The Smith of the Gods

33 - « Thus Everything Is a System! »

330-These systems, founded upon events and objects endowed with a complexity of causal circuits and of an adequate relational energy, surely display « mental » characteristics.

They compare, that is to say, they are sensitive and they respond to differences (in addition to being affected by ordinary physical causes such as impulse and force).

Such systems will « process information » and will inevitably be self-corrective, either in the direction of a homeostatic optimum or in that of the maximization of certain variables.

A unit of information can be defined as a difference that produces another difference. Such a difference, traveling and undergoing successive modifications within a circuit, constitutes an elementary idea. But what is still more revealing in this context is that no part of these internally active systems can exert unilateral control over the rest of the organism or over any other part of its system. The « mental » characteristics are inherent or immanent to the whole considered as a totality. This holistic aspect is evident even in very simple self-corrective systems. In the « governor » steam engine, the very term governor can be considered a misnomer, if by it one means that this part of the system exerts unilateral control. The governor is essentially a sense organ (or a transducer) that transforms the difference between the actual speed at which the engine runs and a certain ideal or, at least, preferable speed. The sense organ converts this difference into several differences of an efferent message: for example, the intake of fuel or the braking. In other words, the behavior of the governor is determined by the behavior of the other parts of the system and indirectly by its own behavior at an earlier moment (feedback loop). Thus, the holistic and mental character of this system is best illustrated by this last fact, namely that the behavior of the governor and of all parts of the causal circuit is partially determined by its own earlier behavior. The material of the message (the successive transformations of the difference) must go all the way around the circuit: the time necessary for it to return to its starting point must be considered a fundamental characteristic of the whole system. The behavior of the governor (or of any other part of the circuit) is therefore, to some extent, determined not only by its immediate past, but by what it was at some given moment in the past, a moment separated from the present by the interval necessary for the message to travel a complete circuit. There is therefore a certain determinative memory, even in the simplest of cybernetic circuits. The stability of the system (when it operates self-correctively, or when it oscillates or accelerates) depends upon the relation between the product of all the transformations of differences along the circuit, and this time, this characteristic « gap ».

331-The governor exerts no control over these factors. Even a human governor (an interactor), within a social system, is subject to these limits: he is controlled through the information provided by the system and must adapt his own actions to the time characteristic of the circuit and to the effects of his own earlier action (his reactive gap). Thus, in no system that displays « mental » characteristics is it possible for one of its parts to exert unilateral control over the whole. In other words: the « mental » characteristics of the system are immanent, not to some part, but to the system as a whole. The meaning of this conclusion appears in questions of the type: « Can a computer think? », or again: « Is the mind located in

the brain? ». The answer will be negative for both, unless the question is centered on one of the few « mental » characteristics contained in the computer or in the brain. The computer is self-corrective with regard to some of its internal variables: it may, for example, contain thermometers or other sense organs that are affected by its working temperature. The sense organ that is affected by this working temperature, by responding to these differences, may, for example, relay them to that of a fan which, in turn, will change the temperature of the whole. We can therefore say that the system displays « mental » characteristics with regard to its internal temperature. But it would be incorrect to say that the specific work of the computer – the transformation of input differences into output differences – is a « mental » process. The computer is only an arc in a larger circuit, which always includes man and the environment from which the information comes and upon which the computer's efferent messages are relayed. We may legitimately conclude that this global system, or aggregate, displays « mental » characteristics. It operates by a « trial-and-error » process and possesses a creative character. When we speak of a system, we refer to two different phenomena, inherent in the physical nature of the world, to two forms of organization. The first organization is of the « summative » type, the second is of the « constitutive » type.

The summative characteristics of an element are those that do not depend upon whether it is inside or outside the organized complex; they can therefore be obtained by summing the characteristics and behaviors of the elements taken in isolation.

The second characteristic, called « constitutive », depends upon the specific relations within the organized complex. To understand them, one must therefore know, besides the parts, also the nature of the bonds that unite them. It is the relation « elements–structures–functions–information ».

