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Edgar Morin

Method

Towards a Study of Humankind
Volume 1
/ The Nature of Nature /

Translated and Introduced by
J.L. Roland Bélangier



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To My Students

Acknowledgements and Note

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Traductor traditor. A cocktail phrase when we began this work, now a searing reality. The very richness of a work precludes its translation into other languages and even other media. Nonetheless, the task had to be performed and there are no regrets. The Anglophone public can now read this first volume of Edgar Morin's *Method* and be as provoked as we were upon first opening this work in 1982. Though we may inevitably have betrayed some elements of the rich style, the frequent metaplasms and metagrams and alliterations and paradoxes and lilting rhythms, we believe we have not betrayed the richness of the thought, insofar as thought is separable from language... Obviously, whatever may be deficient herein is entirely my blame and responsibility.

J.L. Roland Bélanger

Marist College
Poughkeepsie, NY 12601
August 15, 1991

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Translator's Introduction

Edgar Morin, author of some 30 books and numerous articles, is considered one of France's foremost exponents of communications theory, general systems theory, higher complex systems, and the Science of Man (or, preferably, the Study of Humankind).¹ These are not four discrete areas; they all interlock, necessarily. In fact, Morin maintains that every branch of knowledge, though irreducible to any other, is tied to, conditions, and transforms every other. We present here, with summary comment and critique, a biographical sketch of Edgar Morin and a precis of the four volumes published to date which expose the main ideas of his major synthesis, *La Méthode*.²

In the Fifties Morin published two books on the movies³ which have become stock references, particularly in a mythic view of media creations. He then moved into transdisciplinary studies. A group first called CIEBAF (*Centre international d'études bio-anthropologiques et d'anthropologie fondamentale*) transformed itself into the *Centre Royaumont pour une science de l'homme* (1972-78). In September 1972, with the backing of Nobel biologist Jacques Monod (1910-1976), Morin and Massimo Piattelli-Palmarini were able to co-sponsor the Royaumont Center colloquium on the Science of Man, which brought together 36 scholars from around the world, to discuss the origins, purpose, and meaning of Man. The two organizers edited and published the resulting papers in three volumes.⁴ When Royaumont disbanded in 1978 Morin founded CETSAP (*Centre d'Etudes transdisciplinaires: sociologie, anthropologie, politique*) at the University of Paris. This center still exists. Interest in the Study of Humankind became Morin's primary interest. However, overarching Media and Man is general systems theory, with its grounding in the natural sciences, especially biology. Consequently, the nature of complexity and complex systems—of which Man is the crowning achievement—have now become the focus of Morin's thought and energy.

How does a person trained in the university officially as a sociologist come to communications theory, transdisciplinary studies, Science of Man, and complex systems? The odyssey is, indeed, fascinating.

Like the mystic Simone Weil (1909-1943) whom he resembles in his honest search for transcendence in human values and in the primacy accorded love over truth, Edgar Morin (b.1921) also was born into a family of non-practicing Jews.⁵ The loss of his mother at the early age of 10 was a first

deep wound, inciting the angry youngster to question and probe the whys of life. Then, of course, the Jewish question of World War II added its own indelible scars. The young university student joined the Lyons underground, wrote letters in German to incite German soldiers to defect, and escaped the dragnets of Klaus Barbie by fleeing to Toulouse and then to Paris, where he continued his underground activities.

Right after the war, before resuming his university studies in literature, Morin went to Germany for one year as the French government's chief of military communications; there he studied at firsthand the psyche of the great German people gone mad, defeated, and headed where?⁶ In the light of the Jewish Holocaust literary studies now became only the warp and woof of his work, not the design. This shifted to philosophy, anthropology, and especially sociology. Furthermore, precarious health, which has brought him several times to the threshold of death, became a third major factor in the shaping of Morin's thought, and he produced a provocative mythic and anthropological study of *L'Homme et la Mort*.⁷

Through war buddies and university contacts, especially of the social historian Georges Friedmann (b.1902), whom he followed briefly in the paths of communism until repulsed by the atrocities of Stalinism, Morin obtained a position in 1950 in the prestigious French CNRS (*Centre national de la recherche scientifique*). Grudgingly he subjected himself to a school system which he execrates as limiting, mutilating, frustrating, petty, but which nonetheless gives one the time and support needed to pursue personal intellectual interests. He retired from fulltime university and CNRS commitments in 1989.

Unconsciously it seems, Morin followed in the footsteps of Auguste Comte (1798-1857). This brilliant mathematician-turned-philosopher saw exploding around him a host of new sciences: physics, chemistry, astronomy, biology, human sciences. Even before LeVerrier in 1846, sitting at his table in his room, made his landmark discovery of the planet Neptune by sheer mathematical calculation, Comte wanted to integrate all knowledge into one "grand unified system." He chose as core for the study of Man as Man the new science of biology, then he coined the word sociology and proposed that discipline as the core for the study of Man in Society. Comte's propositions can be considered the first modern, "scientific" attempt at unifying all knowledge. There appears to be no direct influence at all of Comte on Morin. One concludes that intellectual affinity led Morin to sociology and general systems theory, namely the fit of Part and Whole whereby, through the play of constraints and emergences, the Whole becomes more than the sum of its Parts. Like Comte, Morin sees exploding around him a host of new sciences:

cybernetics, informatics, mass media, ecodynamics, as well as astounding developments in physics, chemistry, astronomy, biology, and mathematics. Like Comte, he is searching for an integrative core, to order and make sense of the mass of new material daily dumped on the human market and all purporting to be true, nay, the Truth.

Edgar Morin continued sociological studies, producing especially a detailed micro-study of fifty years of a village in Brittany, fictitiously called Plodemet.⁸ This study not only presented standard sociological data, but included as well Morin's media notions of the mythic quality of their lives, their "social imaginary:" the myths people invent, must invent, to cope with such difficult problems as unemployment, bereavement, sickness, death. Myths become more true than so-called "objective" truth, which typical sociological studies purport to present, based on "hard" data. This new sociological methodology he later detailed in his basic text on sociology.⁹ Slowly Morin was profoundly impacting the thinking of younger researchers, turning them towards a realization of inner as well as outer reality. Pierre Teilhard de Chardin's belief is also Morin's: "Co-extensive with the Outside of things there is an Inside of things."¹⁰ Thus also, Morin was naturally invited to preface the French translation of David Reisman's *The Lonely Crowd* (1950). Observing politico-sociological events led him as well to write what remains one of the sharpest views of the political future of France and the world, *Introduction à une politique de l'homme*.¹¹ Morin soon became the "guru"—, if we may use that term without derogatory inference—called upon to interpret explosive youth movements. He collaborated with the social philosophers Claude Lefort and Cornelius Castoriadis on an essay analyzing the student and worker revolutions of 1968.¹² France's prestigious daily, *Le Monde*, asked Morin to comment on this event (May 17-21, 1968) with a follow-up ten years later (May 31, June 1-2, 1978).

Slowly taking shape in Morin's mind during the Sixties was the plan of an "en-cyclo-peding" of knowledge, viz., a looping integration of the various branches of knowledge, especially of the two vast domains of the natural sciences and the social sciences. He published his first thoughts on this in an essay called *Le Paradigme perdu: la nature humaine*.¹³ The essay is not fully satisfactory—he later termed it a "premature shoot."¹⁴ Actually, like Montaigne, he does not intend any essay to be definitive; every article and book is the state of his thinking at that moment in time. Though appearing forceful in his statements and, in his salad days, not quite mellow in manner or timid in judgment, Morin admits totally and repeatedly the "subjective" nature of knowledge, of his own knowledge as well as that of others. He also readily and repeatedly admits his intellectual debts,¹⁵ and these are many. What is

original in Morin is not the individual ideas, but his ingenious vision of the organicity of these apparently discrete ideas in a systems view of Man in Society; this entails, of course, a critique of existing philosophies of Man and Society.

Let us sketch here the broad outlines of what will surely be his most lasting contribution to contemporary thought, his *magnum opus*, *La Méthode*, skimpily introduced in *Le Paradigme perdu* and fleshed out in three volumes to date, with two to follow.¹⁶

Le Paradigme perdu: la nature humaine (1973)

Morin has noted that the starting point of his proposed synthesis of a Science of Man is the work of Wiener, Shannon, and Weaver.[PP25] In 1948 the mathematician Norbert Wiener (1894-1964) published his *Cybernetics* (he coined the word from the Greek for "steersman"), a study of "control and communication in the animal and the machine."¹⁷ Basically Wiener was studying the interrelation between man as living machine and the artificial machines created by man. Also in 1948 another mathematician called Claude Shannon (b.1916), working for Bell Labs, published internally a paper entitled *The Mathematical Theory of Communication*, in which he introduced the now commonplace terms, "information," "redundancy," "message." The following year, with the collaboration of Warren Weaver (1894-1978), mathematical physicist of the Rockefeller Foundation, he wrote a second paper, and the two published them in a book with the same title.¹⁸ These two articles proved to be seminal and have since become classics in the field. Morin sees that the theories of Wiener, Shannon, and Weaver are "applicable to artificial machines, to biological organisms, and to psychological and sociological phenomena." (PP25) This threefold looping systems view—Matter, Man, Society—remains the most fundamental constant of Morin's thought, his basic paradigm for studying humankind. His basic analogue—viz., his central optic for viewing life,—we will see, is genesis: the necessary simultaneity of order and disorder, or, as he says, "chaosmos." Order and disorder are the two polarities of life. Whence a first principle: life is a system of permanent reorganization and reordering generated by "noise" or feedback; this principle, first seen by Norbert Wiener, was amplified by Heinz von Foerster, electrical physicist at the University of Illinois at Urbana. The permanent reorganization and reordering result in ever more complex systems; this second principle Morin takes from the mathematical genius John von Neumann (1903-1957). Such negentropic activity is typical of all living systems. Now, feedback comes from the environment; hence the study of ecology. Morin affirms: "Autonomy

supposes complexity, which supposes a very great richness of relations of all kinds with the environment." [PP32] However, systems not only support; they also compete. Those systems only survive and thrive which integrate the maximum amount of "noise" to reorganize in an ever more complex unity.

In imitation of Jean-Jacques Rousseau (1712-1778), whose *Discourse on the Origins of Inequality among Men* (1755) he quotes at the head of this book, Morin outlines in broad strokes an anthropological development of human society. He submits ideas on fire, adolescence, femininity/creativity/affectivity; he accepts the hypothesis that fire and cooking reduced the need for strong jaws, thus creating more cranial space. [PP93] Juvenilization is also inseparable from cerebralization; juvenilization slows down the "mauring" into adulthood, thus enabling the brain to take shape more slowly, and retain its ability to react to outside stimuli. [PP94] The newborn chimpanzee already has 70% of its cranial capacity, whereas the newborn human has only 23%. [PP95]

Another Frenchman, the paleontologist Pierre Teilhard de Chardin (1881-1955), had offered the world his view of human evolution in a work officially published posthumously in 1955. But a reading of Teilhard's *The Phenomenon of Man* left Morin skeptical. As an atheist, he rejects the Jesuit's Paulinian ultimate integration of everything and everybody in Christ (in "the Christic"), and Christ in God, "so that God may be everything in everybody" (1Cor 15:28).¹⁹ In Morin's logic of life "what is crucial is the uncertainty and ambiguity of the relationship between the brain and the environment. This uncertainty comes first of all from the regression of genetic programs in human behavior and from the progression of heuristic, strategic aptitudes (competencies) to resolve problems of knowledge and decision." [PP118] Let us note as of now the linking of knowledge and decision/action, the intellectual and the ethical. The two are inseparable in Morin.

One of Morin's directive ideas is that "the creativity, originality and eminence of *homo sapiens* have the same source as the irregularity, straying, and disorder of *homo demens*" [PP127], what we have termed his "genesis analogue." "True man is in the dialectic of *sapiens-demens*," [PP218f] "chaosmos," the simultaneity of order and disorder/"noise"/feedback. People ignorant of general systems theory tend naturally to believe that the larger and the more complex the system the stronger the constraints needed to operate smoothly. In point of fact, the very opposite is true! "Innovation supposes or provokes at the heart of a living system a certain disorganization, or slacking of constraints, tied to the action of a reorganizing principle. Proper to hypercomplexity is precisely the diminution of constraints in a system which finds itself in fact in a certain state of permanent disorder." [PP135]²⁰ This

systems view is a first paradigm for ordering life.

A second basic paradigm, uniduality, which will be proposed and developed subsequently, is already broached here. "The genius of *sapiens* is in the intercommunication between the imaginary and the real, the logical and the affective, the speculative and the existential, the unconscious and the conscious, the subject and the object..." [PP144] The interplay of these elements is always "complementary, concurrent, and antagonistic." [PP144n1] These three attributes of systems, Morin will repeat them over and over again. In the end we have "one single bio-psycho-socio-cultural system." [PP146]

The flower of hypercomplexity is *conscience*. [PP148] The French word *conscience* enfolds two English meanings: conscience in its ethical sense, and consciousness or awareness. Almost always, I have translated *conscience* only as consciousness, but there is no doubt that Morin habitually implies as well an ethical dimension, since he firmly holds that all becoming is in the relation with and not in the destruction of the other.²¹ Consciousness progresses only in and through hypercomplexity. [PP153]²² Impinging on sociobiology, Morin gives his own explanation for human violence. He holds that "dementiae constitute grave and profound checks to hypercomplexity, and it is in this framework that we must situate the problem of destructive violence and delirious aggressivity, rather than in that of animal aggression." [PP161]

With the family and mythology, culture also starts to take form in arke-society, and Morin goes so far as to state that it even "constitutes a cultural quasi-code, namely a sort of sociological equivalent of the genetic code for living beings." [PP185]²³ This belief powerfully impacts thinking.

Morin sees humankind situated in four ever-widening systems: "We have been able to constitute the properly anthropological field in the interactions, interferences, and phenomenal activity (praxis) among four systemic poles, complementary, concurrent, antagonistic: the genetic system (genetic code, genotype), the brain (phenotypical epicenter), the socio-cultural system (itself conceived as a phenomenal-generative system), and the ecosystem (in its local character of ecological niche and in its global character of environment)."[PP212] Morin holds that the links between the four systems are quite physical and are looped; all return to each other. Looping, or rotative recursivity, is integral to his vision of Humans in Society, whence the ubiquitous looping graphics in his writings. In fact, rotative recursivity is one of his most significant contributions to modern thought.

Also central to life is praxis, namely intentioned action. Action supposes energy. What is energy? Basically, what enables us to get things done. So, there is physical energy: food, coal, steam, electricity, the sun, the atom. But there is also non-material energy. Deeply indebted to the French-born

Columbia University and IBM physicist Léon N. Brillouin (1889-1969), Morin states, "Science in the past and for over a century used only the concept of energy, and had not recognized, under the name of information, what can control and organize energy." [PP224] Information is non-material energy enabling us to do.²⁴

His Study of Humankind, Edgar Morin tells us, will end in noology, "science not yet born." [PP227] We know that it is Teilhard who popularized the terms "noogenesis" and "noosphere."²⁵ Some scientists like nuclear physicist Pierre Auger and molecular biochemist Jacques Monod suggested considering ideas as 'existents' of a new type. [PP226]

Though Morin, in 1973, does not indicate any awareness of the revolution in the hermeneutic work of Hans Georg Gadamer (b.1900),²⁶ he is in full agreement with the German philosopher: "We are discovering more and more that the key problem of science is, at one degree higher, that of all knowledge: the relationship of observing subject to observed object." [PP228]

Increasing complexity does not lead Morin to despair or immobility. "The full consciousness of the uncertain, the fortuitous, the tragic in all things human is far from having led me to despair. On the contrary, it is tonic to swap mental security for risk, since we gain opportunity thus.... It is tonic to tear oneself away forever from the master word which explains everything, from the litany which pretends to resolve everything. It is tonic finally to consider the world, life, man, knowledge, action as *open systems*." [PP233]

La Méthode, v.1: La Nature de la nature (1977)

Edgar Morin started publishing his Study of Humankind in 1977 with Volume 1 of what he called *Method*. This word is, of course, a very charged term. Morin himself later paradoxically speaks of "non-method" [NN15] and "anti-method." [NN16] His thinking is precisely Bernard Lonergan's. This philosopher-theologian defines method as "a normative pattern of recurrent and related operations yielding cumulative and progressive results."²⁷ Discovery and synthesis ensue, but "neither discovery nor synthesis is at the beck and call of any set of rules."²⁸ And the operations are both logical and non-logical. "The logical tend to consolidate what has been achieved. The non-logical keep all achievement open to further advance."²⁹ Consequently, Morin is not giving us a method; he himself is starting out in search of a method. [NN21]

There was more than a hint of Descartes' *Discours sur la Méthode* (1637) in the title. However, Morin intends something quite different from the paradigm which ruled the Western world from 1637 to, say, Einstein's theory

of relativity in 1905 or Kurt Gödel's shattering of certainty in 1931 with his principle of incompleteness.

He called his first volume *The Nature of Nature*.³⁰

General Introduction (7-24)

Morin takes his cue from Lao Tsu (7th-6th century B.C.), fabled founder of Taoism and author of the *I Ching*, and he subtitles the General Introduction, *The Spirit of the Valley*.

Before we can tackle Morin's thought, we must accept his rules. He calls for nothing less than a major shift in paradigm because it is the very way we think we know that prevents us from knowing. The first rule is to discard the Cartesian dichotomy of object and subject; this is no longer tenable: "In all science, even the most physical, there is an anthropo-social dimension." [NN11] Secondly, all knowledge is determined by the inescapable looping of the physical, the biological, and the anthropo-sociological. [NN11,17] A third rule is that "uncertainty is the only point of departure." [NN15] Fourthly, we must not give in to simplifications like idealizing or rationalizing or standardizing. There can be no linearity, only the spiral. [NN21f] Though there is no forthright mention at this point of two of the most prominent philosophical theorists of knowledge in our time, Michel Foucault (1926-1984) or Hans Georg Gadamer (b.1900), Morin clearly, in his categorical rejection of a dichotomy between object and subject, stands against Foucauldian "archeology" and for Gadamerian hermeneutics.

The Nature of Nature is divided into three major parts. In the first, Order, Disorder, and Organization, Morin studies the laws of order and disorder and, from these "laws of nature" he draws conclusions on "the nature of laws." His view of organization leads him to systems theory, as he goes "from the object to the system." The second part deals with "Organization," a neologism by which Morin suggests "active organization." This section deals heavily with machine-beings, production-of-self, cybernetics, and communicational organization. Morin concludes that all Matter, Men, and Societies are looped inescapably in one system. The third part, Regenerated and Regenerative Organization, deals with negentropy and information theory. Morin determines that the observer is more important than the observed precisely because he is habitually unobserved. Let us go over this ground somewhat more precisely.

Order, Disorder, Organization (31-151)

Until our day people thought of order and disorder as antitheses, irreconcilables. However, recently scientists have spoken of creative disorder. In the 50's John von Neumann discovers that living automata function with disorder. Heinz von Foerster in 1960 proposes the principle, "order from noise;" Morin prefers "organization from disorder." [NN52] In 1968 the new thermodynamics of Nobel chemist Ilya Prigogine (b.1917) shows that organized phenomena can be spontaneously generated from thermodynamic disequilibrium; this had been first instanced in the nineteenth century by Bénard's convection cell. [NN49] The Israeli biologist Henri Atlan especially, in 1970 and 1972, highlights chance as organizer. [NN42] Finally, mathematician René Thom (b.1923) proposes in 1972 a new vision of catastrophe, and shows that disintegration and genesis are linked in one process. [NN44] These discoveries in math and science induce Morin to conclude that we must henceforth think of order, disorder, and organizing potential as inseparable. [NN45] Genesis becomes Morin's fundamental analogue.

These developments in math and science compel Morin to go back to the physical origins of our planet, and he suggests that cosmogenesis is also the key question of the genesis of a method. [NN45] In this perspective, it is essential to accept and to remember that "all morphogenesis is tied to schismogenesis, is necessarily based on catastrophe theory." [NN47] "To have organization there must be interaction; to have interaction, there must be encounters; to have encounters there must be disorder (agitation, turbulence)." [NN51] There is no escaping the tetralogical loop: interactions-disorder-order-organization. Though the key idea is organization, the four terms must be conceived together: they are "simultaneously complementary, concurrent, and antagonistic." [NN56] Classical physics, he asserts, based itself on classical Greek thought, but classical Greek thought forgot Heraclitus and opposed *hubris* (excess) and *dike* (balance). [NN57] Morin maintains, "There is a genesic/generic relation between *Chaos* and *Cosmos*, *Hubris* and *Dike*, *Elohim* (genesis) and *JHVH* (Law)." [NN61] The Aristotelian, Thomistic, Cartesian, Newtonian world is finished. "Everything physical needs disorder to organize itself." [NN80] Later, we will add that everything, physical and other, needs disorder to organize itself. "Everything does not come back to disorder, but everything is immersed in disorder." [NN83]

These proposals may have sounded revolutionary in 1973 and 1977. Today, and especially since the publication of James Gleick's best-seller in 1987, *Chaos: Making a New Science*,³¹ we realize how prescient Morin was.

Gleich refers to many ideas already noted ten and fifteen years earlier in Morin's work: orderly disorder (p.15,266), tightly compartmentalized scientific community (p.31), chaos as method (p.38), knowledge breeding ignorance (p.53), the rare scholar as nomad-by-choice (p.90), disorder mixed with order (p.147), order in chaos (p.157), especially the key notions of the endless feedback loop (p.166), recursion (p.177,195), and organization in life or intelligence (p.251). All of these and more are the very armature of Morin's *Method*.

Morin, of course, does not intend to leave us in disorder; the dialogue of order and disorder results in organization, is the path to, the tool for organization. By no means is Morin originating systems thinking. Leibnitz (1646-1716) back in the seventeenth century thought systems, and Morin quotes Pascal (1623-1662): "I hold that it is impossible to know the parts without knowing the whole, and likewise impossible to know the whole without knowing the parts individually." [NN125; LeGuern 185, Braunschwig 72]³² And in our day the biologist Ludwig von Bertalanffy is known as the father of systems thinking because of his pathbreaking formulation in 1956, *General System Theory*.³³ All serious researchers now accept the fact of systems, and Bertalanffy's thought has not ceased to be defined and refined. The best definition of system, Morin believes, is that of the Swiss linguist Ferdinand de Saussure (1857-1913): a system is "an organized totality composed of solidary elements which can be defined only by their relation to each other in function of their place in the totality." [quoted in NN102]

Parts in a whole follow a fourfold development: they go from interaction to interrelation to organization to system. [NN103] In a system there are both emergences and constraints. It is emergences which make the whole more than the sum of its parts, and even make each part more than just a part. [NN108] The notion of emergence is essential to Morin's concept of evolution, and it will reappear regularly. It is synonymous with Teilhard's "additivity,"³⁴ but this latter term is weaker linguistically. The popular contemporary word "synergy" connotes the same as emergence or additivity.

Morin underscores two essential ideas in systems thinking: "One of the most fundamental traits of organization is the ability to transform diversity into unity without annulling the diversity...and also to create diversity in and by unity." [NN 116] He quotes Stéphane Lupasco: "For a system to be formed and to exist, the component parts of all wholes, by their nature or by the laws which govern them, must be susceptible of both joining together and excluding each other, both attracting and repulsing, associating and dissociating, integrating and disintegrating." [NN118n1] Such paradox is precisely what defines the complex unity of a system: "There is no organization without

anti-organization;... anti-organization is simultaneously necessary and antagonistic to organization." [NN121] It is on this point that Morin feels Bertalanffy did not go far enough; the biologist chose holism over reductionism, but did not pursue the paradoxical nature of complex unity; one must go even beyond holism and reach the relational circuit. [NN123f] "Disorder is not driven out by organization: it is transformed, remains virtualized, can be actualized." [NN132] Should we not say that disorder must be actualized?

Organization: active organization (153-287)

Having established key notions concerning the looping of order, disorder, and organization, Edgar Morin now treats of machine-beings, the production-of-self, cybernetics, complex causality, and the epistemological loop physics-biology-anthropo-sociology.

