the dual **domains**. If we do not incorporate this third **domain** explicitly in our field of view, we force ourselves to find ways to avoid it as has been traditional) and to confront it, when it appears, in **paradoxical** forms” (ibid., p.19).

Known, assumed and well understood self-reference leads to a quite different viewpoint in comparison to unconsciousness of self-reference (see “**Self-reference in logic**”).

For a complete development of this calculus, see VARELA'S reference.

→ **Laws of form**

0351

**CALCULUS OF INDICATIONS**<sup>2)</sup>

A fundamental arithmetic that forms the ultimate basis of **Boolean** algebra. It has been introduced by G. SPENCER BROWN in his book “**Laws of Form**” (1969, 1979).

F. VARELA states: “By succeeding in going deeper than **truth**, to indication and the laws of its form, he has provided an account of the common ground in which both logic and the **structure** of any **universe** are cradled, thus providing a foundation for a genuine **theory of general systems**” (1975, p.6).

BROWN's calculus of indications starts from the ideas of **indication** and **distinction** as “...a necessary condition for an act of **indication** is the drawing of a **distinction**. The **form (paradigm)** of **distinction** is taken as *the form (paradigm)*. All other **forms (paradigms)** are taken out of (follow from) *the form*” (R.A. ORCHARD – 1975, p.102).

“A **state** distinguished by the **distinction** is marked with the mark 1 and the **state** is called the marked **state**” (ibid.).

Arrangements (i.e. combinations) of marked and non-marked **states** and the use of a directional barb allow for the development of the whole of calculus of indications.

0352

**CANTOR SET (Triadic)**<sup>2)</sup>

This set, imagined by Georg CANTOR towards the end of 19th century is probably the first ever abstract **representation** of a **fractal** set.

It is constructed, starting from a segment, which is divided in three equal parts, the middle third being removed. This operation is renewed on the two subsisting segments ad infinitum (supposedly!). In this way, we should obtain finally an infinity of points... whose total length dimension, or linear measure, would be zero. The Cantor triadic set has a fractal dimension of 0.63. Another Cantor set can be constructed removing at each stage two fifth segments within the remaining part of the original segment. It has also a zero linear measure and its **fractal dimension** is 0.68.

The Cantor set is **self similar**.

If we could invert the construction **process** of the Cantor set (i.e. from an infinity of points to a complete segment) we would have modelled the genesis of a macrolevel **system** constructed from discrete **parts**.

Other mathematical objects of the same type are the “snowflake” Koch curve, and the Peano curve, made from an infinitely folded segment which finally would wholly cover a surface. There are also objects of the same kind in three or more dimensions.

0353

**CAPSULATION**<sup>1) – 2)</sup>

The enclosure of a number of hitherto independent **elements** within a common **boundary**.

Such an **event** is generally a result of some kind of pressure within the common **medium**. The more or less accidental concentration of numerous **elements** in a reduced **space** produces **crowding** and, due to the increasing closeness of the **elements**, these start to interact, whether being of the same or of different types. The boundary defines an incipient internal **space**, in opposition to, but in **communication** with the external one, i.e. defines an **invironment** and an **environment**.

A near synonym also used is “**encapsulation**”

0354

**CARRYING CAPACITY**<sup>1)</sup>

1. “... The **population level** for long-range survival” (H. ODUM. 1983, p.125).

2. “The maximum number of living things that can be supported indefinitely by a given **ecosystem** or area without deterioration” (UNESCO-UNEP Glossary, 1983, p.7).

These definitions are proper to **ecology** and related to basic physical **resources** (mineral **cycles**, soil, water **levels**, plants, etc.) However there are also **limits** to the carrying capacity of **transmission channels** of any kind.

An eventual larger carrying capacity must be "based on the continued **flow** of the concentrated potential **energy**" (ibid., p. 123).

The carrying capacity of any **biotope** or **ecosystem** remains stable only when the **environmental** conditions remain within stable **limits**. This does not exclude some more or less periodic maxima or minima, for example during winter, or dry season. Very long term **constraints** are more elusive and, as a result, long range carrying capacity is quite difficult to evaluate with reasonable certainty.

Still another definition is the following: In any **subsystem** - but particularly in a **niche** in an **ecosystem**, the ultimate **limit** to the number of **elements** or individuals able to survive in the niche.