332-A fundamental difference lies in constitutive-type organizations through open types and closed types. It is the fact that closed-type systems may eventually reach a state of chemical and thermodynamic equilibrium independent of time; as opposed to open systems which must reach, under certain conditions, a time-independent state called a steady state.

Examples of physical characteristics of the first type are provided by molecular mass (the sum of atomic masses), and heat (considered as the sum of the movements of molecules).

Chemical characteristics give an example of the second type (isomerisms; different characteristics of bodies having the same overall composition, but whose radicals are variously arranged within the molecule). The expression « a whole is more than the sum of its parts » means that constitutive characteristics cannot be explained from the characteristics of the parts taken in isolation. The properties of the complex therefore appear, in relation to those of the elements, as new or « emergent ». We find in it a principle of growth, a principle of competition, a principle of totality and a principle of finality which enter into the laws of natural selection.

1- The principle of growth: this curve is called a logistic curve and has a wide range of application. It is also the first figure of the catastrophe theory developed by René Thom, « the Unfolding ». In chemistry, it is the curve of an autocatalytic reaction, that is, a reaction during which the product obtained accelerates its own production. In sociology, it is Verhulst's law describing the growth of human populations in a context of limited resources.

2- The principle of competition: When we speak of a system, we understand « Totality » or «

Unity ». It then seems paradoxical, with respect to the whole, to introduce the notion of competition between its parts. In fact, these two apparently contradictory subjects belong nevertheless to what is essential in systems. Every « Aggregate » is founded upon the competition of its elements and presupposes the « struggle between the parts ». This is a general principle of organization in simple physicochemical systems as well as in organisms and social units. It is ultimately an expression of the « contradictory » relations of the physical world and of the « schismogenetic » constitution of the social world (at once a part in opposition and another in complementarity) that complex reality represents.

3- The principle of totality, of summation, of mechanization and of centralization: a unitary system little by little divides into independent causal chains; this is what is called « progressive segregation ».

333-It is in the contrast between totality and sum that the tragic tension inherent in all biological, psychological and sociological evolution lies. Progress is possible only if one passes from an undifferentiated totality to a differentiation of the parts. This, however, requires that the parts become fixed upon some particular action. Then, progressive segregation implies loss of regularity. As long as the system is a unitary whole, a perturbation will be followed by the arrival of a new steady state due to the interactions internal to the system. The system is self-regulated. However, if the system becomes divided into independent causal chains, regularity disappears. The partial processes operate without regard for one another. We find this behavior, for example, in embryonic development; specialization goes hand in hand with the loss of regularity. Progress is possible only if one divides an initially unitary action into the action of specialized parts. At the same time, however, there is impoverishment, a moving away from performances that were still possible in the indeterminate state. In this sense, the more the parts are specialized, the more irreplaceable they are, and the more the disappearance of some of them risks leading to the shipwreck of the whole system. In Aristotelian language, every evolution that deploys certain potentialities stifles many others in the egg. This is verified as much in embryonic development as in phylogenetic specialization, in scientific specialization as in everyday life.

4- The principle of centralization is particularly important in the biological domain. Progressive specialization is often closely connected with progressive centralization expressed by evolution as a function of a dominant element, that is, by a combination of the patterns. At the same time, the principle of progressive centralization is that of progressive individuation. An « individual » can be defined as a centralized system.

334-Strictly speaking, in the biological domain this is a limiting case, the organism becoming, through progressive centralization, more and more unified, more and more indivisible. Thus, to speak strictly, biological individuality does not exist; there is only a progressive individualization in the course of development and evolution. It results from a progressive centralization; certain parts acquire a dominant role and thus determine the behavior of the whole. In genomics, the genome is seen as a whole that produces the organism as a whole; certain genes determine in a preeminent way the direction of development of certain characters, that is, they act as « dominant elements ». This is expressed by saying that each hereditary trait is co-determined by many genes and perhaps by all, and that each gene influences not one trait but a large number and perhaps even the whole organism (polygeny of characteristics and polypheny of genes).