Norbert Wiener, the father of automation, conceived the machine not as a social product or a material instrument but as an organizing physical being. [NN156f] Morin distinguishes various types of machines. The sun is the arkhe-machine, evidently, of our galaxy, around which everything was organized and continues to be organized. Then, there are living polymachines; "living beings are auto-poietic existents." [NN165] We cannot reduce life to the idea of machine as did Descartes (1596-1650) and the materialist physician and philosopher LaMettrie (1709-1751); nonetheless, life does include the idea of machine "in its strongest and richest meaning: organization simultaneously productive, reproductive, self-reproductive." [NN165] Finally, there is the social megamachine, concept highlighted especially by Lewis Mumford (1895-1990). [NN166f]

Besides these living machines, there are artificial machines: windmills, watermills, clocks, and most especially the cybernetic machine in which "an external command becomes internal (program) and organizing (computer), and the cybernetic automaton starts resembling life, no longer by appearance, like the clockwork automaton, but by the organization of behavior." [NN169] We have gone, therefore, "from Sun to Earth to living polymachines to anthropo-social megamachines to artificial machines (cybernetes, automatons, clocks, motors)." [NN175: schema]

Organization exists to produce, self-produce, and reproduce. This is achieved through recursive organization and permanent reorganization. Recursion is the process whose final states or effects produce initial states or causes. Permanent reorganization is necessitated and triggered by "noise." "The retroactive loop brings about the passing from the thermodynamics of

disorder to the dynamics of organization.” [NN185] “Thus, therefore, in order to conceive all active organization, every natural machine, we must couple centrally the ideas of equilibrium and disequilibrium, stability and instability, dynamism and constancy; but this coupling must be conceived as looping, namely recursive relation between the terms forming the circuit, in which what is generated generates in turn what generates it.” [NN190]

This understanding of open system is crucial. No existence is possible without opening. But Morin again takes slight issue with Bertalanffy, this time on the notion of open system: Bertalanffy did not sufficiently underscore the notion of closure. Morin holds that “existence is both immersion in an environment and relative detachment from that environment.” [NN206] “The discoverers of open systems, especially, had not conceived that the full intelligibility of openness required a paradigm of complexity.” [NN208] As we will note further on, it is application or action which requires closure.

Coming from this position, Morin has a provocative analysis of the Judaeo-Christian theogonic evolution. “The archaic idea of God-Creator *Elohim* is not at all expressed in the idea of *Adonai*, the Lord-God, nor in that of *JHVH*, God-Legislator.... *Elohim*—the thermodynamic Whirlwind—(without ceasing to remain, subterraneously, *Elohim*) gives way to the God-Ordainer of the Law *YHVH*. *JHVH* is not a solar god, he is a cybernetic god. *JHVH* inscribes the Law, that is to say institutes an informational apparatus to command-control the anthropo-social machine. He becomes the God-Programmer.” [NN228] Partisans of liberation theology agree wholeheartedly. Praxis is never neat and orderly. “We must conceive the Heraclitean fire reanimated by Carnot (1796-1832), the Elohistc whirlwind seen again by Prigogine (b.1917), the prebiotic tremblings à la Oparine sauce as genestic modalities of existence and organization.” [NN229] There is not the orderliness of being on the one hand and the disorderliness of existence on the other hand. One cannot separate out the neatness of being from the messiness of existence.

The need for complexity is a constant of Morin’s thinking. “Our dominant metaphysics recognized in man only an existential quality, and questioned being in essences, substances, and the idea of God. Physics, not only classical but also modern, and not only physics but also systems theory and cybernetics, reject existential being as waste and residue from the filtering they do on reality. And this filtering, which is evidently clarification, that is to say decomposition of complexity, retains from the real only the rationalizable, idealizable part; being and existence are emptied out. As for the self, it is totally unknown and misknown.” [NN234]

The rights and rules of chaos must figure in all domains of thought.

Physics cannot be denied. The tragedy of our day is that huge systems, such as religious systems, cannot, will not, accept the findings of science. Yet, over a hundred years ago, John Henry Newman, in *The Idea of a University*, justifiably defending the rights of theology as a valid discipline to be contended with, nonetheless agreed that theology is only one discipline among other valid ones: "...these branches [of knowledge] are not isolated and independent one of another, but form together a whole or system; ...they run into each other, and complete each other, and...in proportion to our view of them as a whole is the exactness and trustworthiness of the knowledge which they separately convey..."³⁵

The climax of this five-part section on active organization is a study of the most complex machines ever devised by humans, viz. computers. Morin gives us here one of the most succinct and brilliant critiques of cybernetics to date.

Morin singles out two originalities of cybernetics: first, "to have conceived of communication in organizational terms;" secondly, "to have linked communication and informational command." [NN236] Wiener subordinated communication to command. In fact, Morin observes, "Cybernetics became, not the science of communicational organization, but the science of command by communication." [NN238] Roles have been perversely inverted. "Thus the principle of Spirit commanding Matter, Man commanding Nature, Law commanding the Citizen, the State commanding the Society, became the principle of Information reigning over Organization." [NN238] This distinction, this shift is of monumental importance. "Just as in the mythology of social power, it is always God Who speaks through the mouth of the Monarch, the General Interest which inspires the Sovereign, Historical Truth which guides the Party, so Information became the sovereign, universal, truthful entity, whose authenticity is guaranteed by the computer, its faithful servant. Cybernetic theory masks the problem of the power hidden under the command." [NN238] Cybernetics especially, more than technology in general or capitalist commodity-structure, leads to what Lukacs has called the reification of man: "...a relation between people takes on the character of a thing and thus acquires a 'phantom objectivity,' an autonomy that seems so strictly rational and all-embracing as to conceal every trace of its fundamental nature: the relation between people."'³⁶

Another major danger in cybernetics is the inadaptability of the artificial machine. We have seen that the human brain functions and must function with and by means of "noise." "The more the brain develops, in mammals, primates, hominians, the more it becomes polycentric; the more the relations between parts are both complementary and antagonistic, the more the brain functions with 'noise,' that is to say, disorder," unlike all artificial computers.

[NN242] Therefore, computers cannot, must not, command life, since they are incapable of factoring in "noise" which is the very trigger of life.

Morin does not deny the value of computers. He indicates [NN249f] many cybernetic virtues: retroaction, loop, regulation, finality; command, communication, organization, transdisciplines. These are all needed for the development of life, for continued hominization. Unfortunately, these virtues are accompanied by serious evils: one master formula to solve all problems, simplification, reduction, manipulation; "a theory apparently purely physical, in fact purely ideological;" information which is purely and simply program; communication which is simply transmission; no possibility of disorder; especially, lack of a principle of complexity. [NN251] Cybernetic formalism "is incapable of conceiving being and existence. It lacks the existential, ecological, and organizational sense of the idea of opening, the ontological sense of closing (the self). There is neither essence (which is an advantage) nor existence (which is a deficiency) in the cybernetic grasp of the living being; this becomes very serious as soon as cyberneticism pretends to interpret and treat life, man, society.... Whence consequences both debilitating in theory and eventually terrifying in practice." [NN251f] "Manipulation calls itself Information." [NN252] Later, quoting Heinz von Foerster, Morin calls Information "the most vicious of conceptual chameleons." [NN290]

What is the solution? Morin proposes several. Reverse the sovereignty of command to the benefit of communication. And he coins another word, sy-cybernetics, or simply sybernetics [NN254], that is to say, harmony by command. Information is not communication. The real goal of life is not information, it is communication, communion; it is, in fact, love: "The ultimate developments of communication form the River Love." [NN256] Here Morin joins Weil in her prophetic critique of Judeo-Christianity.³⁷ Pascal also stressed the superiority of the heart over the intellect: "The heart has its reasons which reason does not know" [LeGuern 397a; Brunschvicq 277], and this is what led him to disagree so categorically with Descartes: "Descartes useless and uncertain" [LeGuern 702; Brunschvicq 78].

What is needed, Morin affirms, is endo-causality: causality generated from the inside. Consider the physical instance of body heat; reaction annuls the result, not the cause. [NN258] Morin here is clearly anti-behaviorist. Humans must remain in charge, certainly of effects, when not of causes. And it is this taking charge of one's own life that develops the self: "Endo-causality implies production-of-self." [NN259] In all dealings with computers, therefore, there are essential questions to be asked: "Whence the program? Whence the information? Whence the finality?" [NN261]

On this matter Morin uses the term individualization. "The more there is

individualization, the more there is coincidence and harmony of *vivre* and *survivre*." [NN264] I prefer the Teilhardian term, personalization.³⁸ In point of fact, however, Teilhard's intent is also Morin's, since Morin ends his discussion of active organization with the concept, not simply of endo-causality, but of endo-eco-causality, [NN268] and this is precisely what Teilhard maintains when he distinguishes personality from individuality: relation with the non-Self as necessary means to the development of the Self.

Consequently, Morin's search for a method to understand/lead life takes him to a first epistemological loop: physics-biology-anthropo-sociology, [NN272] that is, Matter, Man, Society. The new physics (read Matter/Object) "will always show its umbilical cord which links it to the conceiver-subject." [NN280] "For the first time in the history of the Modern West, the two universes of Spirit and Matter, Subject and Object, communicate." [NN283] An obviously exasperated Morin concludes this second part by exclaiming that, though rethinking our entire concept of knowledge is frightening, it is not so frightening as "the barbaric emptiness of scientific knowledge, which believes it is the most advanced knowledge." [NN287] The reader perceives the on-going battle between the so-called "hard" natural sciences and the so-called "soft" social sciences. Morin's enterprise is to "en-cycle" the "two cultures."

Regenerated and Generative Organization (289-364)

Information generates organization which generates negentropy which necessitates information. Whence the clear necessity of understanding the origins and nature of information. Hence, the third part of the present volume treats entirely of the physics of information.

Claude Shannon discovers in 1948 that all information is measurable; he and Warren Weaver make this the cornerstone of their communications theory. [NN301] They also discover that redundancy, though economically superfluous, becomes essential in fighting "noise," ambiguity, error. But Shannonian information theory deals only with the physical system delivering the message; it takes no account of the anthropo-social system which information supposes and which gives data its meaning. [NN304]

We must move from bits and bytes of information to organization. Paradoxically, information, real information, "is born from non-information. It is born of a negentropic informational process, which develops from event-full [Fr. *événementielles*]³⁹ chance interactions; information is born at the same time as a generative/regenerative complex is constituted." [NN323] Information is in the relation, and not in the bit. And that relation is in Matter, Man,

and Society. The observer-conceiver is always present, and his knowledge is ever changing. Everything, everybody is continuously re-shaped: "The key character inherent to all production-of-self: the dynamics of re-commencement." [NN326] Re-commencement is not a vicious circle, turning on itself, nor is it a Teilhardian vector "upwards and forwards." "The re-commencement is a spiral movement, distancing itself from its source each time it returns to it." [NN328]

Morin goes back to the notion of redundancy to overcome or compensate for "noise." "Thus the classical problems of transmission in noise, namely the non-arrival (ignorance) and the mis-arrival (error) of traveling information are vital problems." [NN335] Ignorance and error are entropic. "Only information accurately received or error accurately perceived can be transformed into negentropy." [NN336] "Information is what allows negentropy to regenerate organization which allows information to regenerate negentropy." [NN343]

The problem of information overkill can be as serious as the problems of ignorance and error. "One wonders if, beyond a certain threshold, the fabulous multiplication of information doesn't trigger an increase of internal entropy which outstrips informational negentropy." [NN339] This is why Morin agrees fully with the physicist Olivier Costa de Beauregard that information is in all instances only potential negentropy. Information not read, or misread, or misweighted, or misused, is worse than no information. Consequently, the pivotal factor in information is always the subject, never a mere print-out or spread-sheet. And with this subject there is, "always and forever, the crucial problem of the apparatus (sexual, neuro-cerebral, social)." [NN345f] "This tells us that in fact real situations of communication do not depend only on the common code and repertory which is language; they also depend on another type of code, linked to ideology, which depends on a paradigmatology always implicit, always hidden, always present and always dominant." [NN348] Let us substitute the word mindset for ideology. Mindset predetermines conclusions, with or without so-called hard facts. "Every message is in fact multi-connoted and multi-decryptable." [NN348] It is far from being a quip that there are as many truths as there are people. This is the fundamental message of such masterpieces as Robert Browning's poem, *The Ring and the Book*, and Akira Kurosawa's Grand Prize film, *Rashomon*.⁴⁰ The eminent Princeton physicist John Wheeler has even publicly agreed with the statement of Thomas Mann that the observer not only observes his observation, he is "actually bringing about what is happening."⁴¹ This is why statements reveal more about the speaker than about the situation. "While the observer measures reality reality gives the measure of the mind of the observer." [NN352] "Reality takes body, shape, and meaning only in the form of messages which

an observer/conceiver interprets. We have only translations of reality, never the o.v." [NN 356] Gadamer puts it succinctly: "Understanding is always an interpretation."⁴²

Despite such uncertainty, one must not be afraid of mistakes, incompleteness, or flak. "Everything which is living organization functions in spite of, against, and thanks to noise." [NN351] "Ambiguity and misunderstanding in communication are one of the primary sources of progress and inventions." [NN349] Clarification and correction come through redundancy. "Knowledge is transformed into ignorance in the very same movement as ignorance is transformed into knowledge." [NN353] As Paul Claudel (1868-1955) wrote in his *Five Great Odes*, "I read an answer, I read a question in your eyes! An answer and a question in your eyes!"⁴³ Paradoxically, then, "the progress of knowledge is at the same time the progress of ignorance." [NN354] Physics, biology, chemistry, and the other natural sciences are today proof irrefutable.

This is why it is not possible to carry the pursuit of knowledge to an absolute. Truth kills, Love gives life. "Knowledge carried to the absolute is self-destructive." [NN356] Besides, absolutes are untenable in an informational world in which not only the known object—our data base—is, must be daily modified, but in which the knowing subject—our personal self—is also daily modified. "Every observation on the world, accompanied by thought and reflexion, corresponds to modifications in cerebral micro-states and, correlatively, to rearrangements and redealings in our systems of ideas which, as informational beings, are also physical beings." [NN357]

Paradoxically, the resulting condition is a good, not an evil. "With the loss of the absolute we have a gain in communication and in complexity. For what Brillouin has established as new and positive is the communication circuit between the physical and the psychic, the possibility of translation/transformation of the physical/psychic/informational to the physical/thermodynamic/organizational." [NN357f] "We have therefore a rotative complex with double entry: the physico-thermodynamic entry of the phenomenon and the psycho-informational entry of the observer/conceiver." [NN359] Actually, this double entry is itself compounded: "Information is a concept with multiple entries: physical (entropy, negentropy, organization), biological (communicational geno-pheno-eco-organization), anthropo-sociological (cerebral apparatus of *homo sapiens*, culture, ideas, language, society). Its foundation is physical, its arkhe is biological, its flowering and diversification are anthropo-sociological." [NN362] And so, once again, Morin summarizes his position around the three recursive notions of Matter, Man, and Society.

[VV19] The rain forest problem: plants feed off carbon dioxide to generate oxygen which animals need to produce carbon dioxide which plants need to generate oxygen, and on it goes. There is "an uninterrupted rotative circuit of antagonism and complementarity.... Eco-organization is built and maintained, not only in and through association and cooperation, but also in and through struggle, devouring, and predation." [VV25] The genesis analogue.

Every system integrates and organizes diversity into unity. [VV40] Dominant species favor, "not a maximum of diversity, but an optimum of diversity." [VV41] Complexity must be clearly understood and carefully respected. "Complexity is not the rejection of the less complex by the more complex; it is on the contrary the integration of the less complex in the diversity." [VV43]

Who or what controls this organization of diversity into unity? There is no programming/controlling/regulating Centre. [VV44] In fact, paradoxically, "an acentric system can be more powerful logically, computationally, heuristically (problem solving) than a system having a center of control/command." [VV45] "How then can the *pour-soi* (for-self) be transformed into the *pour-tous* (for-all), while remaining frenetically *pour-soi*? We can begin to understand that from the moment one living being becomes an existential exigency for another; this exigency immediately creates, in fact, a solidarity and a complementarity of the one in relation to the other." [VV46]

"Adaptation is the first and general condition of all existence." [VV47] Adaptation is "*integration of an (auto-)organization in an (eco-)organization*." [VV50] Here, Morin differs with Darwin. "Darwinian selection was centered on struggle...; it did not know the integrative and organizational idea of eco-system." [VV51] Today management, business, politics must move out of their Darwinian mode. "The more an eco-system is complex, the more it is rich in diversity, the more it is supple, the more it contains the hazy, the uncertain, the haphazard, the more it allows neutral or useless traits to subsist." [VV52]

In a complex relation, "particular interest works for the general interest *while at the same time continuing to work against the general interest*, but by that very fact maintains antagonism and complexity which, in a sense, are also part of the general interest." [VV59n] Morin writes: "I wanted to illustrate the idea which to me seems essential: the more complex beings are, the more they tolerate, use, need, for their behavior and their development, happenings not only haphazard, but disturbing and aggressive. These play the part of 'challenge' which either brings defeat or triggers achievement or growth." [VV64] Again, the genesis analogue.

Morin pleads for an "ecological" look on all of life, not just on nature.

"Hegel clearly saw that there exists a principle of negativity which transforms every thing and every being and every act into its opposite, but he had put this principle *inside* the self-development of the mind, whereas it must be ecologized, that is to say...go beyond dialectics to dialogics." [VV82] Dialectics promote the intellectual and Truth, dialogics promote the ethical and Love. Dialogics is one of Morin's fundamental stances. Loving dialogics will not replace contentious dialectics with ease. We each have our personal understanding of "the facts." Pascal centuries before wrote so perspicaciously, "It is not in Montaigne but in me that I find everything I see there." [LeGuern 583, Brunschvicq 627] "There cannot be either description or explanation of phenomena outside the double inscription and the double implication at the heart of a complex dialogics which associates complementarily, concurrently, and antagonistically, on the one hand, the autonomous and internal logics proper to the phenomenon, and on the other hand, the eco-logics of its environments." [VV87] Net result: the impossibility of Truth, the necessity of Love.

Fundamental Autonomy: Autos (99-300)

This section numbers two hundred pages, almost half the entire book, which is to say the importance Morin attaches to it. It is, in fact, the core of his Study of Humankind.

The *oikos* and the *autos* are and must be linked. The *oikos* is the encompassing milieu or environment: physical, biological, social, and noological. In centripetal order, this *oikos* includes the *autos*, which includes the *phenon* and the *genos*, these latter being at the heart of the physical and biological Self. Morin's notion of this Self leads him to a fundamental distinction with Descartes. The Self is cellular, and every cell computes. Therefore, *Computo, ergo sum* is and must be forerunner to *Cogito, ergo sum*. This preliminary stage, the *computo*, is essential to Morin's view of Man, viz., that Man is physical and biological, in other words, natural and not super-natural. Nonetheless, Morin affirms free will and personal responsibility; Morin's Man is ethical. Free will leads intelligent Humans to devise strategies, and these actions in turn develop knowledge. The knowledge of knowledge is the third and final stage of Morin's *Method*.

A word on *genos* and *phenon*, which constitute the Self.

The *genos* contains informational memory inscribed in the DNA, with instructions for the cellular machinery. This *genos* is both memory and program. Memory, viz. the past, becomes program, viz. the present, via computation. [VV118] Computation is the work of the living cell. [VV121]

[VV19] The rain forest problem: plants feed off carbon dioxide to generate oxygen which animals need to produce carbon dioxide which plants need to generate oxygen, and on it goes. There is "an uninterrupted rotative circuit of antagonism and complementarity.... Eco-organization is built and maintained, not only in and through association and cooperation, but also in and through struggle, devouring, and predation." [VV25] The genesis analogue.

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Fundamental Autonomy: Autos (99-300)

This section numbers two hundred pages, almost half the entire book, which is to say the importance Morin attaches to it. It is, in fact, the core of his Study of Humankind.

The *oikos* and the *autos* are and must be linked. The *oikos* is the encompassing milieu or environment: physical, biological, social, and noological. In centripetal order, this *oikos* includes the *autos*, which includes the *phenon* and the *genos*, these latter being at the heart of the physical and biological Self. Morin's notion of this Self leads him to a fundamental distinction with Descartes. The Self is cellular, and every cell computes. Therefore, *Computo, ergo sum* is and must be forerunner to *Cogito, ergo sum*. This preliminary stage, the *computo*, is essential to Morin's view of Man, viz., that Man is physical and biological, in other words, natural and not super-natural. Nonetheless, Morin affirms free will and personal responsibility; Morin's Man is ethical. Free will leads intelligent Humans to devise strategies, and these actions in turn develop knowledge. The knowledge of knowledge is the third and final stage of Morin's *Method*.

A word on *genos* and *phenon*, which constitute the Self.

The *genos* contains informational memory inscribed in the DNA, with instructions for the cellular machinery. This *genos* is both memory and program. Memory, viz. the past, becomes program, viz. the present, via computation. [VV118] Computation is the work of the living cell. [VV121]

The *genos*, then, is "the organization of the organization." [VV113] Let us say that it is the potential of individual life. The *phenon* indicates "productive activities, interactions with the environment...behavior.... It is the self-ecological relation and organization." [VV113] Its kingdom "is in the present, the actual, the immediate of existence; in it emerge individuality, subjectivity." [VV125] Let us say, then, that it is the actual of individual life. The two terms *genos* and *phenon* are not separate entities; they are merely "conceptual reference points." In reality, they are "inseparable in self-organization." [VV113] It is the union of the *genos* and the *phenon* which produces the Self.

This Self is, immunologically, physical and biological distinction from the non-Self. This concept leads Morin to develop a bold distinction between himself and Descartes. "The Cartesian *cogito* knows only the I or the Me. There is no Self, that is to say no corporality, no *physis*, no biological organization in the *cogito*." [VV190] To remedy this lack Morin launches the *Computo, ergo sum*. "The cellular being is a computing being." [VV159] "The living being computes ceaselessly, and computation, in this sense, is being itself." [VV160] Every cell is not only an "engine" and a "chemical lab," it is also a "decision making system." [VV160f] Thus, we see that "the *computo* operates the fundamental unity of the physical, the biological, and the cognitive." [VV190] In Morin's thinking, however, the Self appears to be primarily an immunological notion, including only the physical and the biological, whereas the Subject appears to include the cognitive as well.

Morin distinguishes consciousness from life. Consciousness appears to be the potential of life, and not the actual of life. "The Cartesian *cogito* generates conscious subjectivity, but not *living* subjectivity." [VV183] Nonetheless, like the *genos* and the *phenon*, consciousness and life, in point of fact, are also inseparable. "The *computo* does not 'think' ideally, that is to say, isolatedly. It 'thinks' (computes) organizationally." [VV183]

The three terms *autos*, individual, and subject occur frequently, and Morin operates very fine distinctions between them. All three include the Self, but each is different from and more than the Self.

Morin dwells at length on the notion of subject, much less on the notion of individual, and at times the two fuse. "The definition of subject which imposes itself on us rests neither on consciousness nor on affectivity, but on ego-auto-centrism and ego-auto-reference, that is to say the logic of organization and of nature proper to the living individual: it is therefore a definition literally bio-logical." [VV163] And elsewhere, "The quality of subject is the biological character of individuality." [VV273] "Every living being, from bacteria to *homo sapiens*, be it ever so ephemeral, particular, or marginal, takes itself as center of reference and preference.... There is therefore

a biological principle of exclusion...by which every subject excludes every other subject from its site of subject." [VV164] Morin calls this the "ipseity of a living being." [VV165]⁴⁸

At this point Morin pursues one of his recurrent themes: the inescapability of subjectivity in the pursuit of objectivity, what we called earlier his Gadamerian option over the Foucauldian 'archeological' one. "The masking of our subjectivity is the height of subjectivity. Inversely, the search for objectivity includes, not the annulling, but the full use of subjectivity." [VV298] Paradoxically, "Only a subject fully conscious of being a subject can struggle against subjectivity." [VV299] Foreseeing the third and final part of his method, Morin states: "The subject and the object are co-born (Fr. *co-naissent*) and give birth to knowledge (Fr. *connaissance*)." [VV175]⁴⁹

The most encompassing notion of human being is the *autos*. It is from this *autos* that the subject-individual springs: "Like everything which in our universe stems from autonomous organization, the subject-individual is dependent on what makes him independent. Whence the necessary paradox not to be unknotted: the subject-individual is the key emergence of the *autos*, and the hearth of the *autos* is at the heart of subject-individual." [VV274]

Having established the physical and biological character of living being, Morin then develops the next chain of ideas: survival and development necessitate movement, which generates sensations, which force choices, which generate intelligence by generating strategies of survival and development. All of this within a Whole, a society.

Need puts the animal in movement, movement requires energy, energy requires food, food requires movement. Morin posits the evolutive loop: *motorium* develops *sensorium* which develops a nervous system which develops the neuro-cerebral apparatus of individuals of the second type (vertebrates) which culminates in brain and mind. [VV209] Movement generates sensations which force choices. On the matter of personal freedom and responsibility, Morin believes that Humans, though conditioned, are not determined, and, thus, are personally free and responsible. The interplay of engram, program, and strategy is delicate but clear.