The ultimate limit is generally characterized by heavy **overcrowding**, which leads to blockage (for instance in vehicles traffic on truncl roads), massive destruction (by **epidemics**, for example), massive emigration (as the one caused by overpopulation and the potato blight famine in the 1840's in Ireland) or gregarious **mutation** and **behavioral change** (as in **Dicystelium discoideum** or in solitary locusts reaching a **critical density**)

0355

**CASSANDRA'S SYNDROME**<sup>1)4)</sup>

The fate of any clear-sighted individual, able to **forecast** some future **event**, but nearly never believed. This was the case of Cassandra, daughter of King Priam of Troy, who was endowed with such a gift, but fated by the god Hermes never to be given heed. (Homer's Iliad)

The syndrome is in fact systemic and specific to social systems. Some very few individuals are endowed with foresight because they perceive quite concealed and unobtrusive **interactions** in a **situation** or **issue**, that could later on trigger very considerable and possibly dramatic consequences. Meanwhile, common people remain shortsighted and, as they see nothing special in the situation, they don't believe "Cassandra".

Another curious greek tale, more or less similar, is about Tiresias, the Theban prophet, who was blind. In many cases, the foresighting individual seems to be blind to the present issue, as his forecasts or prophecies appear to be incredible according to what common people perceive from the actual facts. Tiresias also is thus not understood or believed.

Let us hope a better fate for systemists concerned or worried about the future of human systems!

→ **Interception; Prospective**

0356

**CATABOLISM**<sup>1)</sup>

The **process** of dis-**assimilation** and emission or elimination of products by a **living system**.

The catabolic **process** includes the following phases:

- **Production**: the synthesis within the system of specific material or energetic products destined to be exported as **outputs** into the **environment**.

- **Encoding**: the **recoding** of internal **information** into a public **code** in order to produce **information** that can be interpreted and used by other systems (specially in **human systems**).

- **Output transduction**: The translation of the prepared products from the system through its **boundary** into its **environment**.

Not all products - specially those of **human systems** - are innocuous for the **environment**. Some, as for example long life radioactive **wastes**, cannot even be artificially **recycled** in an efficient manner.

For the respective **roles** of the **subsystems** concerned in catabolic **processes**, see J. MILLER's **20 critical subsystems**.

The process of absorption and **assimilation** of **inputs** by a system is called "**anabolism**", while "**metabolism**" is the generic term for the whole **process** of absorption, **transformation** and emission of **matter, energy** and **information**.

In a more or less **analogic meaning**, higher **level living systems** (groups, enterprises, **organizations, communities**, etc...) all catabolize specific **outputs**.

0357

**CATALYSIS**<sup>1) - 5)</sup>

The recurrent action of an **element** in a system, which activates some **process**.

This is a systemic extension of the classical chemical **model** of catalysis.

M. ZELNY observes that "...it is unreasonable to assume that the catalyst is unaffected by its participation in the production of **links**. Each single act of production diminishes its catalytic power. Initially, when there is a lot of free substrate, the number of produced **links** is naturally very high. At the same time, the number of holes necessary for **disintegration** is still very low" (1977).

However, the catalyst uses up the **substrate** and, as a consequence, finds less opportunities to act. It is its own **activity** which limits, and finally suppresses its capacity for **activity**.

This seems to open avenues for the explanation of what ZELNY calls "built-in death" of **autopoietic organizations**.

0358

**CATALYSIS (Auto-)**<sup>2)</sup>

"**Cycle** where a product of the reaction catalyzes its own synthesis" (LASZLO 1992, p.242).

This is the simplest type of catalysis.

It may lead to a **runaway process** in the case of an unchecked multiplicative reaction. However, auto-catalytic processes are generally inserted in more complex **hypercycles**, or organizationally closed.

As stated by G. PASK, the concept "is used in **cybernetics** in connexion with all kinds of **change** in the **state** of the system" (PASK, 1961, p.114).

Other authors use the term "**Self-Catalysis**" in an apparently similar sense (see hereafter).

0359

**CATALYSIS (Cross-)**<sup>2)</sup>

"**Cycle** where two different products (or groups of products) catalyze each other synthesis" (E. LASZLO, 1992, p.242).