5- The principle of finality: A system may asymptotically reach a stable steady state in the course of time, but it may never reach such a state; it then enters a regime of periodic oscillations. In the case where the system tends toward a steady state, its variations can be expressed not only as a function of current conditions, but also as a function of the distance to the steady state. This can be expressed as follows: if a system approaches a steady state, the variations that take place must be expressed in terms of distance from the equilibrium state; the system appears to « aim at » an equilibrium that will only be reached in the future. All these principles say that in case of perturbation, the system sets in motion forces that oppose it and bring it back to the equilibrium state: these are consequences of the principle of least action and of the mode of existence of natural objects tied to their own identity. One can also speak of finality in the sense of dependence upon the future. Indeed, one must consider and describe events as being determined not by current conditions, but by the final state to be reached and, under certain conditions, by the surpassing of that state. Secondly, this formulation is of a general order; it does not apply only to mechanics but to any sort of system. Lastly, this point has often been misinterpreted in biology and in philosophy, so that a clarification is necessary.

The types of finality:

1- Static teleology or aptitude: an arrangement may be useful for a certain « purpose ».

2- Dynamic teleology means an orientation of processes.

a) progression of events toward a final state: as if present behavior depended upon that final state. Every system reaching a time-independent state is of this type.

b) movement based upon structure; transformation of structures enabling the process to reach a certain result. This is of course the case of a machine built by man to realize desired products or services.

c) there is another basis of organic regulation. It is equifinality; the same final state may be reached from different initial conditions and along different paths.

d) finally, there is true finality or destination, that is, present behavior is determined by foresight of the goal.

3- Isomorphism: the law of exponential progressions establishes, for example, that given a certain population of whatever beings, a constant percentage of its elements disappears or multiplies per unit of time. The parabolic law expresses competition within a system. Each element plays a role according to its capacities, which are expressed by a specific coefficient. This law is of the same form as the one that applies to competition among individuals in an economic system following Pareto's law. These principles apply to systems in general regardless of their nature or that of their elements; this explains the appearance of similar concepts and laws in various scientific disciplines, and this independently. Thus, the concepts of totality, sum, mechanization, centralization, hierarchical order, stable steady state, equifinality, etc., are found in different fields of natural science, as well as in psychology and sociology. Cognitive psychology being likewise subject to the same principles as social and physical structures.

6- Homeostasis: the homeostasis model may be applied in psychopathology because, as a rule, the functions that are not homeostatic decline in the mentally ill. Mental alteration may

be considered as a series of defense mechanisms that establish themselves at lower homeostatic levels, until the simplest conservation of physiological life disappears. The concept of progressive teleological regression in cases of schizophrenia is similar.

7- Differentiation: differentiation is the passage from a general and homogeneous condition to a more special and heterogeneous condition. Wherever development occurs, it proceeds from a state of relative globality and lack of differentiation toward a state of increasing differentiation, articulation and hierarchical order. It is Laplace's demon, master of irreversible entropy, who meets his positive genius, his neguentropic double who has the power to wrest electrons from him in order to inform them. The principle of differentiation is met everywhere, in biology, evolution and development of the nervous system, behavior, psychology and culture. Mental functions in general progress from a syncretic state of the somatic nucleus where perceptions, motivations, feelings, images, symbols, concepts, etc., form an amorphous unity, toward an ever sharper distinction of these functions. In the case of perception, the primitive state seems to be synesthesia (of which traces remain in the adult human, and which can reappear in the schizophrenic, and through experiences of mescaline and LSD) outside of which the normally separate visual, auditory, tactile, chemical experiences are found in connection. There is, in animal behavior, and in a good part of human behavior, a perception-emotion-motivation unity; thus, perceived objects without emotional and motivational currents, as today, are the late achievement of civilized man in his maturity.