Evolution clearly cannot take place without emergences caused by natural or intentional selection. "*The aptitude to acquire, therefore, is the innate aptitude to acquire non-innate aptitudes....* The individualizing ascent of the primates requires the regression of innate programs and the progression of innate apparatuses apt to elaborate strategies of learning and behavior." [VV135] If, up to humans, natural selection has been the major force, with humans, intentional selection is now the evolutionary propellant.⁵⁰ Choices lead to the development of intelligence and strategies which lead to the

development of the brain and mind. Morin discusses the brain/mind theory only briefly in *The Life of Life*; this will occupy much of his third tome, *The Knowledge of Knowledge*.

Above, we spoke of engram becoming program. Program is chosen and modified by strategies of action, whose feedback develops intelligence. Action and knowledge thus return necessarily to each other, as Maurice Blondel (1861-1949) insisted a hundred years ago: "Every positive truth requires the mediation of an act, the presence of a subject, without which there would not be any positive truth."⁵¹ And likewise Bernard Lonergan in our time: "Judgment is an act of rational consciousness, decision is an act of rational self-consciousness."⁵² Praxis, i.e. intentioned action, is essential to knowledge. All action inescapably comports risk, which is essential to intellectual development. [VV225] On this important point Lonergan wrote pithily: "Security is mated to sterility."⁵³

The last essential idea of this core section deals with Man in Society, the Part within the Whole, the *autos* in the *oikos*. Inevitably there is born what Lewis Mumford called the "social megamachine," with all its advantages and disadvantages. The frightful imbecilities in Jarry's *King Ubu*,⁵⁴ Capek's *R.U.R.*,⁵⁵ and Chaplin's *Modern Times*⁵⁶ have been shown to be all too possible in our day. "Even as of now, the State finds itself endowed with powers which, virtually, exceed all the powers of control and intervention ever concentrated." [VV253] And this applies to the domain of knowledge as well: "Scientific knowledge is less and less produced to be thought and meditated by human minds, but more and more accumulated for computation by computers, namely, for utilization by super-individual entities, in the very first place the super-competent and omnipresent entity: the State." [VV253] Orwellian Big Brother! "As soon as the individual disappears, there is nothing left but algorithms." [VV268]

The Organization of Living Activities (301-330)

These brief pages return to general systems theory and the interplay of part and whole. Key notions are association/differentiation, specialization/loss of autonomy, hierarchy/anarchy. "Association tends to favor differentiation, diversity tends to favor association, and development which organizes association and diversity precedes or announces specialization." [VV305] However, the path to personal and societal development is non-specialization. "The aptitude to despecialization...is an individual quality properly regenerating and beneficial to the community." [VV307]

To discuss hierarchy and anarchy, Morin returns to his earlier notions on

order/disorder: development cannot, must not, be rigidly programmed: "*In all living organization, hierarchical organization needs non-hierarchical organization.*" [VV313] The genesis analogue views contraries as simultaneously necessary.

Morin refers to François Jacob's notion of tinkering [VV308] as the path to development: "[Living organization] seems to stem rather from tinkering, in the sense in which this term includes in its signification opportunist strategy, utilization of materiel coming from all over and perhaps turned aside from their original function." [VV323]⁵⁷ Morin sees all of this as complexity: "This notion of tinkering...reveals to us no doubt the real face of complex rationality, which works and manages with disorder, chance, happening, perturbation, and which includes doubtlessly both irrationality and surrationality." [VV324]

RE: From the Prefix to the Paradigm (331-346)

This is an even briefer section, repeating and emphasizing the key notion of recursivity. Active organization is synonymous with permanent reorganization. "All machine-beings, from the stars to living individuals, organize by reorganizing, in and by the repetition of processes, the renewing of components, the establishment of a stationary state or homeostasis." [VV333] Development is repetition producing recursion producing emergence.

To Understand the Living: Bios (347-452)

In this fifth and final part, which comprises a bit more than a quarter of the book, Morin reviews the complex nature of individual life which is born, lives, and dies, and the necessary ethical component of this individual life which, by and beyond complexity, eventuates in love. The key theme is the nature of complexity and the roles therein of conflict and freedom.

Complexity is the order of the day, and to cope with it Morin offers the "incompressible paradigm: auto-(geno-pheno-ego)-eco-re-organization." [VV 351] Given complexity, there will be conflict, and conflict is a pre-requisite for all human and societal development. "*Bios* contains *Polemos*. *Polemos*, which can be latent or asleep in physical systems, is in permanent activity in living systems and between living beings." [VV363] Fortet and Le Boulanger state categorically: "A system without conflicts cannot self-organize." [VV364] Even resolved, conflict does not go away: "Now, we have to maintain the idea that conflict remains conflict even while becoming meta-conflictual." [VV365] Consequently, nerve-wracking as conflict is, it is necessary and good. How then live in peace and not self-destruct? "We must invoke the living forces of

fraternity and love.” [VV438] Morin writes perceptively of “arkhe-fraternity” [VV439] and over several pages he rhapsodizes over love as negentropy. [VV443ff] “In this sense love is the true religion—in the original sense of the term: what ties—of hypercomplexity: it ties egocentric individualities in their most intimately and intensely subjective characters.” [VV444]

Conclusion (453-458)

Morin summarizes this very complex book with the simple thought that “the work of this volume has been to recognize life as an emergence” [VV453], through the complementary, concurrent, and antagonistic looping of *physis*, *bios*, and *anthropos*.

La Méthode, v.3: La Connaissance de la Connaissance **Part 1: Anthropologie de la connaissance (1986)**

In the general introduction to what Morin conceives as the third and final part of his *Method*, v.3: *The Knowledge of Knowledge*, he informs us that the purpose “is to consider the possibilities and the limits of human knowledge.” [AC33] This third part will itself contain three sub-divisions: *The Anthropology of Knowledge*, *The Sociology of Knowledge*, and *The Organization of Knowledge: Noosphere and Noology*. A final book, *The Possibilities of a Complex Epistemology*, may wrap up the entire *Method* enterprise. To date (1990), only *Anthropologie de la connaissance* has been published.⁵⁸

General Introduction (9-30)

The General Introduction at the head of this *Anthropology of Knowledge* highlights two main ideas. The first is that “all knowledge includes necessarily: a) a competence (aptitude to produce knowledge); b) a cognitive activity (cognition) working in function of that competence; c) a data-base (the result of these activities).” [AC11] As if the study of the brain/mind, of cognition, and of data were not enough, Morin holds that we also “must add the continent non-reconnoitered, unexplored, the noosphere in which knowledge organizes itself into systems of ideas (theories, doctrines), and which necessitates a new science: noology.” [AC12]

The second major point made is the revolution in knowledge brought by the works of the Polish-born Alfred Tarski (1902-1983) in logic, the Austrian-born Kurt Gödel (1906-1978) in mathematics, and the German-born Nicholas Rescher (b.1928) in epistemology. All three scholars found their way

to the United States, Tarski to Berkeley, Gödel to Princeton, and Rescher to Pittsburg. "Conformly to Tarski's logic, a semantic system cannot explain itself fully." [AC17] Tarski's 1933 monograph, "The Concept of Truth in Formalized Languages," supported the German idealist philosophers against the logical positivists of the Vienna Circle. It greatly influenced the Austrian Karl Popper (b.1902) who maintained, among other views, that it is wrong to distinguish science from metaphysics, and that the role of science is to discover error, not truth. Gödel's incompleteness theorem, or theorem of undecidable propositions, published in 1931, is famous, and the results of his work were "shattering.... The one distinguishing feature of mathematics that it might have claimed in this century, the absolute certainty or validity of its results, could no longer be claimed," wrote the eminent mathematician Morris Kline.⁵⁹

The third revolutionary, Rescher, is the leading living proponent of idealist philosophy. According to Morin: "Complex epistemology is deprived of foundation.... Instead of starting from 'basic or protocolar statements' which, in the view of logical positivism, furnished knowledge with an undoubtable foundation, Rescher envisages a network system which is not hierarchical, no one level being more fundamental than the other. We accept this conception fully and we add the dynamic idea of rotative recursivity." [AC24]

The upshot of all this new "uncertainty" in knowledge, including scientific knowledge, is that "We don't know if we will have to abandon the idea of truth, that is to say to recognize as truth the absence of truth." [AC10]

Body (35-202)

Morin develops his anthropology of knowledge in 9 chapters tautly reasoned and composed. He begins, not surprisingly, with the biology and the animality of knowledge, moving then to the brain/mind of the hyper-complex machine which computes and cogitates. The last four sections deal with the existentiality and the twofold interplay of logic and analogy in knowledge, the uniduality of *mythos* and *logos* (connotation and denotation), and finally, the recursivity of intelligence/thought/consciousness.

The Biology of knowledge (35-52) evidently must return to some of the ideas Morin enunciated in *The Life of Life*, particularly that of the *computo* at the heart of life, defined as self-(re)organization, and that without life there can be no knowledge. Computation, then, distinguishes him from Piaget, Morin holds, because Piaget found "only auto-regulation (and not auto-eco-organization) as starting basis for comprehending cognitive processes." [AC35]⁶⁰

Morin continues to draw from the Chilean neuro-scientist Humberto Maturana, especially for the looping notion that life is reorganization through permanent biological computation of information evaluated and selected or rejected by cognition which reorganizes life. [AC47] Knowledge is hologrammatic, that is to say three-dimensional, part, whole, and part-whole. "*Proper to hologrammatic organization is the fact that, in a certain way, the organization of the whole is found inside the part which is in the whole.*" [AC50]

The Animality of knowledge (53-67) repeats the *motorium/sensorium/cerebrum* loop: need puts the animal in motion, which generates sensations, which generate choices and actions, which develop the neuro-sensitive system which culminates in the brain. The key notion in all evolution is again that of emergence: by rotative recursivity the whole becomes more than the sum of its parts. "From computational level to computational level, qualities, inexistant at the level englobed, emerge at the level englobing, right up to the macro-englobing level of the perceptive and intelligent activity." [AC57]

The next set of ideas has also been seen earlier: intelligent action is strategic planning in uncertainty to solve problems and attain endo-finalitary goals. This human development is apparent most of all in the brain.

Mind and Brain (69-84) opens a discussion to be pursued over several chapters. Morin had noted earlier that "Eccles and Changeux, both experts in neuro-science, have two opposite points of view on the mind, the first assured that it is not reducible to the brain, the second convinced of its inexistence." [AC26] For Morin, the brain computes and the mind cogitates, but cogitation is based on and emerges from computation. The emerged mind remains physically and biologically tied to the brain, and we have once more a uniduality. "At the same time, we must conceive, in its very dependence, a certain autonomy of the mind. Thus, whereas the biological decadence of the brain starts, it seems, after 20 years, the mind continues its development." [AC73]⁶¹

It is crucial to Morin's thought to note that, beyond the physical brain and the personal mind, there is social culture. "The mind, which depends on the brain, depends in another way no less necessarily, on the culture," [AC75] which Monod calls a second evolution.⁶² Morin insists, "The sphere of the things of the mind is and remains inseparable from the sphere of culture: myths, religions, beliefs, theories." [AC75] His entire next book, *The Sociology of Knowledge*, will deal specifically with this matter.

The uniqueness of man is that the animal brain has been able to become a human mind. "Mind...is clearly an emergence, in the sense in which we defined this, namely a complex of properties and qualities which, issued from

an organizing principle, participates in that organization and retroacts on the conditions which produce it." [AC78]

In *The hyper-complex machine* (85-114) Morin draws our attention to various aspects of the cerebral apparatus which all affect our knowing. First, of course, is the physical cortex with its neuronal layers and multiple zones, [AC87] which result in an acentric and polycentric brain. [AC88] A second aspect is the right brain/left brain theory first proposed by Roger Sperry. [AC88] But Morin notes that brain specialists today like Magoroh Maruyama, T. Tsunoda, and J. Cohen, while not rejecting the general theory of hemispheres, speak also of brain lateralization which, in some cases, leads to what Morin again wants to call a "uniduality." [AC89f] Thirdly, brain theory has also broached the matter of the "sexualization of the hemispheres" since, very generally, the left dominates in man and the right in woman. [AC90] A fourth aspect is the socio-cultural determination, namely the roles of nature/nurture. [AC90]

One of the most crucial anthropological aspects of knowledge is the relation between rationality and affectivity, "the existential characters of knowledge." [AC94] Morin affirms that rationality is fragile and lends itself easily to "ideological aggressivity," occasionally labeled reptilian. [AC94] Are we to be left permanently with the dilemma of choice between rationality and affectivity? What are the "cerebral conditions of belief and certainty?" [AC94] What is the precise relation of what Jacob Bronowski calls "knowledge or certainty?"⁶³ What exactly does Pascal mean when he says, "The heart has its reasons which reason does not know?" [LeGuern 397a, Brunschvicq 277]

Morin affirms that rationality and affectivity both enter the realm of knowledge, and we must guard unwaveringly against the domination of the one or the other. "Affectivity is inseparable from human knowledge and thought.... Furthermore, the domination of reason over affectivity cannot forever be recognized with certainty, nor be always considered as the optimal condition for knowledge." [AC95]

Given these multiple anthropological characters in the process of knowing, how then do humans learn? Morin proposes "three principles of intelligibility to help us conceive cerebral hyper-complexity: the dialogic principle; the recursive principle; the hologrammatic principle." [AC98] He will take this discussion up again shortly.

To compute and to cogitate (115-125), with the next chapter, serves as transition between the physico-biological factors in knowledge and the psycho-linguistic factors; stated otherwise, the transition from brain to mind, from computation to cogitation. Morin declares: "Nothing in the activity of the

human mind escapes computation, but the whole of this activity cannot be reduced to computation.... Cogitation (thought), which emerges from the computing operations of the cerebral machine, retroacts on these computations, uses them, develops them, and transforms them by being formulated in language." [AC115]

Morin outlines the recursive loop: subject, consciousness, thought, language. "Consciousness is inseparable from thought which is inseparable from language. Consciousness is the emergence of the reflexive thought of the subject on himself, on his operations, on his actions." [AC121]⁶⁴ The results of the recursive loop subject/consciousness/thought/language are an ever greater human development. Morin next moves squarely from the physico-biological brain to the psycho-linguistic mind.

The existentiality of knowledge (127-138) takes up Morin's earlier discussion. Some pages back [AC94] Morin had designated rationality, affectivity, and pulsion as the existential characters of knowledge. He now examines these briefly and concludes: "We can note that our interpretations of reality are not independent of our profound psychic states, which themselves are in interdependence with our bio-neuro-cerebral states." [AC128]

The twofold play of knowledge (139-152) treats of the non-physical and non-biological nature of knowledge, and discusses comprehension, the role that analogy plays therein, and the difference between explication and comprehension.

Morin affirms that "Comprehension...apprehends...by analogy." [AC144]⁶⁵. In our day the United States theologian David Tracy has exposed the most cogently, I believe, the role of analogy in knowledge.

Analogy is a language of ordered relationships articulating similarity-in-difference. The order among the relationships is constituted by the distinct but similar relationships of each analogue to some primary focal meaning, some prime analogue. A principal aim of all properly analogical languages is the production of some order, at the limit, some harmony to the several analogues, the similarities-in-difference, constituting the whole of reality. The order is developed by explicating the analogous relationships among various realities (self, other, world, God), by clarifying the relationship of each to the primary analogue, the meaning chosen as the primary focus for interpreting reality. In Christian systematics, the primary focal meaning will be the event of Jesus Christ (usually mediated through particular forms and particular traditions).⁶⁶

The primary event/analogue for Morin's comprehension of the world is genesis: cosmic, cellular, human. Off genesis he spins his entire *weltan-*

schauung, and formulates his paradigm of rotative recursivity generating emergence.

Morin affirms that "Our daily cognitive activity...functions according to a dialogic comprehension/explication." [AC148] In sum, comprehension and explication are "contained the one in the other, opposed, and complementary" in the two great systems, "symbolic/mythological/magical thought and empirical/logical/rational thought." [AC152]

This leads Morin naturally into the longest of the nine chapters, a discussion of *mythos* and *logos* (153-176). It was, of course, impossible for him to present and analyze the vast corpus of writings on language in this double articulation. Nonetheless, he gives us succinctly a clear outline of the main positions. He treats successively of sign/symbol, myth, and magic. He then touches upon empirical thought and mythic thought, and calls for a union of both: "Every renouncement of empirical/technical/rational knowledge would lead humans to death, every renouncement of its fundamental beliefs would disintegrate their society." [AC154] Rational or direct thought will be studied in detail in Part 3 of *The Knowledge of Knowledge: Noosphere and Noology*.

All the foregoing, from the physical to the biological to the mental to the linguistic, culminates in human intelligence, thought, and consciousness (177-202), which Morin defines thus: "intelligence as strategic art, thought as dialogic art and the art of conception, consciousness as reflexive art, knowing that the full use of each one necessitates the full use of the others." [AC177] "Intelligence precedes humanity, precedes thought, precedes consciousness, precedes language.... However, it is language, thought, consciousness which allow the development of intelligence properly human." [AC178]

Morin lists 15 qualities of intelligence [AC178f]; most of these are self-evident and need not detain us. I would single out only three: the Sherlock Holmes ability to reconstruct the whole from fragmentary evidence [AC179], "serendipity" which combines with the Sherlock Holmes ability a perspicacity in unexpected situations [AC179], and a "tinkering" ability to take something and anything out of its usual reference set and transplant it or integrate it into a new set [AC180].

Consciousness is more than intelligence or thought. "A taking-consciousness is more than a taking-knowledge: it is a reflexive act mobilizing the consciousness of self and engaging the subject in a critical reorganization of his knowledge, even to a questioning of his fundamental points of view." [AC192] "The progress of consciousness is linked to that of knowledge. But, as we have seen, the progress of knowledge does not entail necessarily that of consciousness/conscience." [AC194] Self-consciousness is, of course, the most

difficult consciousness of all. Who am I? What am I? Morin insists, almost like a voice crying in the wilderness, that "Auto-examination can only be auto-hetero-examination." [AC195] We have noted that Lonergan posits decision/action as the path to self-consciousness,⁶⁷ since action would force the "hetero" dimension.

Conclusions of Part One (203-236)

To conclude this first part on the anthropological factors in our knowledge, Morin regroups in the longest chapter of the entire book, the conditions of knowledge, the limits and uncertainties—which he terms, Pascal-like, the miseries—of knowledge, and finally a section on transit, or the future.

The major condition for knowledge is recursivity. Next, the perspective of death: "Thus, the consciousness of our finitude and of our death has always retroacted and retroacts profoundly on our life, our behavior, our ideas, and our consciousness itself." [AC205]⁶⁸ A third condition, harking back to the general systems thinking of *The Nature of Nature*, is that "Knowledge supposes simultaneous closing and opening of the cognitive system." [AC206] Knowledge is for action, and action necessitates a closing of knowledge to begin and a concomitant opening to pursue.

Also, there is no separating the subject from the object. He again cites Heinz von Foerster: "There is not, exterior to us, hot or cold, but only different velocities of molecules; there are no sounds, calls, harmonies, but variations of air pressure; there are no colors or light, only electro-magnetic waves." [quoted in AC217] Morin insists, over and over again, on "the ego-centrism inherent to all knowledge," to which he adds the "cultural and socio-centric determinations inherent to all knowledge." [AC224]

Humans can know only symbols, ideas. "We must not only code but also imaginalize and abstract in order to know; that is to say that the real must necessarily, in order to be known, unrealize itself in signs/symbols, representations, discourses, ideas." [AC214] Morin returns to his primary analogue of genesis and his paradigm of uniduality, which return us to the uncertainty of knowledge. [AC215]

A trinary dialogue is needed: "Thenceforth we can initiate the trinary dialogue between reflexive knowledge (philosophical dimension), empirical knowledge (scientific dimension), and the knowledge of the value of knowledge (epistemological dimension) in order to constitute the loop, always renourished in knowledges and reflexions, of the knowledge of knowledge." [AC232f]

Morin ends here his exposition of the “anthropological universals of knowledge.” [AC233] He announces [AC237] that Part 2 will discuss the sociology of knowledge and Part 3 the organization of knowledge (noosphere and noology); he defines noosphere as “the specific reality of the ‘things of the mind’” and noology as “their proper organization, notably logical and paradigmatic.” [AC237] A Part 4 may also appear, to discuss “the possibilities of a complex epistemology.” [AC237]

Like all interdisciplinary writers, Morin has been attacked from all sides. He is neither physicist, nor biologist, nor anthropologist, nor psychologist, nor philosopher. What is he then? Just a thinker, just a tinker...

Method

I will be very pleased if those who want to object to me do not hasten to do so, and that they try to understand everything I have written before judging one part : for, *all holds together and the end serves to prove the beginning.* Descartes (*Letter to Mersenne*).

All things being both caused and causing, helped and helping, mediate and immediate, and all holding together by a natural and unnoticed bond which ties things most distant and most different, I hold it impossible to know the parts without knowing the whole, or to know the whole without knowing each part in particular. Pascal (ed. Brunschvicg, II, 72).

Join what is complete and what is not, what agrees and what disagrees, what is in harmony and what is in disharmony. Heraclitus.

The isolated knowledge which a group of specialists has obtained in a narrow field has in itself not the slightest value of any kind. It has value only within the theoretical system which unites it to the rest of knowledge, and only insofar as it contributes really, within this system, to answering the question: "Who are we?" E. Schrödinger.

Maybe there is another knowledge to be acquired, other questions to ask today, starting, not from what others have known, but from what they have not known. S. Moscovici.

Starting with the needs of man, I had to push myself to science, and the ideal of my youth had to be transformed into a form of reflection. Hegel (*Letter to Schelling*).

Method can no longer be separated from its object. W. Heisenberg.

GENERAL INTRODUCTION

The Spirit of the Valley

Awake, they sleep. Heraclitus.

*To reach the point that you don't know,
you must take the road that you don't
know. San Juan de la Cruz.*

*The concept of science is neither absolute
nor eternal. Jacob Bronowski.*

*Personally, I think that there is at least one
problem...that interests all persons who
think: the problem of understanding the
world, ourselves, and our knowledge in-
asmuch as it is part of the world. Karl
Popper.*

What Absconded from the Paradigm

I am more and more convinced that the problems whose urgency binds us to actuality require us to break away from them in order to consider them in their depth.

I am more and more convinced that our principles of knowledge hide what is hereon in vital to know.

I am more and more convinced that the relation science



when it is not invisible, is still poorly treated, because of the reabsorption of two of the terms by the third, now become dominant.

I am more and more convinced that the concepts which we use to conceive of our society—allsociety—are mutilated and lead to actions which are inevitably mutilating.

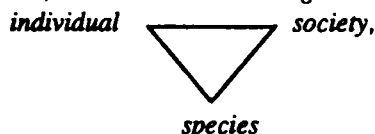
I am more and more convinced that anthropo-social science needs to articulate itself on the science of nature and that this articulation requires a reorganization of the very structure of knowledge.

But the encyclopedic amplitude and the unfathomable radicality of these problems inhibit and discourage, and thus the very recognition of their importance contributes to divert us from them. As far as I am concerned, I needed exceptional circumstances and conditions¹ in order to pass from conviction to action, that is to say to work.

The first crystallization of my thought is found in *The Lost Paradigm* (1973). This premature branch of *Method*, then in gestation, tries hard to reformulate the concept of man, that is to say, the science of man or anthropology.

Sapir had long ago highlighted that "it was absurd to say that the concept of man is at one time individual, at another social" (and I add: at still another biological). "That is like saying that matter obeys alternately the laws of chemistry and those of atomic physics." (Sapir, 1927 in Sapir, 1971, p.36)² The dissociation of the three terms individual/society/species breaks their permanent and simultaneous relation. The fundamental problem, therefore, is to re-establish and question what has disappeared in the dissociation: this very relation. It is, then, of first necessity, not only to rearticulate individual and society (this was undertaken at times, but at the expense of flattening one of the two notions to benefit the other), but also to effect the articulation reputed impossible (worse, "outmoded") between the biological sphere and the anthropo-social sphere.

That is what I attempted in *The Lost Paradigm*. Evidently I was not looking to reduce the anthropological to the biological, nor to bring the "synthesis" of knowledge up to date. I wanted to show that the empirical soldering which could be established since 1960, via the ethology of superior primates and the prehistory of hominians, between Animal and Man, Nature and Culture, necessitated conceiving man as ternary concept,



in which one cannot reduce or subordinate one term to another. That, to my eyes, called for a complex principle of explanation and a theory of self-organization.

Such a perspective poses new problems, still more fundamental and more radical from which there is no escape:

- what does the radical "self" of self-organization mean?
- what is organization?
- what is complexity?

The first question reopens the problematic of living organization. The second and third open chain questions. They have drawn me down unknown paths.