LASZLO observes that cross-catalysis leads to catalytic **cycles** or **hypercycles** and "tend to be naturally selected in the course of time by virtue of their remarkable **stability** under a wide range of conditions." (ibid)

He adds: "The formation of cross-catalytic **hypercycles** allows dynamical systems to emerge on successively higher **levels of organization**" (ibid., p.244).

0360

**CATALYSIS (Self)**<sup>2)</sup>

Reproductive **process** of complex **elements**, by the ordering action of some of their **parts** on simpler **elements** already present in their **environment**.

According to J.de ROSNAY: "A peculiar form of **fluctuations** which plays a fundamental role in the genesis of an organized **structure** is the self-catalytic reaction. There is self-catalysis when products of a reaction act as a catalyzer in this same reaction. A self-catalytic reaction may lead to the **emergence** of a **structure** ordered out of an **homogeneous medium**. It is the case of a **chain reaction** which produces (by **random** molecular collisions) a more complex molecule capable to **catalyze some stages of its own formation**. The chain closes on itself and produces a **positive feedback** starting from simpler molecules already present in the **medium** and available as building blocks. The complex molecule builds itself and the **process** accelerates with the help of the just created products" (1975, p.227).

This **process** is active in the DNA and RNA chain of reproduction... and thus in the reproduction of superior **organisms**.

It plays also a role in the autopoietic **process**. Self-catalysis is an important mechanism for the **emergence**, multiplication and **stabilization** of **complex systems**.

0361

**CATASTROPHE**<sup>2) - 3)</sup>

The sudden **transition** of a **trajectory** from one **basin of attraction** to another.

<sup>1)</sup>general information<sup>2)</sup>methodology or model<sup>3)</sup>epistemology, ontology and semantics<sup>4)</sup>human sciences<sup>5)</sup>discipline oriented

In terms of H. and L. SABELLI: "Catastrophes are the simplest forms of **bifurcations**, i.e. the **transition** from one **point attractor** to another (i.e. **choice** or rejection). The simplest catastrophes are governed by only two **control** variables: a) **asymmetric**, which at mid values is associated with large **changes** between the opposite **modes**, while at extreme values is associated with small **changes** around the **modes**; and b) **bifurcating**, which at low values is associated with **continuous** outcomes and at high values, with a **discontinuous** outcome" (1992, p.663).

0362

**CATASTROPHE (Delayed) <sup>2)</sup>**

A catastrophe occurring after a long and slow **accumulation** of small **effects**.

These catastrophes have been discussed by M. KARSKY (1993, p.1413-21). This is a very dangerous type of **phenomena**, in natural as well in artificial systems. Small **individual effects** are generally irrelevant, and perceived as such. But, as shown by KARSKY, the damped **oscillations** they provoke can suddenly "jump out of the track" and lead to new and unexpected **macroscopic qualitative effects**. KARSKY observes that: "this **phenomenon** takes place only in a very narrow band of **parameters** variations and may easily pass unnoticed in absence of a systematic policy of **simulation** through multiple **scenarios**. It could however explain in some cases the occurrence of seemingly inexplicable catastrophes" (p.1417)

That the **accumulation** be slow implies another danger: the **nonperception** of the progressive buildup of a **macroscopic change** in the making. When finally it becomes evident that a dramatic **change** is to occur, it is generally too late to do something about it.

→ **Cycles and Effects (Delayed)**

0363

**CATASTROPHE THEORY <sup>2) - 3)</sup>**

"A **topological** theory describing the **change** of a system's **structure** along a **continuous morphogenetic** landscape, including occasional jumps" (K. KRIPPENDORFF, 1986, p.9).

In R. THOM's, founder of the theory, words: "It gives a kind of local description of a system within a **control parameters space**. One may modify the **controls** on the basis of a certain system of **values** and describe, through the choice of convenient surfaces in this **space**, the **continuous variations** and the occurring **catastrophes**" (1993, p.30).

THOM thus defines the elementary catastrophe: "Any **conflict situation** between local **regimes**, potential minima, which may occur in a stable manner on the four dimensional **space-time**" (1974, p.71).

K.B.DE GREENE states: "Catastrophe-theoretic **models** deal with systems that show **multiequilibrium behavior** and usually show a path **irreversibility (hysteresis)**" (1990, p.55).