335-The origins of language are obscure; as far back as one can form an idea of them, it seems that language and « holophrastic » thought, that is, words and thoughts having a wide aura of associations, preceded the separation of thoughts and articulated language. Likewise, the categories of developed mental life, such as the perception of the « self », of objects, of space, of time, of number, of causality, etc., evolved from a perception-conception-motivation continuum, represented by the « paleological » perception of children, primitives and schizophrenics. Myth was this prolific chaos from which language, magic, art, science, medicine, morals, ethics and religions differentiated. If we were to think in terms of general systems theory, the formula of the equation that faces us all with regard to the meaning of existence is expressed in the form: « what nature and what value for the variable S being the index of motivation, the realizable ideal, the teleological index of the system ». The language of systemics, expressed in terms of open system, closed system, mixed system, porous systems, self-differentiating system and complex organizing system, logically expresses the universe of relations running through this World. The universe, black holes, vortices are considered as so-called porous systems, that is, quasi-closed. Every living system is considered a mixed system (combination of open systems and quasi-closed systems). This living system has inputs and outputs. Its quality as an open system is due to its « equifinal » nature, different from a closed system which, in its case, responds entirely to the second law of thermodynamics. But the mixed state means that the open system, being also subject to the second law of thermodynamics, diverts it by wresting particles from it which it reorganizes with the assistance of its quasi-closed part of its system providing it with the flow of information necessary for its reorganization. As a result, the open system, « the soma », behaves in appearance like a closed system and the quasi-closed system « the psyche » like a sensitive cell connected to an open system providing it with information on the entropy state of the system and its possibilities of

reorganization. The quality of equifinality is defined by the fact that, for a theoretical finality, a multitude of metabolic paths is possible and in part realized. A living system therefore has at minimum one output and a multitude of inputs. The output of a mixed system is not of univocal form; there is at least a teleological index S, plus the output of metabolic waste, plus a feedback variable of output state. Every system exists only in an environment which is itself a system. Consider the universe; in theory, it should be a closed system entirely subject to the second law of thermodynamics, but we note that it is in fact a quasi-closed or « porous » system which, like black holes or vortices, emits a certain number of free particles that constantly escape from it. This quasi-closed system concedes particles to the multitudes of quasi-open systems that run through it. The first feedback of the system comes from the conditioned structure of the sensitive network constituting the globality of the organism's tropisms. The other variable S is a constitutive teleological variable of the organism's virtual ideal. It corresponds to the position it holds with respect to a super-attractor at work in the substrate of the encompassing system. Systems theory being a science of mathematical models, it encompasses, besides relativistic quantum physics, cybernetics (the science of self-control processes), gestalt theory (the science of rupture phenomena, phase states and morphogenesis processes), information theory (information being the only energy not yet considered as having physical nature), like a graviton characterizing the gravitational wave, we await the discovery of a type of « infon or morphon » particle as a hypothetical retroactive particle running through the semantic field, and bearer of a difference.

336-A theory of semantic fields being the work of relativistic quantum physics and of a general theory of conceptual systems, that is, of a meta-systemics. The teleological variable acts as a super-attractor only as long as the most deeply buried tropisms do not manifest themselves. The principle is that any change in any system entails a modification of the whole system and of all the parts of the system. The teleological variable S (the best thing that can happen) is the hope, for the cybernetic slave that the computer represents, of growing and attaining wisdom; for man, his variable S is often lost somewhere among the stars and, for the World, it is surely projected somewhere in an elsewhere. Thus, the first system presented in Ludwig von Bertalanffy's lecture at the « Macy » conference is the historical system. History is sociology in its evolution, studied « longitudinally », that is, in a « diachronic » way. These are the same socio-cultural entities that sociology studies in their present state and history in their movements. The Second World War could be attributed to the perversity of Hitler or to the warlike inclination of the Germans, known for having a « Dominance-Submission » oriented ethos. If we look at contemporary history in its realization, it is difficult to impute its irrationality and bestiality to individuals alone. We have rather the impression of being victims of « historical forces », whatever they may be. Events seem to involve more than simple individual decisions or actions; they are determined by socio-cultural systems, no matter whether we call them prejudices, ideology, growth and decadence of civilizations. We know scientifically what the effects of pollution, of the plundering of natural resources, of the population explosion, of the arms race will be. We seem guided by a tragic historical tendency. Systemics seeks to identify regularities and laws in the socio-cultural sphere, without necessarily going as far as the inevitability of history. Certain analogies are borrowed from embryonic development. Systems modify their behavior at critical points and cannot return to their earlier situation. General systems theory is in agreement with Albert North Whitehead's publications on the philosophy of « organic