Organization is an original concept if one thinks of its physical nature. It then introduces a radical physical dimension in living organization and in anthropo-social organization which both can and must be considered as developments transforming physical organization. At the same time, the link between physics and biology can no longer be limited to chemistry, nor even to thermodynamics. It must be organizational. Thenceforth, it is necessary not only to articulate the anthropo-social sphere; it is necessary to articulate one and the other onto the physical sphere:

physics → biology → anthropo-sociology

But, in order to achieve such a double articulation, it would be necessary to combine a knowledge and a competence which are beyond our capacity. It is, then, too much to ask.

And yet, it would not be enough, since it would not be a matter of conceiving physical reality as primary stuff, objective basis for all explanation.

We have known for more than half a century that neither micro-physical observation nor cosmo-physical observation can be detached from their observer. The greatest progress in contemporary science has been effected by reintegrating the observer in the observation. Which is logically necessary: every concept refers not only to the object conceived but also to the subject conceiving. We are back at the truth which the philosopher-bishop set forth two centuries ago: there do not exist any "non-thought bodies."³ Now, the observer who observes, the mind which thinks and conceives, are themselves undissociable from a culture, consequently from a society *hic et nunc*. All knowledge, even the most physical, undergoes a sociological determination. There is in all science, even the most physical, an anthropo-social dimension. *By that very fact, anthropo-social reality projects itself and inscribes itself at the very heart of physical science.*

All this is evident. But it is evidence which remains isolated, surrounded by a sanitary cordon. No science has wanted to know the most objective category of knowledge: that of the knowledge of the subject knowing. No natural science has wanted to know its cultural origin. No physical science has wanted to recognize its human nature. The deep gap between the sciences of nature and the sciences of man hides both the physical reality of the latter and the social reality of the former. We run smack into the omnipotence of a principle of disjunction: the human sciences are condemned to extra-physical inconsistency and the natural sciences are condemned to the unconsciousness of their social reality. As Von Foerster says very aptly: "The existence of

Every neophyte embarking on research sees himself imposed a major renouncement of knowledge. We convince him that the era of the Picos de la Mirandola is three centuries back, that it is henceforth impossible to build one's vision both of man and of the world.

We prove to him that the informational growth and the heterogenization of knowledge surpass all possibility of engrammation and of treatment by the human brain. We assure him that this is not to be deplored, but to be welcomed. He must, then, devote all his intelligence to increasing that knowledge there. We integrate him in a specialized team, and in this expression it is "specialized" and not "team" which is underscored. Henceforth a specialist, the researcher sees himself offered the exclusive possession of a fragment of a puzzle whose global vision necessarily escapes each and everyone. He has now become a true scientific researcher driven by this one ideal: knowledge is produced not to be articulated and thought but to be invested and utilized in an anonymous way.

Fundamental questions are returned as general questions, namely vague, abstract, non-operational. The original question which science snatched from religion and philosophy in order to take it upon itself, the question which justifies its ambition as science: "What is man, what is the world, what is man in the world?": science today sends that question back to philosophy, still incompetent in its eyes because of speculative drunkenness, science sends it back to religion, still illusory in its eyes because of inveterate mythomania. It abandons every fundamental question to non-scholars, *a priori* disqualified. It only tolerates that at the age of retirement, its grand dignitaries take some meditative pose, which the young assistants in their white lab coats and bent over their retorts will ridicule. It is not possible to articulate the sciences of man with the sciences of nature. It is not possible to have his knowledge communicate with his life. Such is the main lesson passed down from the Collège de France to the "collèges" of France.

Is Mourning necessary? The Institution affirms it, proclaims it. It is thanks to the method which isolates, separates, disjoins, reduces to units, measures, that science has discovered the cell, the molecule, the particle, the galaxies, the quasars, the pulsars, gravity, electro-magnetism, quantum energy; that it has learned to interpret stones, sediments, fossils, bones, unknown scripts, including the script inscribed on DNA. However, the structures of this knowledge are dissociated one from another. Physics and biology communicate today only by a few isthmuses. Physics no longer even manages to communicate with itself: the queen of the sciences is dislocated between micro-physics, cosmo-physics and our in-between is still apparently subject to classical physics. The anthropological continent has drifted off, becoming an

Australia. In its breast the triad constituting the concept of man,
individual  society, is itself totally disjointed as we have seen

species

(Morin, 1973) and will see again. Man has come apart: there remains over here a tooling-hand, over there a talking-tongue, elsewhere sex organs splashing on a bit of brains. The idea of man is all the more dispensable because it is pitiful: the man of the human sciences is a supra-physical and supra-biological specter. Like man, the world is dislocated among the sciences, crumbling among the disciplines, pulverized into bits of information.

Today we cannot avoid the question: must the necessary analytical decomposition be paid for by the decomposition of beings and things in a generalized atomization? Must the necessary isolating of the object be paid for by disjunction and incommunicability between what is separated? Must functional specialization be paid for by an absurd parcellization? Must knowledge be dislocated into a thousand stupid facts?

Now, what does this question mean, if not that science has to lose its respect for science and that science has to question science? Still another problem which, apparently, adds to the enormity of the problems which constrain us to give up. But it is precisely this problem which prevents us from giving up on our problem.

How, in fact, surrender to the ukase of a science where we have just discovered a gigantic blind spot? Must we not think rather that this science suffers from insufficiency and mutilation?

But then, what is science? *Here, we must realize that this question does not have a scientific answer:* science does not know itself scientifically and has no means of knowing itself scientifically. There is a scientific method to consider and control the objects of science. But there is no scientific method to consider science as an object of science and still less the scientific as *subject* of this object. There are epistemological tribunals which, *a posteriori* and from the exterior, pretend to judge and to gauge scientific theories; there are philosophical tribunals where science is condemned by default. There is no science of science. One can even say that all scientific methodology, entirely given to the expulsion of the subject and of reflexivity, maintains this self-occultation. "Science without conscience is nothing but ruination of the soul," said Rabelais. The conscience which is missing here is not moral conscience, it is conscience period, that is to say the aptitude to conceive itself. Whence these unbelievable deficiencies: how is it that science remains incapable of seeing itself as social praxis? How is it incapable, not only of controlling, but of conceiving its power of manipulation and its manipulation

by power? How is it that scientists are incapable of conceiving the tie between "disinterested" research and the research of interest? *Why are they so totally incapable of examining in scientific terms the relation between knowledge and power?*

Henceforth, if we want to be logical with our plan, we must tackle necessarily the problem of the science of science.

The Impossible Impossible

The mission is more and more impossible. But abdication has itself become even more impossible. Can one be satisfied with conceiving the individual only by excluding society, the society only by excluding the species, the human only by excluding life, life only by excluding *physis*, physics only by excluding life? Can one accept that local progress in precision be accompanied by imprecision surrounding the global forms and articulations? Can one accept that measure, foresight, manipulation make intelligibility recede? Can one accept that information be transformed into noise, that a downpour of micro-elucidations be transformed into generalized obscurity? Can one accept that key questions be relegated to dungeons? Can one accept that knowledge be founded on the exclusion of the knower, that thought be founded on the exclusion of the thinker, that the subject be excluded from the construction of the object? That science be totally unconscious of its social insertion and determination? Can one consider as normal and evident that scientific knowledge have no subject, and that its object be dislocated among the sciences, crumbled among the disciplines? Can one accept such a night on knowledge?⁴

Can one continue to throw these questions into the trash can? I know that asking them, attempting to answer them, is inconceivable, ridiculous, insane. But it is even more inconceivable, ridiculous, insane to throw them out.

The Non-method

Let's understand each other: I am looking here neither for general knowledge nor for unitarian theory. One must, on the contrary, and on principle, refuse general knowledge: it always conceals the difficulties of knowledge, that is to say the resistance which the real opposes to the ideal: it is always abstract, poor, "ideological," it is always simplifying. Likewise, unitarian theory, in order to avoid the disjunction between the separate branches of knowledge, obeys an asphyxiating over-simplification, hanging the entire universe onto a single global formula. Actually, the poverty of all

unitarian attempts, of all global answers, confirms the scientific discipline in its resignation to mourning. The choice, then, is not between a particular, precise, limited knowledge and the general abstract idea. It is between Mourning and the search for a method which might articulate what is separate and link what is disjointed.

It is certainly a matter here of a method, in the Cartesian sense, which would permit "rightly conducting reason and seeking truth in the sciences." But Descartes could, in his first discourse, at the same time exercise doubt, exorcise doubt, establish preliminary certitudes and have Method spring up like Minerva armed from head to toe. The Cartesian doubt was sure of itself. Our doubt doubts of itself; it discovers the impossibility of starting from scratch, since the logical, linguistic, cultural conditions of thought are inescapably prejudging. And this doubt, which cannot be absolute, can no longer be absolutely resolved.

This "French knight" had set out at too fast a pace. Today, we can set out only in uncertainty, including uncertainty of doubt. Today there must be methodically put in doubt the very principle of the Cartesian method, the disjunction of objects among themselves, of notions among themselves (clear and distinct ideas), the absolute disjunction of object and subject. Today, our historical need is to find a method which detects and does not hide the links, articulations, solidarities, implications, imbrications, interdependencies, complexities.

We must start by extinguishing false clarity. Not from the clear and distinct, but from the obscure and uncertain; no longer from assured knowledge but from the critique of assurance.

We can set out only in ignorance, uncertainty, confusion. But it is a matter of a new consciousness of ignorance, uncertainty, confusion. We have taken consciousness, not of human ignorance in general, but of the ignorance which is crouching, buried deep, almost nuclear, at the heart of our knowledge reputed the most certain, scientific knowledge. We know hereon in that this knowledge is poorly known, poorly knowing, fragmented, ignorant of its own unknown as well as of its known. Uncertainty becomes viaticum; doubt of doubt gives doubt a new dimension, the dimension of reflexivity; the doubt by which the subject questions the conditions of emergence of its own thought constitutes henceforth a potentially relativist, relationist and self-knowing thought. Finally, the acceptance of confusion can become a means of resisting mutilating simplification. Certainly, we lack method at departure; at least, we can use anti-method, where ignorance, uncertainty, and confusion become virtues.

Retapping Science

We can trust these discards of classical science all the more that they have become the pioneers of the new sciences. The upsurge of the non-simplifiable, the uncertain, the confusional, by which the crisis of science in the twentieth century manifests itself, is at the same time inseparable from the new developments of this science. What seems like regression from the point of view of disjunction, of simplification, of reduction, of certainty (thermodynamic disorder, micro-physical uncertainty, the random character of genetic mutations), is on the contrary inseparable from progression into unknown lands. More fundamentally, disjunction and simplification are already dead at the very base of physical reality. The subatomic particle has surged up irremediably, in confusion, uncertainty, disorder. Whatever the future developments of micro-physics may be, we will never return to the element simultaneously simple, isolable, indivisible. Of course, confusion and uncertainty are not and will not be considered here as the ultimate words of knowledge: they are the avant-signs of complexity.

Science evolves. Whitehead had already noted fifty years ago that science "changes even more than theology." (Whitehead, 1926, in Whitehead, 1932, p.233) To repeat Bronowski's formula, the concept of science is neither absolute nor eternal. And yet at the heart of the scientific Institution reigns the most anti-scientific of illusions: to consider as absolute and eternal the characteristics of science which are the most dependent on the technobureaucratic organization of society.

Therefore, no matter how marginal it may be, my attempt does not loom like an aerolith come from another sky. It comes from our scientific soil in convulsions. It is born from the crisis of science, and feeds on its revolutionizing progress. In any case, It is because official certainty has become uncertain that official intimidation can let itself be intimidated in turn. For sure, my effort will give rise at first to misunderstanding: the word science includes a fossil meaning, admittedly, and the new meaning has not yet disengaged itself. This effort will seem derisive and insane because the disjunction has not yet been contested in its principle. But it will be able to become conceivable, reasonable, and necessary in the light of a new principle which it will perhaps have contributed to institute, precisely because it will not have been afraid to appear derisive and insane.

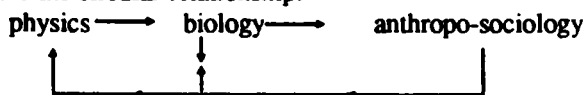
From Vicious Circle to Virtuous Cycle

I have indicated the major impossibilities which condemn my undertaking:

- the logical impossibility (vicious circle),
- the impossibility of encyclopedic knowledge,
- the all-powerful presence of the law of disjunction and the absence of a law for the organization of knowledge.

These impossibilities are imbricated one in the other, and their conjunction results in this enormous absurdity: a vicious circle of encyclopedic amplitude, which has neither law nor method of organization.

Let us take the circular relationship:



This circular relationship signifies first of all that a science of man postulates a science of nature, which in turn postulates a science of man: now, logically this relationship of mutual dependence returns each of these propositions back alternatively to each other in an infernal cycle where neither can take shape. This circular relationship signifies also that *at the same time* anthropo-social reality depends on physical reality, physical reality depends on anthropo-social reality. Taken literally, these two propositions are antinomous and cancel each other out.

Finally, in considering the double circular proposition (anthropo-social reality depends on anthropo-social reality) from a different angle, one notes that an uncertainty will remain no matter what happens to the very nature of reality, which loses all primary ontological foundation, and this uncertainty leads to the impossibility of a truly objective knowledge.

We understand then that the ties between antinomous propositions in mutual dependence stand denounced as vicious, both in their principle and in their consequences (the loss of the base of objectivity). Therefore, we have always broken the vicious circle either by isolating the propositions or by choosing one of the terms as simple principle to which we must refer the others. Thus, in what concerns the relation physics/biology/anthropology, each of these terms was isolated, and the only link conceivable was the reduction of biology to physics, of anthropology to biology. Thus, the knowledge which binds a mind and an object is referred to the physical object (empiricism) or to the human mind (idealism) or to social reality (sociologism). Thus, the relation subject/object is dissociated, science making off with the object, philosophy with the subject.

This very fact means that breaking the circularity, eliminating the antinomies, is precisely to fall back under the empire of the law of disjunction/simplification from which we want to escape. On the other hand,

preserving the circularity is to refuse to reduce a complex datum to a mutilating principle; it is to refuse the hypostasis of a master concept (Matter, Mind, Energy, Information, Class Struggle, etc.). It is to refuse linear discourse with points of departure and arrival. It is to refuse abstract simplification. Breaking the circularity seems to reestablish the possibility of an absolutely objective knowledge. But that is what is illusory: preserving circularity is, on the contrary, to respect the objective conditions of human knowledge, which always, somewhere, includes logical paradox and uncertainty.

Preserving circularity, by maintaining the association of the two propositions both independently recognized as true but which no sooner in contact negate each other, is to open the possibility of conceiving these truths as the two faces of one complex truth; it is to unveil the principal reality, which is the relation of interdependence, between notions which disjunction isolates or opposes; it is, therefore to open the door to searching for this relation.

Preserving circularity is, perhaps, by that very fact, to open the possibility of knowledge reflecting on itself: in fact, the circularity

physics → anthropo-sociology and the circularity object → subject

must bring the physicist to reflect on the cultural and social characteristics of his science, to reflect on his own mind, and to lead him to question himself. As the Cartesian *cogito* indicates, the subject arises in and by the reflexive movement of thought on thought.⁵

To conceive circularity is henceforth to open up the possibility of a method which, by having the terms which refer to each other interact would become, through these processes and exchanges, productive of a complex knowledge containing its own reflexivity.

Thus, we see our hope rise up from what caused the despair of simplifying thought: paradox, antinomy, vicious circle. *We glimpse the possibility of transforming vicious circles into virtuous cycles, becoming reflexive and generative of complex thought.* Whence this idea which will guide our departure: it is not necessary to break our circularities; on the contrary, we must take care not to detach ourselves from them. The circle will be our wheel, our path will be spiral.

The En-cyclo-pedia

Concurrently, the insurmountable problem of encyclopedism changes face,

since the terms of the problem have changed. The term encyclopedia must no longer be taken in the accumulative and stupid meaning where it has lost all value. It must be taken in its original meaning of *agkuklios paideia*, training which puts knowledge in cycle; in very fact, it is a matter of en-cyclo-peding, that is to say of learning to articulate the disjointed points of view of knowledge into an active cycle.

This en-cyclo-pedism does not pretend thereby to encompass all knowledge. That would be to fall back into the accumulative idea as well as to head into the totalitarian mania of the great unitarian systems which enclose the real in a great corset of order and coherence (they evidently let it show). I know what Adorno's statement means: "Totality is non-truth;" every system which aims at enclosing the world in its logic is an insane rationalization.

The en-cyclo-pedism required here aims at articulating *what is fundamentally disjointed and which should be fundamentally joined*. Our effort, then, will not be directed at the totality of knowledge in each sphere, but on crucial knowledge, strategic points, knots of communication, organizational articulation between disjointed spheres. In this sense, the idea of organization, as it develops, is going to constitute something like the bough of Salzburg around which key scientific concepts will be able to cluster and crystallize.

The theoretical bet I am making in this work is that knowledge of what organization is could be transformed into an organizing principle of knowledge which would articulate the disjointed and complexify the simplified. The scientific risks I run are evident. These are not so much errors of information, since I have appealed to the critical collaboration of researchers competent in domains which were foreign to me just seven years ago; they are fundamental errors in detecting the crucial and strategic problems. The umbrella of scientificity which covers me does not immunize me. My path, like all paths, is threatened by error, and, moreover, I am going to go through some narrow passes where I will be in the open. But, above all, my path will risk ceaselessly to lose itself between esoterism and popularization, philosophism and scientism.

Thus, then, I am not escaping the encyclopedic difficulty; but this difficulty ceases to be stated in terms of accumulation, in terms of a system, in terms of totality; it is stated in terms of organization and of articulation at the heart of an active circular process or cycle.

To Relearn to Learn

Everything holds together: the transformations of a vicious circle into a productive circuit, of the impossible encyclopedia into encycling movement,

are inseparable from the constitution of a *principle organizer of knowledge which associates to the description of the object the description of the description (and the deciphering of the decipherer), and which gives as much force to articulation and integration as to distinction and opposition.* (For, we must seek, not to suppress the distinctions and oppositions, but to overthrow the dictatorship of disjunctive and stifling simplifications.)

By that very fact, we will be able to approach the problem of the first principles of opposition, distinction, relation, association in discourses, theories, thoughts; namely, the problem of *paradigms*.

Revolutions of thought are always the fruit of a generalized shock, of a whirling movement which goes from the phenomenal experience to paradigms which organize experience. Thus, to go from the Ptolemaic paradigm to the Copernican paradigm which, by a land/sun permutation, changed the world by pushing us from the center to the periphery, from sovereignty to satellization, there were needed countless shifts between observations disrupting the ancient system of explanation, theoretical efforts to amend the system of explanation, and the idea of changing the very principle of explanation. At the end of this process, the initially scandalous and insane idea became normal and evident, since the impossible found its solution according to a new law and in a new system of organization of the phenomenal data. The articulation

physis —→ anthropo-sociology and the articulation object —→ subject,



which question a paradigm much more fundamental than the Copernican law, work simultaneously on the terrain of the phenomenal data, the theoretical ideas, the first laws of reasoning. The battle will be fought on all fronts, but the master position is the one which commands the logic of reasoning. In science and especially in politics, ideas, often more stubborn than facts, resist the outpouring of data and proofs. Facts actually break themselves against ideas, as long as nothing exists that can re-organize experience differently. Thus, we are experiencing at each moment, in eating, walking, loving, thinking, that all we do is simultaneously biological, psychological, social. Nevertheless, anthropology has been able for the last half-century to proclaim diarrheally the absolute disjunction between man (biological) and man (social). More profoundly still, classical science has been able to this very day, and contrary to all evidence, to be assured that it was of no consequence whatsoever and of no cognitive significance whatsoever that every physical body or object be conceived by the human mind. It is not a matter here of contesting "objective" knowledge. Its good deeds have been and remain inestimable since the absolute primacy granted the concordance of observations

and experience remains the decisive means of eliminating the arbitrary and the judgment of authority. It is not a matter of preserving that objectivity absolutely, but of integrating it into a more ample and reflective knowledge, giving it a third eye open to its blind spots.

Our thought must lay siege to the unthought which commands and controls it. We use our structure of thought to think. It will also be necessary to use our thought to rethink our structure of thought. Our thought must return to its source in an interrogative and critical loop. Otherwise, the dead structure will continue to secrete petrifying thoughts.

I have discovered how useless it is to argue only against error. The latter is reborn ceaselessly from laws of thought which themselves are situated beyond polemic consciousness. I have understood how useless it was to prove things only at the level of the phenomenon: its message is soon reabsorbed by mechanisms of forgetfulness that stem from the self-defense of the threatened system of ideas. I have understood that it was hopeless to only refute: only a new foundation can ruin the old. This is why I think that the crucial problem is the one of the principle organizer of knowledge and, what is vital today is not only to learn, not only to relearn, not only to unlearn, *but to reorganize our mental system to relearn to learn.*

“Caminante no hay camino”

What teaches us to learn, that is the method. I am not furnishing the method; I am starting out on the search for the method. I am not starting out with a method; I am starting out with the refusal to simplify, taken fully consciously. Simplification is the disjunction between entities separate and closed, the reduction to a simple element, the expulsion of what does not enter into the linear scheme. I am starting out with the will not to give in to these fundamental modes of thought which simplify:

—*to idealize* (to believe that reality can be reabsorbed in the idea, that the intelligible alone is real);

—*to rationalize* (to want to enclose reality in the order and the coherence of a system, to forbid it all overflow outside the system, to need to justify the existence of the world by conferring on it a patent of rationality);

—*to normalize* (that is to say to eliminate the strange, the irreducible, the mysterious).

I am starting out also in need of a principle of knowledge which not only respects but recognizes the non-idealizable, the non-rationalizable, the out-normous, the enormous. *We need a principle of knowledge that not only respects but reveals the mystery of things.*

At the beginning the word method signified advancing along a path. Here we must accept to advance without a path, to make the path by advancing. What Machado said: *Caminante no hay camino, se hace camino al andar*. The method can be formed only during research; it can be disengaged and formulated only afterwards, at the moment when the term once again becomes the point of departure, this time endowed with method. Nietzsche knew it: "Methods come at the end." (*The Antichrist*) The return to the beginning is not a vicious circle, if the voyage, as the word trip is used today, signifies experience, from which we come back changed. Then, perhaps, we will have been able to learn by learning. Thus, the circle will have been able to transform itself into a spiral where the return to the beginning is precisely what distances from the beginning. That is clearly what the novels of initiation from *Wilhelm Meister* to *Siddhartha* have told us.

The Spiral Inspiration

The reader, I hope, is starting perhaps to sense the following. Though this work does not put any limit on its perspective, though it does not exclude any dimension of reality, though it has the most extreme ambition, it cannot because of its very ambition be conceived as an encyclopedia, in the sense that this means a balance sheet of knowledge; but it can be conceived as an encyclopedia in the sense that the term, returning to its origin, signifies an encycycling of knowledge. It cannot in any way be conceived as a general unified theory whose diverse aspects in the different domains are logically deduced from the master principle. The break with simplification makes me reject in its very principle every unitary theory, every totalizing synthesis, every rationalizing/ordering system. This, already stated, must unfortunately be repeated because minds which live under the empire of the principle of simplification see only the alternative between fragmented research on the one hand, general idea on the other. It is this type of alternative we have to rid ourselves of, and it is not simple, otherwise there would have been, a long time ago, an answer to this problem within the framework of this law of simplification. It is not a question, finally, of improvising a new science, launched on the market *ready made* to replace the obsolete science. If I have spoken elsewhere (Morin, 1973) of *scienza nuova*, it is the perspective, the horizon; it cannot be the point of departure. If there is a new science, antagonistic to the old science, it is bound to it by a common trunk, it doesn't come from elsewhere, it will be able to be differentiated only by metamorphosis and revolution. This book is a slowly advancing spiral; it is starting out from an inquiring and a questioning; it is pursued through a

conceptual and theoretical chain reorganization which, attaining at last the epistemological and paradigmatic level, arrives at the idea of a method which must allow an advance of thought and action capable of reassembling what was mutilated, of articulating what was disjointed, of thinking what was hidden.

Method here is opposed to the conception called "methodological" where method is reduced to technical recipes. Like the Cartesian method, it must be inspired by a fundamental principle or paradigm. But the difference here is precisely one of paradigm. It is no longer a matter of obeying a principle of order (excluding disorder), of clarity (excluding obscurity), of distinction (excluding adherences, participations and communications), of disjunction (excluding subject, antinomy, complexity), that is to say a principle which ties science to logical simplification. On the contrary, starting from a principle of complexity, it is a matter of linking what was disjointed. "To start a revolution everywhere:" Sainte-Beuve used to speak thus of the Cartesian method. That is because Descartes had formulated the grand paradigm which was going to dominate the Occident, the disjunction of subject and object, of spirit and matter, the opposition of man and nature. If, starting from a paradigm of complexity, a new method can be born, can take flesh, can advance, make progress, then it would be able perhaps "to start a revolution everywhere," including in the notion of revolution which has become flat, conformist and reactionary.