Catastrophe theory is a formalized geometrical theory that cannot even be sketched within the limits of this work (see R. THOM's, E.C. ZEEMAN's and T. POSTON and I. STEWART's references) Let us only try to describe its nature and the wide scope of its applications, as well as to warn against its improper **metaphorical** uses.

T.F.H. ALLEN and Thomas B. STARR explain it as: "A theoretical construct used for the description of certain types of disjunct **behavior**. It derives from a **topological** consideration of folded surfaces describing the **interactions** between **variables**. Catastrophe theory is rather specific in its appropriate application, although it serves a more general usefulness as a mathematical **metaphor**" (1982, p. 263).

F. HEYLIGHEN observes: "It was developed by R. THOM (1975) in order to model the (**continuous**) **development** of (**discontinuous**) forms in **organisms**, thus extending the much older work of the biologist D'ARCY THOMPSON (1917)" (F. HEYLIGHEN, 1997, p.33)

Catastrophe theory is undoubtedly a systemic one, since it addresses to a wide field of general **phenomena**, starting from a qualitative **topological** view and giving them a common basic ground through **isomorphic models**. It is basically a theory of **discontinuous phenomena**, related to sudden **phase transitions**, marking a jump from one **attractor** to another. It is closely related with the following topics: **Field gradients** leading to **singularities**; **markovian systems** and **LIAPOUNOV stability**; **bifurcations** and **unfolding**; **morphologies** and **morphogenesis**; and the different corresponding **attractors**.

The best known part of catastrophe theory are the seven basic elementary catastrophes, upon which according to THOM a general catastrophe theory is to be built upon. (in ZEEMAN, 1977, p,633)

The seven elementary catastrophes (a synthesis of THOM's (1974) and ZEEMAN's (1977) presentations):

	Dimensions of state space		Typical Phenomena
<b>a) Cuspoids</b>			
Fold	1	1	No dynamics
Cusp	1	2	<b>Hysteresis, breakdown, sudden regime change, phase transition</b>
Swallowtail	1	3	<b>Conflict</b> between two regimes
Butterfly	1	4	<b>Stability</b> in a zone through equilibrated forces

	Dimensions of state space		Typical Phenomena
<b>b) Umbilics</b>			
Hyperbolic	2	3	breaking <b>waves</b> submitted to an organization center
Elliptic	2	3	Surface penetration with breakthrough
Parabolic	2	4	

Graphical **models** have been produced by THOM (1972).

Numerous applications of the elemental catastrophes have been proposed in physics and chemistry (the relation to **dissipative structuration** and **bifurcations in far from equilibrium systems** is still a fuzzy area); in engineering; in biology and embryology; in animal and human ethology; in psychology (**perception** and **behavioral** shifts) and in social sciences (economics, markets shifts).

However, J. CASTI observes that there have been "... attempts by practitioners to use the theory as a vehicle for **predictions in situations** where it can at best be used only to explain" (1994, p.48).

In effect, in some cases – undoubtedly and at least partly due to the "mediatic" name given by THOM to his theory – the catastrophe **models** became a somewhat misused and abused **metaphor**.

0364

**CATCHMENT <sup>1) - 2)</sup>**

The incorporation by a system of some formerly independent **elements** or systems.

Catchment is in fact a **process** of expansion of the **attractor basin** of the system, corresponding to the expansion of its **field** of influence.

A typical example is the catchment by a river **basin** of some adjacent area.

0365

**CATEGORIES FORMATION <sup>3)</sup>**

According to D. BOHM and F.D. PEAT: "... categorizing involves two actions: **selection** and collection. According to the common latin root of these two words, *select* means "to gather apart" and *collect* means "to gather together"...

"The second phase of categorization is that some of the things that have been selected (by virtue of their difference from the **background**) are collected together by regarding their differences as unimportant while, of course, still regarding their *common* difference from the **background** as important" (1987, p.112).

All dogs are selected in the animal taxonomy, possibly together with cats and horses, as distinct from, let us say, marine mammals. Thereafter, we collect them in the family canidae, and more specifically in the species *canis*, in order to distinguish them from any other mammals.

<sup>1)</sup>general information <sup>2)</sup>methodology or model <sup>3)</sup>epistemology, ontology and semantics <sup>4)</sup>human sciences <sup>5)</sup>discipline oriented