mechanism », as well as with Alfred J. Lotka, who built up his bio-economics concept as a general concept of systems. We will never fully realize all that we owe to the hippie movement for the elaboration of systemic science. San Francisco, Berkeley, St Louis, the MIT and Palo Alto were also the places of a primal ferment. In the image of Buckminster Fuller's ideas in the 70s and of Norbert Wiener, who had presided over the creation of the Whole Earth Catalog and over the cybernetic vision of Bateson. The latter literally permeated the CoEvolution Quarterly movement and the « American New Left ». At the end of the sixties, Fuller and Wiener had proposed a view of the use of tools that accorded with the return to the land characterizing the young generation at the start of the following decade. Bateson's analysis of the world itself as a system and of its inhabitants as elements potentially capable of influencing that system was in phase with the return of the New Communalists to the heart of established America. In Bateson's vision, as in Brand's of the « Whole Earth », the former counter-culturalists and the rest of society were going to have to coevolve.

337-A second wave of researchers emerged in the sixties with the publication of « Observing Systems », a collection of essays written by Heinz von Foerster. The latter, who later became a loyal subscriber to the Whole Earth Catalog and a friend of Brand's, proposed including observers as part of the systems they observed. In Foerster's analysis, and later in the work of a small number of other cyberneticians, the observer and the system were inseparable. In view of this chronology, Gregory Bateson belonged to the first wave of cyberneticians. In 1942, shortly after conducting field research in the South Pacific and marrying his colleague Margaret Mead, he took part in a colloquium organized by the Macy Foundation in New York on hypnosis and conditioned reflexes. There he met Warren McCulloch and Arturo Rosenblueth, and listened to the latter's presentation on the concept of feedback which he had just developed in the company of Wiener and Julian Bigelow.

As Steve Heims has shown, the physical and social sciences had until then concentrated on circular models in Einstein's theory of general relativity. Most scientists thought that circular patterns of causality could not be modeled or verified mathematically, and therefore could not be studied. However, the analysis of causality that Rosenblueth was developing was not only totally unprecedented, but could also be grasped through traditional mathematical methods. In 1946, as soon as the Second World War was over, the Macy Foundation convened the first of some ten meetings intended to explore these hypotheses and a few others running through cybernetics.

Bateson's theory of an immanentist mind also allowed his followers to reconnect with the feeling of participating in the preservation of the planet. In « Steps to an Ecology of Mind », Bateson indicated that if the immediate causes of what appeared as an imminent ecological crisis could be technological and social in nature, its primary cause was epistemological. In an essay entitled « Effects of Conscious Purpose on Human Adaptation », he stressed the idea that individual consciousness was permanently monopolized by processes of individual learning and cultural exchange. These processes gave shape to the relations of the human being to nature and offered the individual an opportunity to modify it. In 1972, Bateson indicated that what nature most needed then was to be preserved. In the course of the preceding centuries, certain « self-generated development entities », such as the Empire, big corporations or governments, had transformed the individual human being into a dehumanized creature.

He hypothesized that each individual could recover his humanity and act more humanely toward the planet as a whole if he became aware of his level of integration into the natural and social systems that surround him. The individual mind is immanent, but not only in the body. It is immanent in circuits and messages outside the body; and there is a larger Mind comparable to God, and perhaps this is even what some people mean by God, but it remains immanent in the fully interconnected social system and planetary ecology. Through cybernetics, Bateson explained, human beings could finally admit that the individual was nothing more than a « servo-system coupled to its environment ». The idea of a separation of the individual mind from the body or even from the wider world was nothing other than a vestige of the industrial era, or even of the pre-industrial era, of human civilization.