The Spirit of the Valley

This book takes off from the crisis of our century, and it is to that crisis that it returns. The radicality of the crisis of society, the radicality of the crisis of humanity pushed me to look at the root level of theory. I know that humanity needs a political theory. That this political theory needs an anthropo-sociology. That anthropo-sociology needs to be articulated on a science of nature, that this articulation requires a chain reorganization of the structure of knowledge. I had to plunge into this fundamental problem by turning away from the solicitation of the present. But the present is this very crisis that reaches me, disperses me, transpierces me. The proper object-subject of this book returns unceasingly to my work to dynamite it. The noises of the world, armaments, conflicts, ephemeral and destructive liberations, lasting and hard oppressions come through the walls, strike me in the heart. I am working in the midst of these olive trees, of these vines, in these hills, near the ocean, while a new midnight advances on the world; its order crushes; its violence inspires respect, terror and admiration to those around me, and who, because of

my silence, think I am one of them. I turn aside from the call of those for whom I must testify, and, at the same time, I give in to the invitation of a bottle of wine, a friendly smile, a loving face...

Why speak of me? Is it not decent, normal, serious that, when dealing with science, knowledge, thought, the author be effaced behind his work, and evaporate in a discourse become impersonal? We have to know, on the contrary, that it is there that comedy triumphs. The subject who disappears from his discourse in fact takes over the Control Tower. By pretending to give way to the Copernican sun, he reconstitutes a Ptolemaic system whose center is his spirit.

Now, my effort at method tends precisely to tear me away from this absolute self-centeredness by which the subject, while disappearing on tip-toe, is identified with sovereign Objectivity. It is not anonymous Science which is expressed by my lips. I am not talking from the height of a throne of Assurance. On the contrary, my conviction secretes an infinite uncertainty. I know that to believe oneself possessing or possessed by the Truth is already to be intoxicated, it is to mask to oneself one's weaknesses and deficiencies. In the kingdom of the intellect, it is the unconscious which believes itself fully conscious.

I know that no indubitable sign will confirm or infirm my work. My marginality proves nothing, not even to myself. The precursor, as Canguilhem says, is the one who we know only afterwards came before. In anomie and deviance, the avant-garde is mixed with all the low forms of delirium... The judgment of others will not be any more decisive. If my conception is fruitful, it can be as despised or misunderstood as applauded or recognized. The solitude to which I constrain myself is the lot of the pioneer, but also of the strayed. I have lost contact with those who have not undertaken the same voyage, and I do not yet see my companions who exist, without doubt, and who also do not see me... Finally, I am working as at an absolute, at a relative and uncertain work... But I know more and more that *the only worthwhile knowledge is that which feeds on uncertainty and that the only living thought is that which maintains itself at the temperature of its own destruction.*

It is not certainty or assurance but need which has driven me to undertake this work day after day, for years. I have felt myself possessed by the same evident necessity of transsubstantiation as that by which the spider secretes its thread and weaves its web. I have felt myself plugged into the planetary patrimony, animated by the religion of that which bonds, the rejection of that which rejects, and infinite solidarity; what the Tao calls the *Spirit of the Valley* which "receives all the waters which flow into it."

VOLUME 1

The Nature of Nature

Foreword to Volume 1

*Physis is first of all the title of a question:
"Where do things come from? How are they
born and how do they grow?" P. Auberque*

At the start of *Method*, I thought I would be able to treat the problem of organization within the framework of systemic (*General Systems Theory*) and cybernetic ideas. En route, these ideas, of solutions, became starting points, then finally scaffolding, necessary certainly, but to be dismantled after having raised us to the concept of organization. Starting at a certain stage then, these liberating ideas locked me in. I was able to develop their message only by metamorphosing them. Thus, as always, the first guides to evolution become the principal obstacles to revolution. They resist the metamorphosis whose tadpoles, however, they have been. It was extremely difficult for me to criticize notions which served me as crucial armaments to go beyond former modes of thought. It is easy to go beyond the past but not to go beyond what makes you go beyond the past. It seems to me that systemic and cybernetic (including information) ideas are integrated here, that is to say preserved in their sap and their truth, but at the same time provincialized, criticized, transformed, complexified.

Instead of locking the idea of organization in the system or in the machine (cybernetics), I have on the contrary towed the idea of system and of machine by the idea of organization. This concept, the nature of which could only be physical, made me resurrect the idea of *physis*; this idea signifies that the physical universe must be conceived as the very place of creation and of organization.

The primary object of this first volume is *physis*. But *physis* is neither a base, nor a stratum, nor a support. *Physis* is common to the physical universe, to life, to man. The idea—trivial—that we are physical beings must be transformed into a signifying [Fr. *signifiant*] idea.

Consequently, in this volume, I do evoke biological organization and anthropo-social organization, but always under the angle of physical organization. At each development of the physical concept of organization there will arise biological or anthropo-sociological examples/references. That will seem quite confusing to minds for whom physics, biology, anthropology, sociology are separate and incommunicable essences. But that is all the more

necessary here, not only because everything which is organization concerns biology and anthropo-sociology, but also because organizational problems and phenomena, virtual or atrophied at the level of organizations strictly physical, manifest and deploy themselves in their biological and anthropo-sociological developments. This is to say, by the same token, that biological and anthropo-social phenomena and problems, to be conceived and understood, require a formidable organizational, that is to say physical, infrastructure.

*

This first volume worked enormously in me (that is to say, it obliged me to work hard). I have to consider it as a work both totally solitary and totally solidary. Solitary, because I had to consecrate myself to it personally and wholeheartedly. Solidary because it was stimulated, corrected, controlled by others.

At the origin of the ideas which I develop herein, I find, first of all, Henri Atlan who woke me from my empirical sleep by initiating me to the idea of creative disorder, then to its variants (chance as organizer, disorganization/reorganization). Atlan introduced me to Von Foerster, our electronic Socrates, to whom I am indebted for many of my seminal ideas; Von Foerster made me discover Gunther, Maturana, and Varela. Each in his own way allowed me finally to look at the invisible, the notion of *self*, and to reintroduce the concept of subject. That does not exclude my debt to other authors, thinkers, researchers, who are cited in this text.

I had as collaborator, or rather as principal interlocutor, John Stewart, a biologist who until then had devoted himself principally to population genetics. Stewart did a critical reading of the first draft of my copy (that is to say of the three volumes); he read and criticized the four successive versions of this first volume. His manuscript notes run to more than five hundred pages. I no longer know clearly which are the ideas he inspired in me, and which I tend egocentrically to consider my own (because we have the tendency to forget our inspirators), but I know that his fundamental contribution has been essential, especially when it was enraged, and when it enraged me against him. There took place, thus, a strange and unforeseen conflictual cooperation or antagonistic collaboration between him and me. A disheartened biologist, he was moving towards sociology and towards that reduction to politico-socialist schemes which are wrongly identified with Marxism; I, a disheartened sociologist, was moving not only toward biology but towards *physis*; he was tending to sociocentrism, I to physiocentrism. Now, this antagonism was absolutely necessary and I will say that Stewart's friendly enmity was providential for me, because I was obliged, from the beginning, to link up the

twofold movement

nature → society

←

nature → society

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whereas in my first draft this double movement was linked up only in Volume 3. Thenceforth, I had to complexify my intent at the base (whereas I had believed it "didactic" to move by degrees to the Gordian knot).

No less providential was the intervention of Bernard Victorri (Assistant in Mathematics at the University of Lille) at the next-to-last polishing of my manuscript. Not only did he give me "punctual" criticisms that were all together necessary, but he led me to rethink and to rework. When I thought I was finishing, he showed me that I was only at the pupal stage. His maieutics, or, better, maieu-criticism, made me give birth to what, all alone, I would not have been able to carry to full term.

This manuscript has benefited from the critical reading, in a first version, of a man become encyclopedia, Claude Gregory; then in successive versions, of Henri Atlan, Massimo Piattelli, André Bejin, and my Paulhanian Monique Cahen.

Anne Kovaks took charge of the bibliography of this work. Nicole Philouzat found for me works unfindable and reread many many pages. Marie-France Laval fulfilled the most thankless chores concerning and protecting this manuscript; Marie-Madeleine Dusza assisted her. All this was accomplished evidently within the framework of CETSAS (*Centre d'études transdisciplinaires*) at the *Ecole des Hautes Etudes en sciences sociales*. The collaboration of John Stewart and Anne Kovaks could not be effected without the help of the DGRST, within the framework of concerted Socio-Ecology action. It is thanks to Lucien Brams, in the first and last instance, that all was achieved, and Lucien intervenes beneficially once again in my destiny.

This itinerant work, which I consider as research in the elementary and full meaning of the term, was accomplished within the framework of my direction of research at the CNRS (direction signifies, not that I direct some researchers, but that I direct myself: fabulous privilege of which I am conscious). I protest against the Institution, but for my part, I have found in it, once again, and more than ever, the supreme good: *liberty*.

*

Certain people will find that I abuse of neologisms. To tell the truth, I do not invent any new words; I give verbs and adjectives to notions which were only substantives and vice versa.

Others (the same ones) will find that I abuse of similes or metaphors. I am not embarrassed to use similes when they come to me. Reassure yourself: I

know that they are similes.

In this text I go from *I* to *we*, from *we* to *I*. The *I* is not pretentious, it is the taking of responsibility for the discourse. The *we* is not majestic, it is an imagined work-solidarity with the reader.

The first outline of this study was worked out at the Salk Institute (San Diego). The first draft was started in New York in September 1973. I pursued the work in Paris, London, Sintra, Argentario, Orbetello, Figline-Valdarno, Bolgheri, Carniol, Fourneville, Crouy-sur-Ourcq, Saint-Antonin. I think particularly of those places of lengthy stays where I found joy and inspiration: Campo-Fioretti, Castiglioncello de Bolgheri, Le Palagio, La Cabane-de-Carniol, Les Hunières, Le Moulin: thanks to Lodovico Antinori, Anatole Dauman, Claude and Myriam Gregory, Mario Incisa, Mathilde Martinaud-Déplat, Charles and Jocelyne Nugue, Simone and Florence San Clemente.

Complementary Notes for the Second Edition

1. In this volume, I should have made the relation and distinction between "classical science" and "modern science" more precise.

2. Part One, 1, "Order and Disorder:"

(a) I am introducing in this present edition, the notions of Chaomos and of Pluriverse.

(b) In what concerns the meaning of the notion of entropy, I believe I am outside the polemics introduced by Tonnelat and aiming at identifying entropy with disorder. As far as I am concerned, the idea of entropy, in this text, is not a physical idea to which I reduce or relate the idea of disorder. It is a thermodynamic idea which leads us to the general physical idea that there is, in the time of our universe, a tendency to change and to dispersion and, in what concerns organized things and beings, to disorganization.

3. Part Three, 2, "The Physics of Information:" I neglected to consider the idea of "informational motor" (Rybak) concerning "living machines." In the same chapter, I will transpose today the accent from *information* to *computation* (which I accomplish in *Method 2*).

4. I regret the important gaps found in my bibliography. As soon as I have the leisure to return seriously to this volume, I will try to repair the injustices unconsciously committed.

5. This is to say that I have not made an in-depth critical rereading of this volume. I have limited myself to making corrections of various typographical, grammatical, or syntactical errors detected since its publication.

E.M., September, 1980.

Part 1

**Order, Disorder
and Organization**

1. Order and Disorder

(from the laws of Nature to the nature of laws)

The most beautiful arrangement is a pile of filth disposed haphazardly. Heraclitus.

...An order had arisen from the Decadence and Disorder. He Xiu.

Let them no longer speak to us of the Laws of Nature. Léon Brillouin.

I. The Invasion Of Disorders

I am not fooling myself about what a surprise it is to strain your mind by announcing the fatal destruction of heaven and earth. Lucretius (De Natura Rerum, Book V).

*King Order*¹

Order, Master-Word of classical science, reigned from the Atom to the Milky Way. It displayed itself so much the more majestically as the earth became a small planet (Galileo, 1610) and as the sun reentered the pale of the galaxy (Thomas Wright, 1750). From Kepler to Newton and Laplace, it is established that the innumerable nations of stars obey an inexorable mechanism. A few comets seem to go their own way in the cosmos; in fact they follow a path traced beforehand. The weight of bodies, the movement of tides, the rotation of the moon around the earth, the rotation of the earth around the sun, all earthly and heavenly phenomena obey the same law. The eternal Law which regulates the fall of apples has supplanted the law of the Eternal which, for an apple, caused Adam to fall. The word revolution, if it concerns stars and planets, signifies faultless repetition, not revulsion, and the idea of Universe evokes the most perfect of clocks. Right up to the experiment of Michelson (1881), the marvelous machine bathed in oil, that is to say, ether...

This clockwork Universe marks time and crosses time unalterably. Its texture, everywhere the same, is an uncreated substance (matter) and an indestructible entity (energy). The laws of physics, except for the strange exception of the second law of thermodynamics, know no dispersion, wear, and degradation. The self-sufficient Universe maintains itself perpetually. The sovereign order of the Laws of Nature is absolute and immutable. Disorder is excluded, from the beginning, forever. Only the weakness of our understanding forbids us to conceive in its fullness the universal, impeccable, unalterable, irrevocable determinism. But as Laplace had imagined it, a demon capable of observing all the universe at a given moment and knowing its laws would be able to reconstitute all its past events and foretell all its future events.

Certainly, on an earthly scale, one's view can be shocked by a few disorders and chances, a few noises and furors. But they constitute only the quasi-phantasmic foam of reality. "The play of irrational chance reigns only on the surface," Hegel said. True Reality is physical Order where everything obeys the Law of Nature, biological Order where every individual obeys the Law of the Species, social Order where all humanity obeys the Law of the City.

However, the society of mankind now unfreezes, transforms itself. Behold, since 1789, the word Revolution no longer signifies the same starting over again the same, but break up and change. Behold, we discover that life, far from being fixed once and for all, is part of evolution. The Universe itself—and Laplace himself had already supposed it—seems issued from a "primitive cloud." But the idea of Order emerges grown up, adult: is it not a sign that the Universe has passed irrevocably from the vaporous limbos to the fullness of Order? That life, obeying natural laws of adaptation and selection, has developed itself to reach this rational order which the name *homo sapiens* symbolizes? That societies obey a Law of progress which makes them accede to a superior Order? The Laws of Evolution and of History illustrate and consecrate the imminent coming of rational Order. The latter makes his last sketches, like an artist before his masterpieces. The ultimate disorders, on the little planet Earth, are going to be reabsorbed and dissipated.

*From the Degradation of Energy to the Degradation of Order:
The Upsurge of Disorganization.*

Now suddenly, in the course of the 19th century, a small pocket of disorder is created at the very heart of the physical order. Hermetically confined at first, and feeding exclusively on gas, it becomes omnivorous, gets closer and closer, until it threatens the whole Universe.

It eats away at what has become the unvarying motor of physics and the key to the industrial age: energy. The first law of thermodynamics recognizes in energy an indestructible entity, endowed with a polymorphous power of transformation (mechanical, electrical, chemical energy, etc.). This law offers, therefore, to the physical universe a guarantee of self-sufficiency and of eternity for all its movements and works.

The second law, outlined by Carnot, formulated by Clausius (1850), introduced the idea, not of loss—that would contradict the first law—but of *degradation* of energy. Whereas all the other forms of energy can be transformed integrally from one to another, the energy which takes a calorific form cannot be entirely reconverted and thus loses part of its aptitude to do work. Now, all transformation, all work gives off heat, therefore contributes to this degradation. This irreversible diminution of aptitude to transform itself and to do work, proper to heat, Clausius called entropy.

Since then, if we consider a system which is not fed by exterior energy, namely a "closed" system, any transformation therein is accompanied necessarily by an increase of entropy and, according to the second law, this irreversible degradation can only increase to a maximum, which is a state of homogenization and thermic equilibrium wherein the aptitude for work and the possibilities of transformation disappear.²

The surprising thing is that the law of degradation of energy from Carnot, Kelvin, Clausius was transformed into the law of degradation of order in the course of the second half of the 19th century, with Boltzmann, Gibbs, and Planck.

Boltzmann (1877) elucidates the energetic originality of heat by situating his analysis at a level till then unknown: that of micro-units or molecules constituting a given system. Heat is energy proper to the disordered movements of molecules within this system, and every increase of heat corresponds to an increase of agitation, to an acceleration of these movements. It is, then, because the calorific form of energy carries disorder in its movements that there is an inevitable degradation in aptitude to work.

Thus, all increase of entropy is an increase of internal disorder, and maximum entropy corresponds to total molecular disorder at the heart of a system, which manifests itself at the global level by homogenization and equilibrium.

The second law is no longer stated in terms of work. It is posed in terms of order and disorder. It is stated, consequently, in terms of organization and disorganization, since the order of a system is constituted by the organization which arranges the heterogeneous elements into one whole.

Therefore, entropy is a notion which means simultaneously:

- | | | |
|------------------------------|---|---|
| —degradation of energy | { | <i>molecular disorder, macroscopic thermic equilibrium, homogenization, impossibility of transformation</i> |
| —degradation of order | | |
| —degradation of organization | | |

It signifies at the same time that this triple degradation obeys an irreversible process inside closed physical systems.

Here again Boltzmann develops a totally new approach: that of statistical probability. The number of molecules and the configurations they can take inside a system are immense, and can be calculated probabilistically. From this perspective, disordered configurations are the most probable and ordered configurations the least probable. Consequently, the increase of entropy becomes the passage from the least probable configurations to the most probable.³ In other words, *disorder and disorganization are identified with the greatest physical probability for a closed system.*

Clausius had not hesitated to generalize the influence of the second law to the whole universe, which, conceived as a Whole possessing finite energy, could be considered a closed mega-system. Whence his formula, "the entropy of the universe tends towards a maximum," that is to say towards an unavoidable "thermic death," which would mean, according to the perspective opened by Boltzmann, towards disorganization and disorder.

The second law would stir up, therefore, an attack on cosmic order. But the prophecy of Clausius had been contested in its premise: the legitimacy of the transfer of the notion of closed system to the cosmic scale. Can we consider the universe not only as closed or open, but as a system? The inadequacy of the extrapolation appeared evident on one essential point: in the closed system of thermodynamics, the states of order/disorder are both initial and improbable. If order and organization were improbable, how is it that we would be able to count atoms, molecules, and stars to infinity? How could the irreversible progression of disorder be compatible with the organizing development of the material universe, then of life, which leads to *homo sapiens*?

Besides, on the human and social scale, the corrosion of the second law was more than compensated for by the technical and scientific benefits which derived from it, benefits which constitute a victory for scientific order (under the aspect of statistical mechanics) and for techno-industrial organization over calorific disorder. Carnot's law enabled us to calculate the conditions for a machine's maximum output. Boltzmann's formula permitted us henceforth to

measure and to foresee the evolution of disorder, thus in one sense to control it. The chemistry which then develops integrates entropy in the definition of free energy, free enthalpy, and chemical affinity. The notion of entropy contributes to the development of the theory of thermic machines and of thermo-chemistry. Entropy thus appears, not as a regression of order, but as a progress of science.

Finally, Maxwell discovers the Achilles heel of the second law; the imaginary experience of Maxwell's "demon"⁴ shows that the prediction of homogenization and equilibrium can be contradicted, at the very heart of a closed system, that is to say without any outside contribution of energy to the system.

So then, the corruption of disorder, far from invading everything, was undermined logically (by Maxwell's demon), controlled scientifically (by Boltzmann's theory), used productively (by thermic machines); it dissolved in a grand cosmic question mark as soon as we wanted to consider it on the scale of the universe. It went against contrary evidence from biological, anthropological evolution. Order thus seemed restored.

Yet as in all restoration, a pillar of the ancient order had collapsed, and the very idea of order had become problematic. Starting from the moment when it is posited that the states of order and organization are not only degradable, but improbable, the ontological evidence of order and organization is found to be overturned. The problem is no longer: why is there disorder in the universe even though universal order reigns therein? It is: why are there order and organization in the universe? Ceasing to constitute ontological evidence, order and organization now become a problem and a mystery: they must be explained, justified, legitimized.

Does not the question concern only "closed systems?" Not at all, since "open systems" work, and all work poses the problem of an increase of entropy. The question, therefore, is amplified and developed: *What are these open systems? How are they organized? How do they avoid disorganization? Do they avoid it in the long run?* How to explain the appearance, existence, evolution of biological organization? Social organization? Is there, as Bergson⁵ once suggested, he who had the merit of confronting the problem (but could only state it in Manichean alternative), "living matter" other than physical matter, which escapes the reaches of degradation? A virtue proper to living organization? We had to wait a long time before these questions were drawn out of their lethargy. Meanwhile, order had choked their impertinence with its crushing weight. It is admirable that these problems had been choked as it always happens when the confrontation of two contrary laws leads to explosive tension or total incoherence; in that case, the culturally stronger law cancels

out the question raised by the other. Thus it was for decades with the enormous questions raised by the Boltzmannian problematic.

Surely, a new partner had burst out of the closed box of thermodynamics: *a law of irreversible degradation always at work everywhere in the universe where there is work and transformation*. The breakthrough of disorder was both limited (in the physical pocket of "closed systems") and unlimited (in the sense that it accompanies all work, even in an "open" system).

But this disorder, spurting up in the tracks of the second law, is only a parasite, a sub-product, a waste product of work and of productive transformations. It has not the slightest utility, fertility. It brings only degradation and disorganization. Its place, then, is in the latrines of *physis* and of the cosmos. Order can continue to reign over the world.

The Disarray in Micro-physics

In 1900, suddenly, a formidable breach was opened in the micro-physical foundations of order. Yet, the atom had not at all betrayed physical order by ceasing to be the primary, irreducible, substantial object: Rutherford had changed it into a little solar system composed of particles gravitating around a nucleus, as marvelously ordered as the great astral system. Micro-physical order seemed then to have to be symmetrical to macro-cosmic order, when the accident happened. The virus of disorder, nourished by Boltzmann and Gibbs, suddenly implanted itself in micro-physics with the discontinuous notion of quantum energy (Max Planck) and swamped the basements of matter.

Particles which appear can no longer be considered elementary objects clearly definable, retrievable, measurable. The particle loses the surest attributes of the order of things and of the things of order. It clouds up, dissociates itself, undetermines itself, polydetermines itself under the observer's gaze. Its identity is dislocated, distributed between the state of corpuscle and the state of wave. Its substance is dissolved, the stable element becoming chance happening. It no longer has any fixed and unequivocal localization in time and space. A delirious subatomic soup of photons, electrons, neutrons, protons disintegrates all that we understand by order, organization, evolution. Certainly, everything returns to order at the statistical level. Certainly, the atom remains an organized entity, a system, which a coherent mathematical formalism explains. Therefore, the disorder lies in the lower microcosmic depths. Apparently, it does not reach our scale of thought and reality. Is it micro-physical reality which eludes our concept of order because of the order of concepts, or else is it our thought that does not manage to conceive this other order, which cannot do without what we call disorder?

Now, this disorder is present in the micro-tissue of all things: suns, planets, open or closed systems, inanimate things or living beings. At the same time, *it is totally different from the disorder attached to the second law of thermodynamics*. It is not a disorder of degradation and of disorganization. It is a constitutional disorder, which is necessarily part of *physis*, of all physical being. It is part—but how?—of order and organization, while being neither order nor organization!

Thus, therefore, disorder has rung a second time. A second time physical order evidently supports all things. A second time order and organization are a problem, become an enigma. This second time, disorder is a disorder which, instead of weakening, creates. But, becoming inconceivable and incomprehensible, it is kept bolted in the cellars of micro-physics, and a sanitary cordon is established around the source of trouble to prevent it from contaminating the rest of the universe.

Genesis Disorder

In one century, disorder has gradually infiltrated *physis*. Beginning with thermodynamics, it passed through statistical mechanics and has ended up in the paradoxes of micro-physics. Along the way, it has transformed itself: from waste product of the real, it henceforth is part of the stuff of the real. But, just as the first disorder was sent back to the latrines, this one is thrown into the dungeon. This is because cosmic order, imperial, absolute, eternal, continues to rule an ordered, spherical clockwork universe.

But from the 1920's this universe expanded, then dispersed; then in the 1960's, it showed cracks, became dislocated, and suddenly crumbled.

A curtain raise, in 1923, discovered the existence of other galaxies, that soon will be counted by millions, each one squirming with one to one hundred billion stars. Unceasingly since then, infinity recedes into infinity, and the visible gives way to the unheard of (quasars are discovered in 1963, pulsars in 1968, then "black holes"). But the great revolution is not to discover that the universe extends unbelievable distances, and that it contains the strangest stellar bodies: *it is that its extension corresponds to an expansion, that this expansion is a dispersion, that this dispersion is perhaps of explosive origin.*

In 1930, Hubble's proof of the displacement towards red of the light emitted by distant galaxies allows us to conceive and to calculate their speed going away from us and furnishes the first empirical basis for the theory of the expansion of the universe. The observations which follow are integrated in this theory which disintegrates cosmic order. The galaxies journey one from the other in a universal drift which seems at times to reach terrifying speeds. In

1965, an isotropic radiation coming to us from every horizon of the universe is recorded. This thermic "rumble" can be logically interpreted as the fossil residue of an initial explosion. This stuttering message from the end of the world crossed ten to twenty billion years to announce to us finally the extraordinary news: the universe has crumbled. Since then, the discoveries in astronomy from 1923 to today link up to present us a universe whose expansion is the fruit of a primordial catastrophe, tending towards an infinite dispersion.

The grandiose arrangement of the great stellar ballet has been transformed into a general rout. Beyond the provisional order of our little galactic suburb, which we had taken as universal and eternal order, unheard of events happen which are starting to be announced on our telescriptors: flashing explosions of stars, collisions of heavenly bodies, clashes of galaxies. We are discovering that the star, far from being the perfect sphere marking off the sky, is a hydrogen bomb ticking away, a flaming motor; born of catastrophe, it will burst sooner or later in catastrophe. The cosmos is burning, spinning, decomposing. Galaxies are born, galaxies die. We no longer have a reasonable, ordered, adult Universe, but something which seems to be still in the spasms of Genesis and already in the convulsions of agony.

The physical pillar of order has been corroded, undermined by the second law. The micro-physical pillar of order had collapsed. The ultimate and supreme pillar, that of cosmological order, collapses in its turn. In each of the three scales with which we consider the Universe, the macrocosmic, the micro-physical, and the scale of our physical "average band," disorder rises up to claim audaciously the throne which order used to occupy.

But since then an unsuspected, fabulous problem is posed. If the Universe is an explosive diaspora, if its micro-physical tissue is indescribable disorder, if the second law recognizes only one probability, disorder, then, how is it that the Milky Way numbers billions of stars, how is it that we have been able to count 500 million galaxies, how is it that we can count possibly up to 10^{73} as the number of atoms in the visible universe? How is it that we have been able to discover Laws which govern the heavenly bodies, atoms, and everything that exists? How is it that there has been a development in the organization of the cosmos, from atoms to molecules, macro-molecules, living cells, multicellular beings, societies, up to the human mind which poses these problems?

Let us pose the problem, no longer as an alternative of exclusion between disorder on the one hand, order and organization on the other, but of liaison. In that case, the genesis of material particles, nuclei, atoms, molecules, of galaxies, stars, planets is undissociable from diaspora and catastrophe; in that

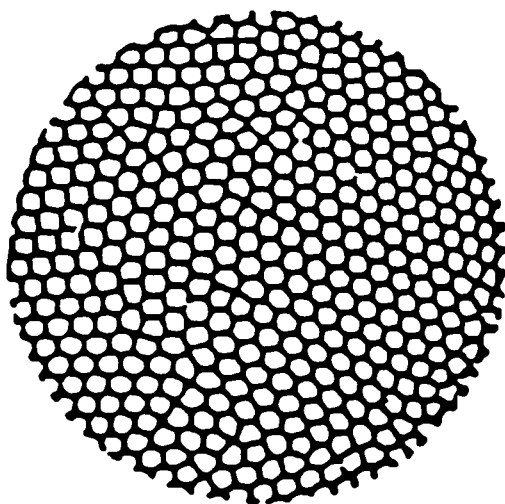
case, there is a crucial relation between the unleashing of disorder, the constitution of order, the development of organization.

Thenceforth, there arises a third and grandiose face of disorder, itself inseparable from the other two faces which we have seen here: this disorder while containing the disorder of calorific agitation and the disorder of the micro-tissue of *physis*, is also a disorder of *genesis and creation*.

Disorder as Organizer?

Now, we can today question the possibility of a genesis in and by disorder, by returning to the thermodynamic source from which disorganizing disorder had sprung, and from which today the idea of disorder as organizer springs. This is because the new development of thermodynamics, whose initiator is Prigogine, shows us that there is not necessarily exclusion, but perhaps complementarity between disordered phenomena and organizing phenomena.

The example of the Bénard convection patterns comes even to demonstrate experimentally that calorific fluxes, in conditions of fluctuation and instability, that is to say of disorder, can be transformed spontaneously into "structure" or organized form.



Bénard's convection patterns

Let us extract a few points from the description of the Bénard convection patterns which Prigogine gives. "We heat a liquid layer from underneath. Following the application of this constraint, the system leaves the state of equilibrium corresponding to the maintenance of a uniform temperature in the layer. By a few little gradients of temperature, heat is transported by conduction, but starting with a critical gradient we also have transportation by convection. The figure gives us a picture of the convection cells photographed vertically. We must note the regular arrangement of the cells, which have an hexagonal form. We have here a typical phenomenon of structuration corresponding to a high level of cooperativity on a molecular level." (Prigogine, 1972, pp. 552-553)

This apparently infantile example has general physical and cosmic value. It shows us that deviance, perturbation, and dissipation can provoke "structure," that is to say, both organization and order.

It is therefore possible to explore the idea of a universe which constitutes its order and its organization in turbulence, instability, deviance, improbability, energy dissipation.

Much more than that: in trying to understand living organization from the point of its internal machinery, Von Neumann discovers, in the course of the 1950's, in his reflection on self-reproducing automata (Von Neumann, 1966) that the great originality of the "natural" (read: living) automaton is to function with disorder. In 1959, Von Foerster suggests that the order proper to self-organization (read: living organization) is constructed with disorder: it is the *order from noise principle* (Von Foerster, 1959). Atlan, finally and above all, formulates the idea of *chance as organizer*. (Atlan, 1970 a, 1972 b)

Thus, therefore, the first (thermodynamic) apparition of disorder brought us death. The second (micro-physical) brought us being. The third (genetic) brings us creation. The fourth (theoretical) links death, being, creation, organization. Let us try to understand.

II. From Genesis to the Tetralogue

A. The Problem of Origin

The answers brought to the cosmologic problem are marked by a double fragility. The first comes from the fact that the more removed we are in space-time—therefore, the further back we go—the more the data of observation become uncertain, equivocal; the more we discover black holes and black oceans, the more the shadow of the unknown and the inconceivable

grows; the more at the same time hypotheses require the active concourse of the imagination. At this point the second fragility arises: calls to the imagination are at the same time calls to the imaginary; the problems of the universe mobilize, most often unconsciously even in astronomy, the occult powers of mythologization and rationalization (which, here, are *the same*). Since its birth in the first half of our century (J. Merleau-Ponty, 1965), cosmology has leaned towards the "rationalization" of order, that is to say towards an uncreated, self-sufficient universe sustaining itself by itself forever. Such a vision not only cleverly had the classical aporia, where the absence of beginning and absolute beginning are both inconceivable, but, by eliminating a problematic of genesis, it eliminated at the same time the fundamental perspective of becoming and evolution which had been acceptable in all the sciences. This vision has collapsed under the thrust of Hubble's observations, which have become the support of a new vision.

This new vision can be considered under at least two aspects: the expansion of the Universe and the origin of the Universe. The theory of expansion, if it means that the cosmos was previously less dispersed than it is today, is generally no longer in question. What is contested, rather, is the reduction of cosmic development to a rigid and absolute concept of an expansion which would have started at point zero and would be prolonged in infinite dispersion. At any rate, the problem raised by certain paradoxical observations (like the photograph of a galaxy which seems connected by a bridge of matter to a quasar which should be much further away than the galaxy) or the counter-hypotheses (like attributing to possible photonic "fatigue" the displacement towards the red of light emitted by distant galaxies), far from tending towards reestablishing the ancient order, bring, as the case may be, disorder or complexity in the expansion.

The *big bang* theory is in one sense a logical consequence of the theory of expansion, which rebounds up to the origin of the Universe by basing itself on the discovery of isotropic radiation at 3°K considered as fossil witness of an initial explosion. But this theory is more fragile than the theory of expansion, not only because it crowns a hypothetical castle of cards, but especially because it rests on an epistemological deficiency.

The *big bang* theory supposes that a concentrated state of infinite density would have been at the source of the Universe, which would have been born in and by an explosive happening.

The idea of an initial point, which would concentrate infinite density in a spatial zero imposes itself no more rightly than the idea of an infinite negative entropy receding into past infinity. Like the theory of the stationary state of the universe, but in an inverse sense, it cleverly hides the aporia of the beginning.

It presents, as logical solution to the problem of the beginning, a contradiction which obliges us to make the punctual and the infinite coincide. In the previous universe, order was the simple and evident support: the *big bang* theory looks for an elementary and punctual beginning, and only finds an aporia. This is because the search for origin has deteriorated into a search for a starting *point*, and the search for a rationalization has led necessarily to an irrationality.

Let us repeat, the problem of origin includes an insurmountable contradiction in its terms. It is a matter, not of undergoing aporia while believing we are avoiding it, but of conceiving it head-on.

Whence a preliminary to all theory of origin: we cannot theorize as if this problem were not fundamentally mortgaged by our own mental structures. The first choice, therefore, is not theory: it is in the mode of constitution of the theory. It is not only a matter of interrogating ourselves on our knowledge [Fr. *nos connaissances*], we must also interrogate ourselves on our understanding.

That is going to lead us very far, in this work, as we shall see (if we have the patience). For the moment here, it means that the aporetic contradiction has to reveal, not only the complexity of the problem posed, but also the logical complexity of the foundations of our universe. It incites us to see in the unknown inconceived which precedes and triggers the birth of our universe neither a void nor a lack of reality, but reality other-worldly and pre-physical,⁶ source of our world and our *physis*. Given this, it is useless to look for spatio-temporal or logomorphic figuration concerning the state or the being which precedes our universe.⁷

Let us come to the *big bang* theory itself. The *big bang* theory is in fact a subnotation which cleverly conceals under an onomatopoeia of big boom the problematic of a formidable transformation. Certainly the interest of the *big bang* is to evoke for us a thermic explosion. Its insufficiency is to reduce the origin to the sole dimension of the thermic explosion. We must, therefore, go beyond the *big bang* by a truly theoretical notion: the notion of *catastrophe*.

The term *catastrophe* has to be conceived, not only in its traditional and geo-physical and geo-climatic sense, but especially in the one which René Thom gave it. (Thom, 1972) This sense, associated to a new topological conception where the term *form* takes on a strong sense, means: change/rupture of the form in condition of irreducible singularity. The fundamentally complex and rich idea that Thom brings is to tie all morphogenesis or creation of form to a rupture of form or catastrophe. *It allows us, therefore to read disintegration and genesis in the same processes.* Metamorphic idea, catastrophe is not identified with an absolute beginning, and it leaves open the mystery of the a-cosmic or proto-cosmic unknown. It carries in it the idea of

Event and cascades of events. Far from excluding the idea of disorder, it includes it, and in a genestic way, since the rupture and disintegration of a previous form is the very constitutive process of the new form. It contributes to making us understand that the organization and the order of the world are built in and by disequilibrium and instability.

I add finally that, different from the *big bang* which is a concentrated moment in time and which becomes a cause separated from the processes which triggered it and which it has triggered, the idea of catastrophe, while welcoming the idea of an explosive happening, is identified with the whole metamorphic process of transformations which disintegrate and create. Now, this process *is still going on today*. Consequently, we are not going to circumscribe catastrophe as a pure beginning. It is the origin, explosive or not, of our universe which is part of a catastrophe, and *this is still going on today*. The idea of catastrophe is *inseparable from our entire universe*.

Original Complexity

The irreversible proof of Hubble's revolution is not only to have irremediably destroyed the old order, the perpetual machine, the steady state, the trivial and flat cosmos, but especially to necessitate a complex principle of explanation. The simple idea of external order cannot be replaced by another simple idea, even that of disorder. The true message which disorder brought us, in its voyage from the thermodynamic to the micro-physical and from the micro-physical to the cosmos, is to enjoin us to set out on the search for complexity. Evolution can no longer be a simple idea: ascensional progress. It has to be simultaneously degradation and construction, dispersion and concentration. It will be impossible for us, as we shall see, to isolate a master-word, to hierarchize a primary notion, a primary truth. The explanation can no longer be a rationalizing schema. Order, disorder, organizing potentiality must be thought of together, both in their well-known antagonistic character and in their unknown complementary character. These terms shuttle from one to the other and form a sort of moving loop. In order to conceive this, we need more than a theoretical revolution. A revolution of principle and of method are called for. The question of the genesis of the cosmos is, therefore, at the same time, the key question of the genesis of method.

B. Disintegration as Organizer

We cannot escape the unbelievable idea: *it is by disintegrating that the cosmos organizes itself*.

Now, this unbelievable idea is the only one which can furnish today the texture of a plausible theory on the formation of the physical world. In fact, it is starting from a thermic unfurlment that the apparition of particles, nucleo-syntheses, the formation and the lighting of stars, the constitution of heavy atoms can become comprehensible, by and for astro-physics, on the basis of nuclear physics and astro-observation.

The scenario presently admitted (R. Omnes, 1973; D.W. Sciama, 1970; J. Merleau-Ponty, 1970; H. Reeves, 1968; E. Schatzmann, 1968; J. Heidmann, 1968) does not have any weight of certitude, evidently. Our new knowledge of the universe includes too much unknown and inconceived not to find itself soon modified and even overthrown. But what concerns me at this point is not so much the proposed scenario as the necessity of a scenario which accounts for both dispersion and organization, disorder and order. What is going to interest me is not the "novel" of the Universe (even though the Universe, in becoming a story of chance with *suspense*, has henceforth its incontestable imaginative dimension); it is the conceptual, theoretical, even logical and paradigmatic choices which, after the collapse of our world, are going to permit us to conceive a new one.

The Scenario of Cosmogenesis

A cloud of photons rises up, dilates. As it transforms itself, it is going, as Michel Serres says, "to make the world." (Serres, 1974, p.61) The initial temperature of this fiery cloud which is going to cool is estimated to be 10^{11} °K. The first particles materialize in it: electrons, neutrinos, neutrons, protons. As the temperature begins to decrease, but still with very great heat and density in the cloud, that is to say in a formidable thermic agitation, the first nucleo-syntheses take place by chance encounters in which protons and neutrons aggregate to constitute nuclei of deuterium, helium and hydrogen.⁸ Cosmogenesis begins, therefore, in micro-genesis.

This first micro-genesis (which will follow its course at the heart of future stars) permits the triggering of galactic and astral macro-genesis. In fact, turbulences provoke inequalities at the heart of the cloud which increases its volume, and some first dislocations split it apart. From then on, in each of these first fragments, gravitational interactions attract particles in masses; regional increases of density increase the gravity which in turn increases the density of these regions; *the schismatic process is at the same time a morphogenetic process*: the cloud splits everywhere, dissociates into proto-galaxies; the proto-galaxies, under the effect of the same processes, in turn break up. Proto-stars are constituted by gravitational assemblings; the increase

of density increases the increase of density; this density becomes such, at the heart of astral nuclei, that collisions between particles are multiplied in an ever more violent fashion, until they trigger thermonuclear chain reactions: thenceforth the star is lit. It should explode, like a hydrogen bomb, but the gravitational rush to the heart of the star is by nature almost implosive, and the two antagonistic processes cancel each other out and link up with each other in a sort of mutual regulation, which allows the star to begin its life, perhaps lengthy, up to the final explosion or contraction.

Henceforth, it is at the heart of and starting from the stars that cosmic order and organization are deployed. The stars impose their gravitational empire on immense spaces. With their planets they constitute almost perfect clockwork systems. They are machines manufacturing physical matter; they produce in fact heavy atoms, including those which are going to constitute planets, among these the third planet of a suburban sun which one day will see living beings born, whose carbon, oxygen, nitrogen have been forged in the brazier of the star.

The Transformations of Disorder and the Disorder of Transformations

This polymorphic cosmogenetic process can only be understood by appealing to notions which include, each in its way, the idea of disorder.

Materializations by the formation of particles can be conceived as "first steps towards quality and organization" (Ulmo, 1967). But they can be conceived at the same time as a disintegration of the primitive radiance: Act I is also a cosmic crumbling, and this pulverization into disorder becomes the condition of assemblings, syntheses, linking, then later of communications between the crumbs of diasporated matter.

Nucleo-syntheses, at the heart of the cloud as at the heart of incandescent stars, are inseparable collisions and shocks. Formations of galaxies are inseparable from tears and ruptures at the heart of the cloud, and formations of stars are inseparable from tears and ruptures at the heart of the proto-galaxy. The lighting of the stars happens at the point of explosion, with the risk of explosion. We see plainly, therefore, that the rupturing idea of catastrophe is essential in order to conceive the birth of cosmic organization and order.

At the same time the idea of schism becomes an idea consubstantial to all morphogenesis. This key idea, that all morphogenesis is tied to a schismogenesis, is articulated necessarily on catastrophe theory; thus, materialization appears as a schism and a deviation in relation to the radiance; masses are then constituted as schisms in relation to the cloud, in relation to the movement of diaspora, in relation to other masses. Deviations transform locally the process

of diaspora into a process of concentration. Astral condensation is a deviance which ruptures and reverses the movement of generalized dispersion without escaping nevertheless (because the galaxy and the star in formation are carried away in the expansion of the universe); condensation works with increasing force and accelerating speed at assembling particles, which are going to become a star. At this point we can already have the concept of positive retroaction intervene (positive feedback), which means accentuation/amplification/acceleration of a deviance itself. The constitution of the star is an increase of density which is increased by itself until the lighting, which triggers a counter-process.

Thus, the genesis of the star can be envisaged in function of the catastrophe which is the rupture of the cloud, which triggers, in a sense inverse to the general process of dispersion, a positive retroaction (self-accelerating condensation), a process triggering a new catastrophe (lighting) which triggers a new positive retroaction in the explosive sense; thenceforth, the antagonism of these two inverse retroactions gives birth to the flamboyant stability of a sun.

Heat

Cosmogenesis is a thermogenesis. Heat, which is in this instance the idea of energy as matrix and motor, associates in its very concept energy and disorder, transformation and dispersion.

The universe is born in extreme heat, and this heat includes these forms of disorder: agitation, turbulence, inequality of process, chance character of interactions, dispersion.

The idea of inequality is capital. The general recooling is not homogeneous: it includes its zones of unequal character and its local moments of reheating. Thus, a first inequality in the recooling determines those diverse granulations which are particles (electrons, protons and neutrons); the temperatures, still very high in this first state of the cloud, are proper to the synthesis of the first nuclei and light elements, whose existence accentuates the inequality, that is to say henceforth the diversity of the material tissue of the universe. Next, a relative recooling is necessary, at the core of the stars, to make them light up. Then, a very high internal heat must be maintained at the heart of these stars to smelt the chemical elements which are to become preponderant, at least in our solar system. Then, a new recooling is necessary so that, on the surface of a planet like the earth, gaseous molecules might aggregate and form liquids, crystalline sets; finally, adequate thermic conditions are necessary to constitute molecules and macro-molecules, in short,

the materials of the living being which is constituted as a thermic machine.

Thus, we see that to very high temperatures there corresponds what is explosive, but also what is creative (nucleo-syntheses in the cloud, the constitution of atoms in the stars); to the relative recooling correspond liquifactions, solidifications, crystallizations, molecular linkages. Thus, cosmogenesis, which becomes biogenesis, is inseparable from a capricious, complex, and unequal dialectic of hot and cold.

The inequality of heat is the expression of an inequality in movement. Agitations and turbulences create the conditions of encounter (of particles, of atoms), of dissociation (at the heart of the cloud), of morphogenesis (of stars); and turbulences are reborn at the heart of the stars whose fire gives birth to atoms. Turbulence has an energetic character which can become a motor: the star is in a sense a vast turbulence which is concentrated, is intensified, and becomes after lighting an untamed motor which feeds a spontaneous internal machinery producing atoms and watering its environment with photonic energy. We begin to catch a glimpse of the possibility of what appeared inconceivable before: the passage from turbulence to organization. What is effected cosmogenetically in the birth of the stars corresponds to the idea that Prigoginian thermodynamics has brought to the fore (Prigogine, 1968), that organized phenomena can be born of themselves, starting from a thermodynamic disequilibrium (cf. the example already given of Bénard's convection patterns).

Inequality of development has as starting point the thermic character of the initial catastrophe. Beginning there, and no matter how minimal the catastrophe, there is inequality in the very emission of the cloud. Now, and this is what undermines in its very foundations the previous deterministic vision of the world, which was a vision of ice and not of fire: any deviation, even minute, which is constituted in the emitting source tends to grow and be amplified in an extraordinary way in the course of the process of diffusion. The minute variations which are produced in the very first conditions of dispersion are going to lead subsequently to extreme and extraordinary varieties. In this instance thermic inequalities are enchainned in a generative fashion, inequalities born of turbulences, inequalities of encounter, inequalities of transformation, inequalities provoked by ruptures, dissociations, collisions, explosions. These inequalities will be over-amplified, over-developed across multiple positive retroactions which are themselves inseparable from the bi-faced processes of schismo-morphogenesis. And this surprising praxis of mixed disorders (because inequalities, turbulences, agitations, chance encounters, etc., are forms of disorder) is the cosmic forge of order and organization, inseparable, we now understand, from a formidable and general dispersion,

inseparable from a fabulous waste...

This multiform inequality is at the same time the matrix of diversity: the small diversity of three types of primary material particles permits a big diversity of nuclear then atomic combinations between these particles, then an infinite diversity of molecular combinations between the ninety-two types of natural atoms. Now, diversity, which cannot be born outside of the inequality of conditions and processes, that is to say outside of disorder, is absolutely necessary for the birth of organization—which can only be organization of diversity (as we see with the nucleus, the atom, the molecule)—and for the development of order, inseparable, we will see, from such organizations.

Thus, disorder appears to us as the partner and component of all cosmogenetic processes. Consequently, it appears to us as a very rich notion: there is not *a* disorder (as there was *an* order) but several disorders: inequality, agitation, turbulence, chance encounter, rupture, catastrophe, fluctuation, instability, disequilibrium, diffusion, dispersion, positive retroaction, runaway, explosion.

At the generative source of cosmogenesis, there is disorder in its epoch-making form of rupture—the catastrophe—and in its energetic form—heat. Thenceforth, disorders are multiplied, in and by the disorder of transformations and the transformations of disorder, in and by equality of development: the disorder in disorders has become cosmogenetic.

The Birth of Order

Whence does Order arise? It is born at the same time as disorder, in thermic catastrophe and in singular primeval conditions which determine the constitutive process of the Universe.

These singular conditions, insofar as they are determinations or constraints, exclude henceforth *hic et nunc* other forms of universe, they orient and limit the possibilities of interplay at the heart of the process. Thus, these singular determinations which are both constraints and “rules of the game” constitute the first face of general order. I will have the opportunity to illustrate this indefensible paradox in the old vision of the world: it is the singular and event-full character [Fr. *événementialité*] of the cosmos which is at the source of its universal laws! They are universal in this precisely singular sense: valid exclusively for our universe. Another universe, born in different conditions, would obey other “laws.”

The first and fundamental constraints result from the constitution, in thermic conditions extremely precise and perhaps very limited in time, of particles which orient the universe in a well defined path of materiality. (In

fact, matter will take precedence over radiance in the cosmic cloud and today there remains from this radiance only a fossil echo, returning, from the horizons of the universe, in the form of a feeble thermic noise.) Each type of particle has singular characteristics from the point of view of mass and electric charge. Three of these types have a very great capacity for life and survival: protons, neutrons, electrons. The singularities proper to these limited categories of particles act as constraints which limit the types of possible interactions in the atomic core (strong and weak interactions) or in any material body (gravitational and electro-magnetic interactions). Thenceforth, we shall see, the rules of interaction are going to constitute the keystone of cosmic order, its "natural laws."

Thus, genesic conditions are determinations which give rise to Order at the same time as to the Universe. The determinations/constraints are going to become more precise and more numerous with materialization, in which the possibilities of interactions between particles become fixed; these particles will constitute the basis of physical processes, among them processes of organization. Thenceforth, the interplay order



through the interactions.

C. The Play of Interactions

Interactions are reciprocal actions modifying the behavior or the nature of elements, bodies, objects, phenomena present actually or influentially. Interactions

1. suppose elements, beings, or material objects capable of encountering each other;
2. suppose conditions of encounter, that is to say agitation, turbulence, contrary fluxes, etc.;
3. obey determinations/constraints inherent to the nature of elements, objects or beings in encounter;
4. become in certain conditions interrelations (associations, linkages, combinations, communication, etc.) that is to say give birth to phenomena of organization.