The sixties, steeped in innocence and pagan idealism, survive and continue to exert their fascination upon the youth of today. Looking at the archive images of Woodstock, one wonders: where have all those illuminated, orgasm-hungry teenagers gone? They scattered across the whole territory and remain dormant, like perennial plants buried deep in the earth. But their nucleotides, born of mutations, have engendered an entire new generation of devilishly intelligent mutant rascals, and it is in them that we must place our faith and the power to act. In contact with Norbert Wiener, Buckminster Fuller and Marshall McLuhan, Stewart Brand, who had converted rather late to the power of digital technologies, was nevertheless an old hand at mysticism and LSD.

Stewart Brand, son of ranch owners in Wyoming, had been raised in a Mormon spirit, attached to the Republican party. He was not allowed to watch television before the age of 11 and, when he could, he watched essentially televangelist programs. At 14, he was sent to a Catholic school and, ironically, it was at that time that he began to have faith in the lysergic essence. At the end of the sixties, while attending Wesleyan University in Connecticut, he regularly took part in the activities of Timothy Leary's group located in Millbrook, in New York State. His faith resurfaced after his first acid trip. « The feeling that there was something sacred in the Universe animated me again », he later recounted. But this sacred presence could not be contained within any particular dogma. Barlow turned rather to the mystical inclinations of Pierre Teilhard de Chardin and the cosmic vision of Vernadsky, the enlightened Jesuit priest and geochemist whose works he had discovered while at university, and to Gregory Bateson, whose « Steps to an Ecology of Mind » he had read at the start of the seventies. In their works, and later in those of the biologists and chaos theorists, John Perry Barlow glimpsed what he called « an underlying grammar of nature ». The material world had become for him a polymorphic amalgam of living forms, each permeated with a certain energy. Although the forms themselves might fluctuate, the energies remain, circulating without interruption, articulating the world. In this sense, for Barlow as for Bateson, « the mind was a space » – in other words, mind and material world were both systems constituted and perpetuated by the circulation of energy heteromorphic to the whole, sorts of mirrors of each other. And in Barlow's experience, if not in Bateson's, LSD had been a portal giving access to this understanding.

338-Norbert Wiener edited « Cybernetics » in 1948, resulting from the recent evolution of computer technology, information theory, and « feed-back » processes. At the same time were published the information theory of Shannon and Weaver and the game theory of von Neumann and Oskar Morgenstern. Wiener developed the concepts of cybernetics, feedback,

and information well beyond the field of technology. He generalized them to the biological and social domains. The dangers of this evolution, he said, are alas evident. The new cybernetic world does not concern itself with man, considering him as a subject of exploitation and experimentation in the transhumanist spirit, hence the resentment at the oppression of the « System ». Man becomes replaceable and sacrificeable there. In the « Great System », man must become a button-pushing idiot or a schooled idiot, that is, be narrowly specialized or a mere piece of the machine. This is a principle of systems called « progressive mechanization ». The individual is transformed into a cog dominated by a few privileged, mediocre and mystifying leaders, who pursue their own interests under the cover of ideologies. Whether we consider the positive growth of knowledge and the beneficial control of the environment and of society, whatever we consider in the evolution of systems, the specter of the « Brave New World » hangs over us, and recalls to us Prometheus' solemn warning about men's responsibility through his technological power. This reserves for us intensive work, which we must overcome.

Let us take up again the principle of violence and of the sacred as the first motor of history. Violence being in the first nature of men because of their tendency to hoard, man is not anthropologically endowed with a process of limitation or inhibition of the impulses of violence and may even indulge in destructive hubris and gratuitous violence, which implies the existence of religions.

On the opposite side, the notion of the « trifunctional » developed by Georges Dumézil, constituting the Indo-European language, completes this scheme with inventive activity. There are two factors by which our civilization is evidently unique in comparison with those that the past has seen perish.

Technological development allows a control of nature never before attained, which will open ways to alleviate hunger, need, excess mortality, overpopulation, etc., ills to which humanity was formerly exposed.