Thus, to have organization, it is necessary to have interaction; to have interaction, it is necessary to have encounter; to have encounter, it is necessary to have disorder (agitation, turbulence).

The number and the richness of the interactions increase when we pass to the level of the interactions, no longer only particles, but between organized

systems, atoms, stars, molecules and especially living beings, societies; the greater the diversity and the complexity of the phenomena in interaction, the greater the diversity and the complexity of the effects and the transformations born of this interaction.

Interactions constitute a sort of Gordian knot of order and disorder. The encounters are aleatory, but the effects of these encounters, on well-determined elements, in determined conditions, become necessary, and they establish the order of "laws."

Relationing interactions generate forms and organization. They give birth and long life to those fundamental systems that are nuclei, atoms, stars:

— "Strong" interactions bond protons and neutrons, and their bonding force, dominating the electric repulsion between protons, gives the nucleus a formidable cohesion.

— Gravitational interactions determine, cause, accelerate the concentration of galaxies, the condensation and lighting of stars.

— Electro-magnetic interactions bond electrons to nuclei, bind atoms into molecules, and in a complex fashion play a role in all stellar processes.

Once those organizations are constituted which are atoms and stars, the rules of the game of interactions can appear as Laws of Nature. Thus, the gravitational interactions discovered by Newton were interpreted as necessities imposing themselves on all physical bodies; therefore, as supreme laws, absolute, eternal, exterior to the objects in play. In fact, heavenly bodies, the keystones of cosmic organization, have their order reign and radiate over quasi-unlimited stretches. Since Newton, we could certainly sense that attractions depend on masses which depend on attractions. But we could not sense that these laws had a genesis. We could especially not conceive that these "laws" contribute as much to disorder as to order. Thus, "laws" of gravity have participated in cosmic dispersion (by contributing to the dislocation of the primitive cloud), and they have contradicted it (by determining the processes which form the stars). Thus, this law has one foot in organization, one foot in dispersion. The Laws of Nature constitute one face of a multifaced phenomenon which also includes its own face of disorder and its own face of organization. The laws which ruled the world were only a provincial aspect of a complex interactional reality.

Interaction thus becomes the turntable notion among disorder, order, and organization. By the same token, this means that the terms disorder, order, organization are henceforth bound, *via* interactions, in a solidary loop, where none of these terms can any longer be conceived without reference to the others, and where they are in complex relation, that is to say complementary, concurrent, and antagonistic. Two examples are going to help clarify my

thought.

The first illustrates the principle called order from noise by Von Foerster (1960): I will say, rather, the principle of organization by disorder.

Take a certain number of light cubes covered with a magnetic material and characterized by the opposite polarization of the two pairs of three sides joined in two opposite corners. We place the cubes in a box which we close and agitate. Under the effect of the agitation, the cubes are associated according to chance (whimsical) and stable architecture. At each new agitation, cubes re-enter the system and complete it, until the totality of the cubes constitutes an original unity, unforeseeable as such initially, both ordered and organized.

The condition of such a construction are:

a) determinations and constraints proper to the material elements present (cubic form, metallic constitution, differential magnetization) and constituting principles of order;

b) a possibility of selective interactions able to bind these elements in certain conditions and occurrences (magnetic interactions);

c) a supply of non-directional energy (disordered agitation);

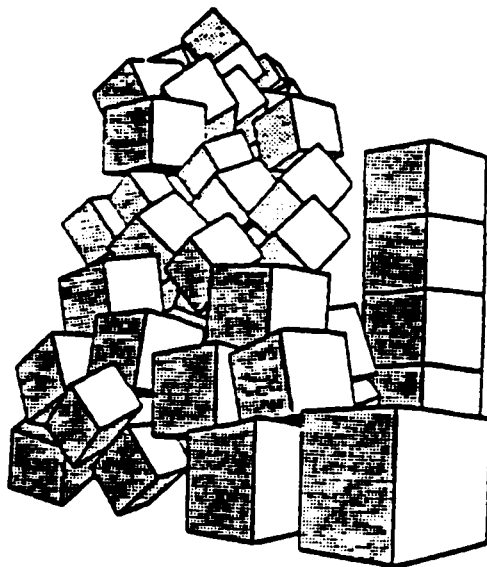
d) the production, thanks to this energy, of very numerous encounters among which an *ad hoc* minority establishes selectively stable interactions, which become, thereby, organizational.

Thus, order, disorder, organization have co-produced themselves simultaneously and reciprocally. Under the effect of chance encounters, the original constraints have produced organizational order, the interactions have produced organizational interrelations. (page 50 diagram) But we can also say that, under the effect of the original constraints and organizational potentialities, disordered movements, while triggering chance encounters, have produced order and organization. There is, therefore, clearly a loop of mutual co-production: order → disorder → interaction → organization

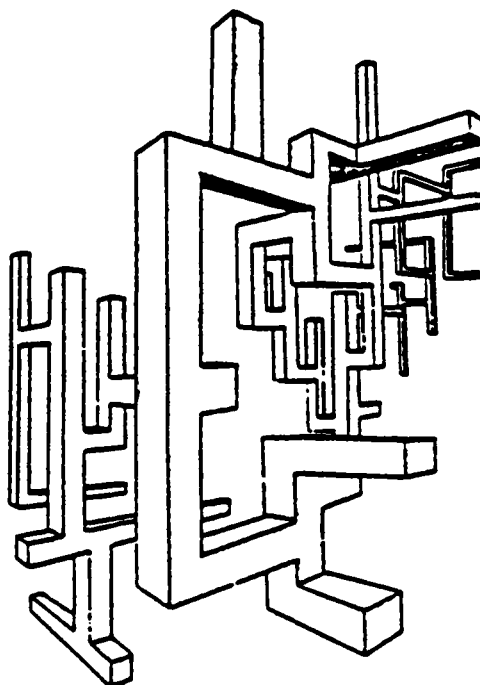


Thus constituted, organization remains relatively stable, even when the box continues to be agitated by the same jolts as those which produced it. Whence the remarkable characteristic: *once constituted, organization and its own order are capable of resisting a great number of disorders.*

Order and organization, born with the cooperation of disorder, are capable of gaining ground on disorder. This character is of capital cosmological and physical importance. Organization, and the new order tied to it, though born of minority interactions in the innumerable play of interactions in disorder, have a force of cohesion, of stability, of resistance which makes them privileged in a universe of fugitive, repulsive, or destructive interactions (cf. ch. 2, p.137); they benefit, in sum, from a principle of



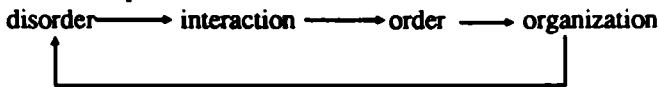
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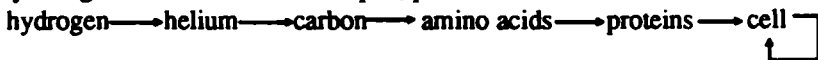
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natural physical selection. (We will see, even, that the sole principle of natural selection is physical, not biological.)

The second example ushers us into the very heart of morphogenesis: it is a question of the only hypothesis presently plausible concerning the formation of carbon at the heart of the stars. The constitution of a carbon nucleus requires the linking of three helium nuclei in extraordinarily improbable conditions of temperature and encounter. Two helium nuclei which encounter each other flee one another in less than a millionth of a millionth of a second. It is only if, in such a brief time, a third helium nucleus joins the pair, and bonds itself to them, that all three will be bonded, and that thus the stable triad of the carbon nucleus will be constituted. *In abstracto*, the birth of a carbon atom could only result from a fabulous chance. But, if we place ourselves at the heart of those fiery forges which are the stars (constituted mostly of helium), where the temperatures of reaction stay maintained for a rather long time, then we conceive that there is produced therein an unheard-of number of chance collisions of helium nuclei, and that among these collisions there is effected a minority of collisions producing carbon. Thus, there is a local and temporal probability that the very improbable carbon nucleus will be constituted at the heart of a star. Once constituted, these very strongly coherent nuclei are going to resist innumerable collisions and forces of rupture, and will be able to survive innumerable hazards. Benefiting thus from a natural physical selection, this improbable/necessary carbon, which possesses very rich associative qualities, makes possible, in determined local conditions, the constitution of amino acid molecules, which themselves are going to find in living cells the conditions both improbable and necessary of their making. And thus, this interplay in form of a loop:



by being transformed and developed, produces the chain:



The Grand Game

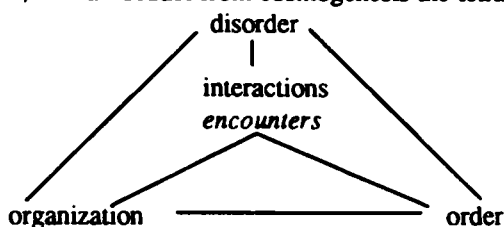
There is a grand game of disorder, order, and organization. We can say game because there are the pieces of the game (material elements), the rules of the game (initial constraints and principles of interaction), and chance distributions and encounters. This game initially is limited to a few types of operational, viable, singular particles and perhaps to only four types of interaction. But in the same way as at the beginning, from a very small number

of letters, there is the possibility of combining words, then sentences, then discourse, likewise, starting from a few "basic" particles, there are constituted, *via* interaction/encounters, combinatory and constructive possibilities, which will produce ninety-two kinds of atoms (the elements of Mendeleev's table), starting from which, by combination/construction, there can be constituted a quasi-unlimited number of molecules, whose macro-molecules, by combining, will permit the quasi-unlimited play of possibilities of life. The game is, therefore, more and more varied, more and more aleatory, more and more rich, more and more complex, more and more organizing. A principle of variety, already present in the electronic disposition around the core of the atom (Pauli exclusion principle), is deployed more and more at the level of chemical elements, molecules, and, of course, living beings. On the astral scale there is the diversity of the stars, and still more: we have discovered that there were not only suns of hydrogen/helium, but neutron stars, unbelievable masses and assemblages, perhaps of anti-matter. There again, the game produces diversity.

Thus, the game of the world goes on. As we will see, it permits local insular developments of order and organization, inseparable from the developments of diversity.

D. The Tetralogical Loop

Therefore, we can deduct from cosmogenesis the tetralogical loop:



The tetralogical loop signifies that interactions are inconceivable without disorder, that is to say without inequalities, turbulences, agitations, etc., which provoke encounters.

It signifies that order and organization are inconceivable without interactions. No body, no object can be conceived outside of the interactions which have constituted it, and of the interactions in which it necessarily participates. The particle, as soon as it becomes solitary, is blurred as object, seems to interact with itself,⁹ and in any case cannot be defined except in interaction with its observer.

It signifies that the concepts of order and organization develop only in function of one another. Order develops only when organization creates its

own determinism and makes it reign over its environment (and the gravitational order of the great heavenly bodies can, thenceforth, appear to the dazzled eyes of Newtonian humanity as the sovereign order of the universe). Organization needs principles of order intervening across the interactions which constitute it.

The tetralogical loop also signifies, and this we will see better and better, that the more organization and order develop, the more they become complex, the more they tolerate, use, indeed necessitate disorder. In other words, the terms order/organization/disorder, and of course interactions, mutually develop each other.

The tetralogical loop signifies, therefore, that we cannot isolate or hypostasize any of these terms. Each takes its meaning in its relation with the others. *It is necessary to conceive them together, that is to say as terms simultaneously complementary, concurrent, and antagonistic.*

Finally, this tetralogical relation, which I believe I have been able to deduct from cosmogenesis, must be placed at the heart of the problematic of *physis*. *Physis* emerges, unfolds, is constituted, is organized through the interplays of cosmogenesis which are the very interplays of the tetralogical loop.¹⁰ Consequently, we see however vaguely that this *physis* is much ampler and richer than was the old matter: *it possesses, henceforth, an immanent principle of transformation:* the tetralogical loop that we have seen at work.

III The New World: Chaosmos . Chaos, Cosmos, *Physis*

The Return of Chaos

Greek myth had chronologically dissociated originary chaos, a sort of monstrous pre-universe where Ouranos the Furious copulates with his mother Gaia and destroys his children, from the cosmos, an organized universe where law and order reign. Forgetting Heraclitus, classical Greek thought logically opposed *Hubris*, irrational excess, to *Dike*, law and equilibrium.

We are heirs of this dissociating thought. Moreover, we have consigned *Hubris* and *Chaos* to oblivion. Classical science would have nothing to do with an originary chaos in an eternally and substantially ordered universe. It had even, at the beginning of the 20th century, dissolved the idea of cosmos, that is to say, of a universe constituting a singular totality, in favor of an indestructible and uncreated matter/physical energy extending to infinity. In this physics, as I already mentioned, the Greek idea of a *physis*, rich with an

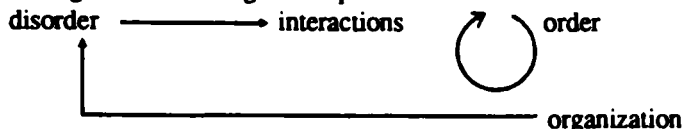
immanent principle of organization, had disappeared, the concept of organization being absent.

Now, post-Hubblean astronomy has explicitly regenerated the idea of cosmos by showing that the Universe was singular and original. I want to show here that this has implicitly rehabilitated the idea of chaos.

What is the idea of chaos? We have forgotten that it was a genesic idea. We see in it no more than destruction and disorganization. But the idea of chaos is first of all an energetic idea: it carries in its loins bubblings, flammings, turbulences. Chaos is an idea antedating distinction, separation, and opposition, an idea, therefore, of indistinction, of confusion between destructive power, between order and disorder, between disintegration and organization, between *Hubris* and *Dike*.

And consequently, what appears to us is that cosmogenesis takes place in and through chaos. *Is chaos exactly that which is inseparable in the bi-faced phenomenon by which the Universe simultaneously disintegrates and self-organizes, disperses and polynucleates...*

Chaos is disintegration as organizer. It is antagonistic unity of the explosion, the dispersion, the crumbling of the cosmos and of the nucleations, its organizations, its orderings. The genesis of particles, atoms, stars takes place in and through agitations, turbulences, stirrings, dismemberments, collisions, explosions. The processes of order and organization have not cleared the way for themselves like a mouse through the holes of the cosmic gruyère; they have constituted themselves in and through chaos, that is to say the circlings of the tetralogical loop:



In one of his densest aphorisms, Heraclitus made "the lower road" (let us translate: dispersive integration) and "the upper road" (let us translate: progressive evolution towards organization and complexity) identical.

The cosmos was formed in a genesic fire: everything which was formed is a metamorphosis of fire. It was in the fiery Cloud that particles appeared, that nuclei were bonded. It was in the fury of fire that stars lit up and atoms were forged. The idea and the image of Heraclitian fire belching, rumbling, destructive, creative is surely that of the original chaos whence logos arises.

What amazes us is precisely this genesic transformation of chaos into logos: it is that the originary fire, in its explosive delirium, can construct with neither engineer nor plan, through its disintegration and metamorphosis, those billions of fire-machines which are the suns. It is that disordered and

irreversible thermodynamic fluxes lead to quasi-cybernetic regulations. It is that chance turbulences, which break up the primitive cloud, become, by forming and transforming themselves into stars, the sovereign centers of a cosmic determinism, which, by linking planets to suns, took on the appearance of a universal and unalterable order.

It is, in a word, that bubbling up is at the very source of all organization (*organ*: to bubble up with intense heat).

Chaos is indeed originary; I mean that all that is originary partakes of this indistinction, this antagonism, this contradiction, this concord/discord where one cannot dissociate "what is in harmony from what is in disaccord." From this chaos arise order and organization, but always with the complementary/antagonistic co-presence of disorder.

But it is not enough to recognize originary chaos. We must break a mental, epistemic barrier. We are ready to admit that, in fact, the universe was formed in chaos, because we discover thereby all of the profound archaic myths of humanity. But provided it be well understood that the times of chaos are gone forever. The universe today is grown-up. Henceforth, order reigns. Organization has become the physical reality with its 10^{73} atoms and its billions upon billions of suns.

Now, we must give in to new evidence. Genesis has not stopped. We are still in the expanding cloud. We are still in a universe where galaxies and suns are being formed. We are still in a universe which is disintegrating and self-organizing in the same movement. We are still in the beginning of a universe which has been dying since its birth. It is this permanent and working presence of chaos which we must make people see, and, first of all, by considering the pillars of what is order and organization: atoms and suns.

Suns and Atoms

Let us consider the two centers, pillars, foundations of order and organization in the universe, the Atom which reigns over the microcosm, the Sun which reigns over the macrocosm. Both extend over very long distances, the atom in its sphere of electronic attraction, the sun in its sphere of planetary attraction. They are the two hard cores of what we call the real. They are, moreover, genesically associated: the stars were constituted from light atoms, the other atoms were constituted in the stars...

The atom is the brick with which the organized universe builds itself; its bonds form liquids, solids, crystals. The edifices of the diverse atoms are the molecules, from which macro-molecules are built, then, on our earth, living

cells, organisms, societies, humans.

Nevertheless, at the level of the particles which constitute the atom, all is indistinction and confusion; the particle has no logical identity: it oscillates between element and event, order and disorder. If we consider the universe on the micro-physical scale, it is nothing more than a "soup of electrons, protons, photons, of all beings with poorly defined properties in perpetual interaction." (Thom, 1974, p.205)

This fabulous omnipresent subatomic "soup" indicates to us that chaos is permanently below the surface as the infratexture of our *physis*. The atom is the transformation of this chaos into organization. In fact, a coherent mathematical formalism attests to this organization. But only to this organization, not to the elements which constitute it; these continue to flicker from a base of stability, indetermination, disorder. The organization of the system can be described as a set of interactions, but in which each interaction cannot be described separately. Moreover, it seems indeed that the atom is not only chaos transformed once and for all, organization and order, but that it is in permanent genesis, as if it were self-organizing without discontinuity in the unceasing play of its internal interactions.¹¹

Thus, the atom does not cancel out the infraphysical chaos; it carries it along and transforms it by its permanent internal activity. In this transformation arise order, organization, evolution, without however enabling us to eliminate disorder.

Suns illustrate in a striking fashion the inseparability of the ideas of chaos and cosmos. We have seen what an astounding genesis transforms swirls of particles into stars, how a formless mass becomes a clockwork of suns and planets, how fire is transformed into fire-machines, and that not just once, but billions and billions of times.

Suns are formidable machines¹² simultaneously timekeepers, motors, factories. They produce heavy atoms, that is to say complex organization and radiation, that is to say the manna on which life feeds. In short, whatever is order and organization in the cosmos, whatever produces always more order and organization has a sun as its source.

Now, indefatigably we must note: this fire-machine *is on fire*. The sun is in flames. Our sun does not give light like a lamp. It spits fire, pops fire, in a senseless self-consumption, a mad spending which no treatise on cosmic economy had foreseen. Its core is pure chaos. It is a permanent gigantic hydrogen bomb, it is a raging nuclear reactor. Created in catastrophe, lighting up at the very temperature of its destruction, it lives in catastrophe, since its regulation stems from the antagonism of an explosive retroaction and an implosive retroaction. Sooner or later it goes towards one or the other

destruction: hyperconcentration, or the ultimate cluster of fire of the nova or supernova. Thus, the billions upon billions of suns are supreme order, admirable physical organization, and the volcanic chaos of our cosmos.

Chaos, Physis, Cosmos

The order of classical physics is no longer the texture of the universe. It has shrunk, it has undergone the infiltrations and the corruptions of disorder, it is sandwiched between two chaoses. Even more: son itself of genetic chaos, it is plugged into microphysical chaos and macrophysical chaos. These two chaoses, the one present in every atom, the other at the heart of every sun, are in a certain way present in every physical being; the texture of our earthly, biological, and human world is not in an isolation chamber; it is made up of atoms, born in our sun, nourished by its radiation.

Old physical matter, therefore, dries up and comes apart, as the new *physis*, daughter of chaos, rises up. This new *physis* emerges from genetic babbings, subatomic soup, boiling solar heat. It is squirmings of interactions. Chaos is no longer only a genetic principle, it is a permanent generic principle, which is expressed, in *physis* and the cosmos, by the mediation of the tetralogy disorder/interactions(encounters)/order/disorder. This tetralogy constitutes the immanent principle of transformation, and thereby of organization and disorganization, which principle was missing in physics.

Thus, *physis*, cosmos, chaos can no longer be dissociated. They are always co-present to each other...

We have barely begun, we will never finish questioning the nature of chaos, a concept which less than any other must be conceived as a clear and substantial concept, since it comprises indistinction, confusion, contradiction. Chaos is beyond our logical intelligibility, it obliges our antagonistic notions to twist towards each other and fasten themselves to each other. It is in this sense that Heraclitus was able to assimilate chaos to Polemos—Conflict—"father of all things," which René Thom echoes: "Our models attribute all morphogenesis to a conflict, to a battle between two or several attractants." (Thom, 1972, p.324)

Conflict is but one semblance among others; no unity of opposites, no dialectic will be able to exhaust the mystery of chaos, that is to say, also, the mystery of the genetic/generic relation of *Chaos* to *Logos* (the discursive development of order and organization), of *Hubris* (madness) to *Dike* (moderation), of *Elohim* (genesis) to *JHVH* (law). Chaos returns us to what is both the under-dimension and the over-dimension of our universe and which, as François Meyer says, "speaks the language of delirium." It offers us a

grandiose universe, profound, admirable, for which I invite you to swap without hesitation your little clockwork order, constructed by Ptolemy and around which Galileo, Copernicus, Newton had caused only revolutions, without bringing the Revolution.

The New Uncertain World

We must change worlds. The universe inherited from Kepler, Galileo, Copernicus, Newton, Laplace was a cold, chilling universe of celestial spheres, perpetual order, of moderation, equilibrium. We must swap it for the warm universe of a flaming cloud, balls of fire, irreversible movements, of order mixed with disorder, of expenditure, waste, imbalance. The universe inherited from classical science was centered. The new universe is acentric, polycentric. It is more *one* than ever in the sense that it is a very singular and original cosmos, but it is at the same time shattered and crumbled. What constituted the armature and architecture of the universe becomes an archipelago adrift in a dispersion without structure. The old universe was a perfectly regulated watch. The new universe is an uncertain cloud. The old universe controlled and distilled time. The new universe is carried away by time: galaxies are products, moments in a contradictory becoming. They take shape, stagger, flee each other, knock each other about, and disperse. The old universe was reified. All that was shared an essence or an eternal substance: everything—order, matter—was uncreated and unalterable. The new universe is dereified. This means not only that now everything is in process or transformation. It also means that the universe is simultaneously, perpetually in childbirth, in genesis, in decomposition. The old universe settled down into clear and distinct concepts of Determinism, Law, Being. The new universe isolates concepts, outstrips them, shatters them, obliges the most contradictory terms to cling together, in a mystic unity, without nonetheless losing their contradictions.

Was the old universe rational, and is the new one irrational? I will come to the theme of rationality in volume III. The new universe is not rational, but the old one was even less so; mechanistic, deterministic, without events, without innovation; it was an impossible universe. It was “intelligible,” but everything that occurred in it was totally unintelligible... How could we not have understood that pure order is the worst folly which exists, that of abstraction, and the worst death which exists, that which never knew life?

The Two Divergent Universes

Do we really have one universe now? To tell the truth, we have an

oscillation between two universes, at opposite poles to each other though having the same trunk, one principally polarized on disorder, the other principally polarized on order and organization.

The first conceivable universe is initially and essentially a cloud in dispersion.

The organized was born by chance, in the extraordinary number of interactions between an extraordinary number of particles, in function of constraints which themselves were born by chance, in the first happenings of a universe born by accident.

If there are, as we suppose, 10^{73} atoms in the universe, this number is pitiful with regard to the particle dust dispersed or agglomerated. If there are billions upon billions of suns, we must also see their infinite solitude, we must think of all those which exploded before being born, we must think that all have to explode or implode, that they constitute a moment of mad praxism, an upsurge of fever unleashed by this strange sickness, gravity. Gravity-Sisyphus has the obstinate mania of reassembling and condensing the dispersed, but sooner or later the condensed, having become too hot, explodes, and everything starts all over again, but with more and more dispersion. Suns are chance beings, rafts of the Medusa temporarily escaped from unavoidable shipwreck...