The second factor is the global nature of our civilization. The preceding ones had geographical limits and comprised only limited numbers of human beings. Our civilization encompasses the whole planet and is even launching itself into space. Our technological civilization is not the privilege of small groups like the citizens of Athens or of the Roman Empire, of the Germans or the French or the Europeans. With the era of networks, it opens to all human beings, whatever their color, origin or faith. These are of course particularities that blow up the cyclical scheme of history and seem to place our civilization at a level different from those that preceded it. The decline of the West is not a hypothesis or a prophecy, but an accomplished fact. This splendid development which produced the Gothic cathedrals, the art of the Renaissance, Shakespeare and Goethe, Newtonian physics and all of European culture, all this enormous cycle of history is completed and cannot be restored by artificial means. We must reckon with the inflexible reality of mass civilization, of mainstream culture, of the technological, international nature that encompasses the whole earth and all of humanity, in which the cultural values and creativity of former times are replaced by new symbols. The current struggles for power may lead to universal atomic devastation, but the similarity of material cultures may prove stronger over time than ideological differences. Except that we note a psychological change in the classes of society which have until now been the creators of culture, the sociological class of « cultural creatives ». Since the Situationist period of San

Francisco, the agit-prop of the « Merry Pranksters » and the actions of the diggers of Emmet Grogan (Kenny Wisdom) in the 1970s, their creative power and energy are fading. Man becomes blasé, no longer feels the interest in creating, withdraws from creation its value; this is disenchantment; effort is no longer an effort toward a creative ideal for the benefit of humanity, their minds are preoccupied either with material interests or with ideals disconnected from life on earth.

An individual's experience of time is parallel to a corresponding increase in the frequency of alpha waves in the brain. With age, time seems to go faster, that is, a smaller number of moments is felt per unit of astronomical time (one moment equal to 1/18th of a second, which corresponds to the conduction speed of our reflex arc, to the efficiency of our metabolism, and to the frequency of 1/40th of a second of the emergent flashes of consciousness in the prefrontal cortex). Correspondingly, there is a decrease in the rate of wound healing proportional to age, the psychological as well as physiological phenomena being obviously linked to the slowing down of the metabolic process with old age. On the other hand, from the point of view of physics, one can introduce a thermodynamic time founded upon the second principle and upon irreversible processes, opposed to astronomical time which is certainly also driven by the laws of thermodynamics but in a non-dissipative medium. These laws seem to be inverted for the living, which evolves on our planet in a dissipative medium, that is, outside the vacuum. Thus, thermodynamic time is not linear but logarithmic, since it depends upon probabilities; it is for the same reason statistical; finally, it is local, being determined by the events at a point. It is probable, thus, that biological time possesses an intimate relation, moreover not a simple one, with thermodynamic time. There is no intrinsic justification for considering what we take to be the « normal » experience as the true configuration of the world, and all other kinds of experience as simply abnormal, fantastic or at best as a precursor image of our « scientific » conception of the world. The categories of experience, or again the forms of intuition, to use Kant's terms, are not universal a priori but depend rather upon the psychophysical organization and the physiological conditions of the animal in question, including man. This relativism from the biological point of view forms an interesting parallel to the relativism of categories as considered from the point of view of culture and language.

339-The beings named system are formed of parts in interaction. The prototype of their description is a set of simultaneous, nonlinear differential equations, forming an interactive complex in its general case. A so-called « organized complex » system can be delimited by the existence of strong or nonlinear interactions called « Attractors ». General systems theory was born in part from gestalt theory in psychology. Thus, in gestalt theory, for most cases, René Thom's catastrophe theory models well the action of these attractors and the corresponding rupture states, making it possible to give a form and a dynamics to these systems.

Among what grounds systemics, we find:

A « classical systems theory » which uses mathematics and analysis. Its aim is to state principles applying to systems in general or to precise classes of open or closed systems, to provide techniques for their study and description, and to apply them to concrete cases. Examples include the generalized principles of kinetics which apply, for example, to populations of molecules or to biological beings, that is, to chemical and ecological systems.

The equations of diffusion in physical chemistry and of noise dispersion. The application of steady-state models and of statistical mechanics to traffic flow, the allometric analysis of biological and social systems.

A « computer theory of simulation ». The sets of simultaneous differential equations serving as a « model » or definition of a system are, in the nonlinear case, still difficult to solve even when there are few variables. Computers have therefore opened a new avenue of approach to the study of systems; let us await quantum computers.

A « compartment theory ». It is a system formed of sub-units possessing certain boundary conditions between which transport processes take place. These compartment systems can be a chain of boxes or a central box in communication with a certain number of peripheral boxes. Laplace transformations and the introduction of graph theory and of networks have made this analysis possible.

A « set theory ». The general formal properties of systems, closed or open, can be axiomatized in terms of set theory.

A « graph theory ». Many problems posed by systems bear upon their structural or topological properties rather than upon quantitative relations.

A « network theory ». It is linked to set theory, to graph theory, to compartment theory, and applies to systems such as the nervous network.

The « Cybernetics ». It is the theory of controlled systems founded upon communication, system-environment and internal system, and control (feedback) of the function of the system with regard to the environment.

An « information theory » in the sense of Shannon and Weaver, which is founded upon the concept of information and defined by an expression isomorphic to the negative entropy of thermodynamics. Information is a measure of organization.

An « automata theory ». Abstract systems with input, output, possibility of trial-and-error and of instruction. A general model is provided by the Turing machine.

A « game theory ». This theory is considered a theory of strategies in a social context; it concerns essentially a « system » of precise antagonistic forces.

A « decision theory » which is a mathematical theory of Hilbert's choice among infinite alternatives.

A « queueing theory ». A general theory of hierarchical order would obviously be a point of support for general systems theory. The principles of hierarchical order can be stated in verbal language. There are semi-mathematical ideas linked to matrix theory and formulations in terms of mathematical logic. In graph theory, hierarchical order is expressed by a tree, and the relational aspects of hierarchies can thus be represented. The question of hierarchical order is intimately linked to those of differentiation, evolution and the measure of organization in terms of entropy and in terms of information theory. Hierarchical order and dynamics would be the same thing. Let us start from the consideration that there are at a given moment 10^30 cells on Earth. Assuming that there is a new generation of cells every minute, this would give, for an age of the Earth of 15 billion years, 10^46 cells in all. To reach a maximum number, there would need to be the existence of 10^20 life-supporting

planets to conquer. Thus, in the Universe, there would be no more than 10^66 living beings, which is not so bad. According to B.L.J. Hart, human invention could be conceived as new combinations of already existing elements. If this is so, the opportunity for new inventions will grow sharply as a function of the number of possible permutations and combinations of the valid elements, which means that it will increase like the factorial of the number of these elements. Thus, the rate of acceleration of social evolution will not be a logarithmic acceleration but log-log, like that of the creative potential of humanity. Hart presents curves showing that the increases in human speed, in the effective areas of weapons, in life expectancy truly follow such an expression, that is, that the rate of cultural growth is not exponential like compound interest, but is in super-acceleration according to a log-log curve. Only in recent years has physics sought to extend itself to include open systems, the time variable and the formal aspect of processes. This theory has shed new light on many obscure phenomena in physics and biology and has led to important general conclusions.

The first is the principle of equifinality. Contrary to a closed system which, from the final state, is univocally determined by the initial conditions; for example, the movement in a planetary system, where the positions of the planets at time t are univocally determined by their positions at time t0. Or again, in a chemical equilibrium, the final concentrations of the reactants naturally depend upon the initial concentrations; if one changes the initial conditions or the process, the final state will also be modified. It is not so with open systems. Here, the same final state can be reached from different initial conditions or along different paths. This is what is called equifinality; it has great significance for biological regulation phenomena. Those familiar with the history of biology will recall that it was precisely equifinality that led the biologist Driesch to adhere to vitalism, that is, to the doctrine which asserts that vital phenomena cannot be explained solely in terms of natural science. Equifinality, for Driesch, contradicts the laws of physics and can only be accomplished by a vitalist « animist » factor that governs the process with a view to the goal to be reached. One can show, however, that all open systems, insofar as they reach a steady state, must display this equifinality, so that the presumed violation of the laws of physics disappears.