The near-totality of the universe, whose volume grows without end, exists, if we may say so, only in the state of inorganization and dispersion. We must never forget that organizational phenomena, upon which the order of the world depends—atoms, molecules, stars—are minority, local, temporary, improbable, deviant. They are small clots, parentheses, archipelagoes in the immense probabilitary ocean of disorder. Certainly, we see that from a small number of these islets there is outlined an evolution towards more organizational complexity (constitution of macro-molecules, of amino acids) but how minority in this minority of minorities! We know even that on a small planet of a small peripheral sun an organized form of unheard-of complexity appeared. But it was by quasi-miraculous chance: in fact, nothing suggests the existence of another life in the cosmos, everything suggests that its birth was a unique event (since all of the living are of the same molecular constitution and organize themselves exactly according to the same genetic code). Life spread because chance endowed it with the power to multiply crystals. Life progressed thanks to the chance of genetic mutations. Life is at any rate minority in the earthly *physis*; the most complex forms of life are minority in comparison to less complex forms, and this while the cosmic diaspora continues, while general disorder grows. Everything happens as is normal in fluctuations: the stronger the deviance, the more it is minority and provisional. Probabilitary

becoming towards disorder can be accompanied by improbable deviances. Therefore, the large disapora can tolerate these deviances in its statistical good-naturedness, like small recreations. Organization is physically improbable because it is cosmically improbable. Sooner or later everything will be dissipated. The last star will be extinguished and, even before the exhaustion of solar radiation, life, born from the silt of the planet earth, will be turned into *dust*, in the infinite dust which will have lost the form and the name of universe.

A contrary conception of the universe is no less plausible. It also starts from the same catastrophic data. But it is precisely in order to notice that organization, originally at state zero, has not ceased to develop. Indeed, order and organization are inseparable from disorder, but does this not mean that disorder put itself at the service of order and organization? Cosmogenesis produces order and organization as phenomena not deviant from but central to the universe; dispersive disorder becomes an anomic halo, more and more foreign to the transforming and forming praxis. In this perspective, where order and organization place themselves downstage and become the actors of the world, the cloud appears to us as the placenta of their developments. The ocean which bathes the organizing archipelago nourishes it. The universe is not a thermic delirium, it is a blacksmith's forge. What is forged, like what creates, must be paid for by very big waste, unheard-of expenditure, failures. This organizing/creating universe is a Bernard Palissy.

Organization is indeed minority. But every sovereign is minority and solitary. Organization possesses true cosmic power: *the physical principle of natural selection*. In fact, it self-maintains, resists chance, self-develops. It possesses Law in a world without law, and this law gears down into several laws, among them the law of gravity which extends very far and which, precisely, makes organization, as Newton had very well grasped, the sovereign of the Universe. Dispersion is the *outlaw*.

Indeed, in the present state of knowledge concerning becoming, statistical projection leans in favor of the ultimate triumph of dispersion. But the present state of knowledge and the present state of becoming are both uncertain. Statistics have no definitive meaning for a universe unique since its origin and in which everything develops uniquely. Statistical projection before the birth of the universe would have considered this universe quasi-impossible. Yet it is, and its existence has annihilated other possible universes, intellectually less improbable. Today order and organization have a life expectancy much more favorable than that of the cosmos before its birth: a general improbability

transformed itself into a myriad of local probabilities; order and organization remain indeed statistically minority, but what statistics do not say is that they are nuclear. And a past of more than ten billion years is there as witness: *everything which was constituted as organizer and creator was made outside all statistical probability*. Statistical probability is out of its own depth before all that is innovation, invention, evolution. This is why statistical probability in what concerns the future can only be erroneous, since this future must be evolutive; it can only be evolutionary since organization has barely begun its developments.¹³

Thus, we have two conceptions which possess the same data, the same principles of explanation, but which differ by the disposition of what is satellite and what is central. For the one, organization and order are provisional deviance and fluctuation in the great diaspora; for the other, disorder is the life-sustaining ecology of a developing order and organization. To resolve the issue, supposing of course the cosmogenetic hypothesis common to these two interpretations is valid, we would need an observation post enabling us to control the becoming of the world. For it is the rest of this cosmic history which will show us whether organization and order were an episode, just a twitch in the great disorder, or whether on the contrary order and organization, adventurers in the cosmos, were to be its conquistadores.

But the uncertainty cannot be dissipated, because no one, not even Laplace's demon, can possess an objective point of view from which to discern the future of the universe, and thereby diagnose its past. Are we, therefore, reduced to wagering, according to our metaphysical or hepatic inclination, for one of the two versions of the universe? But then we would turn away from the only great intellectual acquisition that we can effect, In fact, *regression from deceitful certainty will allow us to link the two antagonistic points of view on the nature of the universe in a sort of enriched binocular vision*.

Our uncertainty allows us, then, to consider together the two divergent faces of the same Janus. Simplicity summons us to choose one of the two reference systems, order/organization or disorder. But does not complexity prove to us especially that we must not choose? Must we not, can we not conceive of organization and order as both deviance and norm of the universe, *as both improbability and probability, namely, deviance transforming itself into norm while still remaining deviance, improbability transforming itself into local probability while still remaining improbability*? We have seen that schismogenesis—that is to say, deviance—and morphogenesis—that is to say constitution of an organizational nucleus—were linked. We must, therefore, see

the phenomenon under its two angles, both as deviation in reference to a preponderant process, but also as constitution of a new process which tends to become preponderant. All morphogenesis must, therefore, be seen as a phenomenon of nucleation and of deviance. This means that everything is still ambiguous, rich in possibilities in one sense as in the other, uncertain. And that uncertainty which is inevitably ours, who are peripheral observers, limited in our senses, deformed in our intellect, ignorant of most of what goes on in space and of all that will unfold in time, may also be, to boot, the uncertainty of the universe itself, which does not yet know what is going to happen to it...

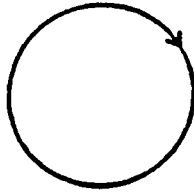
A Different World: Irreversible Knowledge Gained and Uncertainty

These two possible, antagonistic worlds start from a same world-trunk. But is this world-trunk certain? It cannot be certain, but it is plausible today because all physical sciences, in the first place microphysics and thermodynamics, converge to support or develop the hypotheses generated by astronomical observation. It is even more profoundly plausible in my eyes for another reason: once the presence of disorder in *physis* has been noted, the idea of physical evolution established, we are led to conceive a complex principle of the universe.

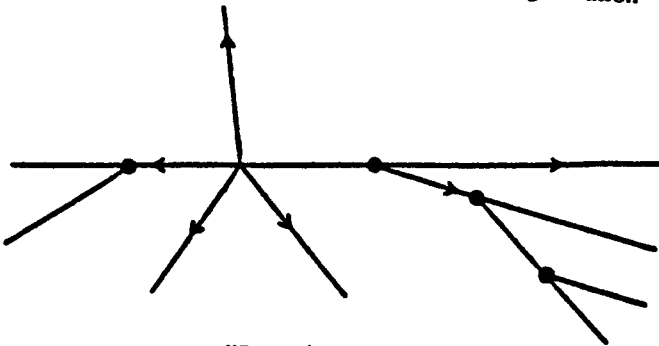
But, if we know clearly which world is broken, we still have only a very flickering image of the new world. We are at the beginning of this new world. The latter is taking its first steps in the unknown. It carries in itself not only the aporia of the beginning, but the mystery of the avant-world, where is crouched a matrical constituent of our world, the knowledge of which escapes us. It establishes for us the eventuality of a plurality of complementary/antagonistic worlds, among them anti-universe dominated by anti-matter, as Lupasco suggests (Lupasco, 1962), following a hypothesis of Dirac. Everything about Chance still remains to be thought out, and Chance perhaps is inscribed in an undecidable complexity (Chaitin, 1975) on Time, whose irreversibility perhaps allows marginal exceptions or inversions in our very universe, and on Space, which the Greeks had cleaned up with emptiness, and which can take being with a new topology (Thom, 1972).

Thus, not only do I not exclude, but I sense that the vision of the world will once again have to be transformed and relativized. *As always, theoretical change will come from the dialectic between astounding discoveries and a new way of conceiving the evidence.* Our world, like the old one, will again be

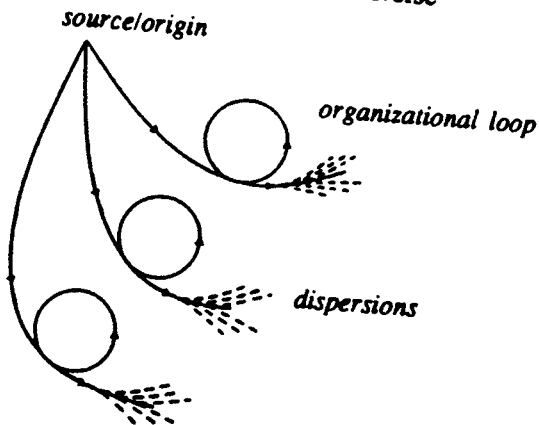
stationary universe
perpetual movement
vicious circle



disaporic universe with small clumps of organization



uncertain universe



called into question. But, as was the old one, *only in the sense of complexity*. It could therefore, as the case may be, be provincialized and become, who knows, a little avatar of a chain metamorphosis and/or a small fragment within a polypary of universe. Even as of now our universe is at the same time a *pluriverse*.

It is not possible for us to regress to simple physics, to the simple cosmos, to simple order. The knowledge gained about irreversibility is irreversible. The knowledge gained about complexity is unsimplifiable. One universe, then, is dead, the universe which, since Ptolemy and through Copernicus, Newton, Einstein, has continued to revolve around order. The universe being born before our eyes no longer turns around order. Certainly it will keep by provincial right the knowledge acquired under the aegis of the paradigm of order, just as we still keep the knowledge acquired at the heart of the Newtonian, the Copernican and even the Ptolemaic vision. But it can only be based on and enriched by the elucidation of complexity.

The true knowledge gained of the new universe is this: it is not a Hubblean universe, it is the universe which the Hubblean rupture makes possible. It is not an amateur astronomer's vision, it is a conception of principle. The true knowledge gained, here, is the necessity of the principle of complexity. This signifies that there is not permutation of a simple term, order, into another simple term, disorder. This signifies that there is a search for intelligibility, not in alternative and exclusion, but in the interrelation, the interaction, the interdependence of the ideas of order, disorder, organization in a "tetralogical loop;" not in the disjunction between the notions of chaos, cosmos, *physis*, but in their confrontation. It is in this sense that the first complex universe is outlined...

I have attempted also to define the first open world: *Uni-Pluriverse*. The new cosmos brings the observer an insurmountable uncertainty. Having become acentric, it does not possess any privileged observation point. Having become a double process of organization and disintegration, it does not furnish any sure axis on which to inscribe its becoming, whence the inevitable upsurge of the two axes of universe starting from the common cosmogenetic trunk. Finally, this new version of the world gives rise to mystery at its very heart.¹⁴ It opens upon the unknown, the unfathomable, instead of repressing it, exorcising it. For the first time, a vision of the world does not close in on itself in an explicatory self-sufficiency. This change of world will take us much farther than the change of an "image" of the world. It will have to entail a change in the world of our concepts and once again put in question the master-concepts with which we used to consider and imprison the world. This will be the matter here of three volumes...

IV. The Articulation of the Second Law of Thermodynamics.. and of the Law of Entropy with the Law of Physical Complexity

Since Boltzmann, the second law of thermodynamics no longer concerns only energy, but order and especially organization. Now, its place could only be uncertain and controversial in a physics where no communication at all could be established between the idea of order and the idea of disorder (except the superimposition of the statistical order of populations upon the disorder of individuals), where especially no room was made for the notion of organization. The second law, therefore, could not be articulated either on a concept of order—still repulsive—or upon a concept of organization—still.. absent. It could only oscillate between the insignificance of a minimal version and the enormity of a maximal version.

At its minimum, entropy is but an apterous measure stripped of all power of inference upon *physis* and the cosmos taken together. At its maximum, the second law unfolds as the great law of the Universe, which applies not only to all physical objects conceived separately, but to universal becoming, up to its end included. But we are thereby incapable of understanding why everything is not already disorder and cosmic dust, that is to say why order and organization were constituted and developed.

I intend to show that we can and must go beyond such an alternative, on condition that we enrich our conception of *physis* and renew our conception of the cosmos. After that, we can and must conceive the second law as the partial and amputated expression of a complex cosmological law, and as the necessary and insufficient expression of a fundamental physical law which associates and dialectizes order/disorder and organization.

The First Law of Cosmology and the Second Law of Thermodynamics

Let us, first of all, state the problem in its cosmic majesty. We can now eliminate, not so much the idea that the universe is a “closed” system (for, one could maintain that it disposes of a finite energy, and thus would be “closed”), but *the idea of system*. It has henceforth appeared to us that the universe, even though under certain aspects it is *one and whole*, is not, when viewed as process [Fr. *devenir*] whence we have apprehended it, really a system: it is an apprentice-system which crumbles and comes apart in the very movement in which it is constituted: it is a process, which, through its avatars, proliferates into polysystems and archipelago-systems (galaxies, solar systems), but which by that very fact finds itself stripped of all systemic organization as a whole.

Given that, the frame of reference of the second law cannot fit the universe, and consequently universalization of the second law would be denaturing. In fact, the correlative developments of disorder, order, organization would be unintelligible therein. Let us say more: all generalization of the second law hides the key genesic idea: the fundamental link between the irreversible cosmic diaspora and the development of islands and archipelagoes of order and organization.

Nevertheless, the idea formulated by the second law, of an irreversible growth of entropy, seems like a refracted echo, in the interior of "closed systems," of the irreversible cosmic process towards degradation and dispersion. In consequence, we ask if the second law is not, within a circumscribed physical framework and a limited and deficient epistemic framework, the expression of one of the two faces of the cosmological law, the one which carries in it disintegration and dispersion.

*The Second Law of an Organization Without Law:
Integration in a Generalized Physis*

Let us now return to the original residence of the second law, which is the physical system in which it is defined as statistical law of degradation (of energy), of disorder (of constitutive elements), and, thereby, of disorganization. The increase in entropy of a system signifies that disorder, and consequently disorganization, will also necessarily increase.

As soon as we conceive entropy, not only as degradation and disorder, but as disorganization, we introduce therein the reference to organization. By the same token, the notion of entropy, while remaining fully a citizen, goes beyond the domain of thermodynamics as such and concerns a theory of organization. But as it was lacking and still lacks the support of such a theory, the idea of entropy has remained as if suspended in air. Or rather, entropy overlaps both concrete thermodynamic measure and a phantom organizationist concept.

Now, we must give organizationist life to entropy. Maybe then, as François Meyer suggests, it will even appear to us that "the thermodynamic expression of the idea of entropy is only a less comprehensive and less general case." (Meyer, 1954, p.231)

Conceived in organizational terms, the concept of entropy designates an irreversible tendency to disorganization, proper to all systems and organized beings. It represents a universal tendency, that is to say not limited to overly abstract "closed systems," but which also concerns "open systems," including living beings. But, in order to understand this, we must complexify the framework of observation of entropy and the notion of entropy itself.

First of all, we must no longer consider a system isolated, but in an environment. That done, we see that the formation of an organized phenomenon, for example a star, corresponds to a local diminution of entropy—the disorganized mass transformed into an organized whole—but this diminution, by the very fact of transformations which organize, entails an increase of entropy in the environment. Furthermore, the thermodynamics of irreversible processes shows us that organized states, stationary in character (Bénard's convection patterns), can be constituted and maintained only at the cost of a strong dissipation of energy (increase of entropy in the environment).

We can say, in the most general way, and this includes living organization, that all regression of entropy (all organizational development), or all preservation (by work and transformation) of stationary entropy (namely, all organizational activity), is paid for in and by an increase of entropy in the environment which encompasses the system. Which means, in final terms, that all local regression of entropy (or negentropy) increases the entropy in the universe. Thus, we have here very exactly the reverse of the morphogenetic law whereby cosmic dispersion works, in one sense, for organization. We see here that all organization works, in another sense, for dispersion.

The Wrong Side and the Right Side

Thus, the second law is much more than a statistical tool and entropy much more than a measurable size. But the second law is not thereby the key to the universe, and entropy is not the only law to which organization is vowed. The second law and the idea of entropy must always be associated, and always in a complex way, with the new conception of *physis* and of the cosmos. Now, we had always isolated the second law, and the notion that entropy had been, either put to work in the boiler of locomotives, confined in the dungeons of closed systems, or hypostasized into master-law of the Universe.

We are able to articulate the second law:

organization/order —————> disorder

on the cosmo-physical law that we have formulated thus:

disorder —> interactions (associative) —> order/organization

They were separated, partitioned, non-communicating:

cosmo-physical law of

disorder $\longrightarrow$ interactions
 $\longrightarrow$ order/disorganization

second law of thermodynamics

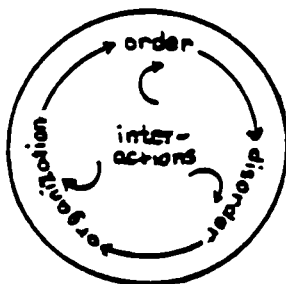
order/organization $\longrightarrow$ disorder

It is a matter of departmenting both, the one by the other. In consequence, an absurdity jumps up: *one sees that the second law considered order and organization as initial states because it did not know the preceding sequence:*

disorder $\longrightarrow$ interaction $\longrightarrow$ order/organization $\longrightarrow$ disorder.

But is it equally absurd to have two sequences cling together as one large sequence which would begin with pure disorder and end in pure disorder. If there is a beginning (catastrophe), it carries in itself in an indistinct way, with its disorder, the law of order and the potentiality to organize, and cosmic history begins with the turning of the "tetralogical loop." Thus, the law of cosmophysics is this very loop, and the sequence of the second law is inscribed in fact in the tetralogical loop, enriching and completing it:

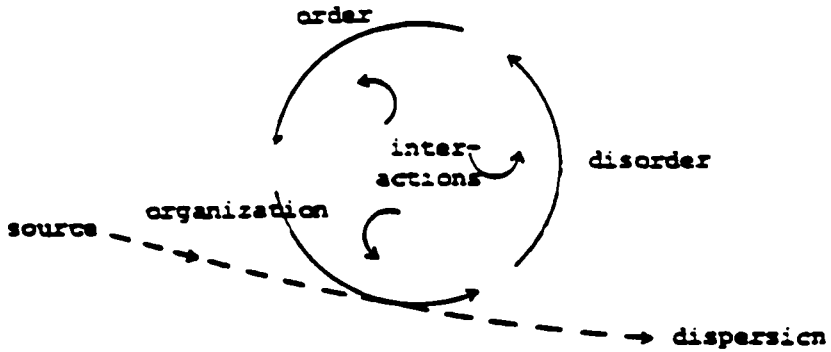
This loop is not a vicious circle since by means of it irreversible transformations, geneses, and productions take place. This loop is not a



perpetual motion since it is nourished by an initial energy source—catastrophe—which gears down, after the avatars we have seen, into myriads of active sources: suns.

Finally, and here is the specific effect of the second law, which distances us even more radically from perpetual motion and vicious circle: there is

always deperdition, namely, an unrecuperated part of disorder which becomes dispersion.



It is a matter, therefore, of an irreversibly spiraloid circuit, produced by the original thermic catastrophe, and which does not cease to take shape through the relation disorder/order/organization.¹⁵

This relation finds itself enriched and complexified by the integration of the second law. We see in fact henceforth that:

a) disorder produces order and organization (from initial constraints and interactions);

b) order and organization produce disorder (from transformations);

c) everything which produces order and organization *also* begets irreversible disorder.

We can now recapitulate the insufficiencies, the strengths, the message of the second law.

Insufficiencies

Deprived of organizational support, the second law is either confined in closed thermodynamics (pre-Prigogine), or universalized in an abstract statistical law whose dragnet picks up nothing but the ocean, for it knows only probability, and does not know that everything which exists and is created is the improbable become necessary *hic et nunc*.

Strengths

—It brought disorder into the closed system of classical physics, and was the initiator of a chain disintegration of simplifying order.

—Its universality is not only loose and abstract, it is also radical, but on the negative plane. As Michel Serres says, "The second law is universal in what it prohibits: perpetual motion." (Serres, 1973, p.596)

—It bears the mark of temporal irreversibility which physical laws ignored until then.

—It gives rise resonantly to the problem of organization and order.

And Here Is Its Message.

—*There is and always will be, in time, a dimension of degradation and dispersion.*

—*No organized thing, no organized being can escape degradation, disorganization, dispersion. No living being can escape death. Perfumes evaporate, wines go flat, mountains smooth out, flowers fade, living beings and suns return to dust..*

—*All creation, all generation, all development, and even all information (cf. pp.305f) must be paid for by entropy.*

—*No system, no being can regenerate itself isolatedly.*

V. The Dialogue of Order and Disorder

The Impossible Couple

At this point we can attempt to examine the relation order/disorder. It is a key problem. The terms order and disorder control, in fact, the derived or consequent notions, on the one hand of determinism (link between a simple order and a simple causality) and of necessity (where the character of inescapable constraint is highlighted); on the other hand of indeterminism (purely privative notion), chance (notion which highlights unforeseeability) and liberty (possibility of decision and of choice). As we shall see, the problem of the relation order/disorder is at a root or paradigmatic level: the definition of such a relation controls all theories, all discourse, all praxis, and, to be sure, all politics.

Now, the relation order/disorder has been repulsive, not only in classical physics, but in Western thought. The ideas of order and disorder oppose each other, deny each other, flee each other, and all collision entails the disintegration of one by the other.

Statistics could only superimpose a macro-order (at the level of populations) and a micro-disorder (at the level of individuals) but without ever establishing the least logical connection between these two scales.

macro-order (large numbers, populations)

micro-order (individuals, particles, micro-states)

The second law of thermodynamics could only formulate a univocal transition of probabilitary character:

order (organization) $\longrightarrow$ disorder

while biological evolutionism and social progressivism were defining the inverse and adverse orientation:

disorder $\longrightarrow$ order (organization)

but without our ever being able to conceive logically how these two orientations could, I will not even say, communicate, but merely coexist. Now, we have seen appear out of everywhere, in the course of examination, interesting, multiple, double-meaning, ambiguous, rich relations between order and disorder. To attempt to conceive the complexity of these relations, we must consider the new complexity of each of the two terms.

The Order of Disorder

Michel Serres exclaims: "Yes, disorder precedes order, and only the first is real; yes, the cloud, namely large numbers, precedes determination and only the first ones are real." (Serres, 1974b, p.224) Yes, there is a promotion of disorder, an uncrowning of order, but I will not invert the hierarchy as Michel Serres does; rather I will dehierarchize. If there is anything first, it is the inexpressible state, in terms of order or disorder, before catastrophe. As soon as catastrophe occurs, disorder and order are born almost together: from the first moments of the universe, as early as the cloud, the first constraints appear. *What is "alone real" is the conjunction of order and disorder.*

In fact, cosmogenesis shows us that disorder is not only dispersion, froth, slaver, and dust from the world in gestation; it is also carpentry.

The universe was not built only despite disorder, it was also built in and by disorder, that is to say in and by the originary catastrophe and the ruptures which followed, in and by the disordered spread of heat, in and by turbulence, in and by the inequalities of the process which prescribed all materialization, all diversification, all interaction, all organization.

Disorder is active everywhere. It permits (fluctuations), nourishes (encounters) the constitution and the development of organized phenomena. It co-organizes and disorganizes alternately and simultaneously. All becoming is marked by disorder: ruptures, schisms, deviances are conditions of creation, birth, morphogenesis. Let us remember that the sun, born in catastrophe, will die in catastrophe. Let us remember that the earth, while rotating obediently and regularly around the sun, has a history of cataclysms, subsidences, foldings, eruptions, floods, drifts, erosions...

Disorder is not an entity in itself; it is always relative to energetic, interactional, transformative, or dispersive processes. Its characters are modified according to these processes. As we have seen, there is not one disorder: there are several overlapping and interfering disorders: *there is a disorder in disorder. There are orders in the disorder.*

One cannot classify, on the one hand, "positive" disorders which generate, which construct, and on the other, disorders which destroy, which disperse. If one excepts the disorder of dust, whence no shape, no design any longer comes out, all the other disorders, even Brownian movement, are ambivalent: the disorder of fire is bearer of creativity, of synthesis, but also of deflagration, ashes, and dispersion. The disorder of ruptures, faults, instabilities, and schisms is also the disorder of morphogenesis. Surely, one can discern in numerous cases, according to conditions and processes, the opposition between generative disorders and degenerative disorders, but at the very source of the process, through which the cosmos simultaneously disintegrates and organizes itself, disorder is in an ambiguous way simultaneously generative and degenerative.

In the wake of disorder there follows a constellation of notions, among them chance, happening (Fr. *événement*), accident. Chance denotes for an observer the irregular, non-repetitive, singular, unexpected character of a physical fact. Accident denotes the perturbation provoked by the encounter between an organized phenomenon and a happening, or the event-full [Fr. *évènementielle*] encounter between two organized phenomena.

Thus, there is richness and diversity, polymorphism, multidimensionality in disorder(s). There is omnipresence, permanent Mephistophelian activity in disorders. Disorder henceforth claims its place: every theory must henceforth bear the mark of disorder, make room as amply as possible for disorder, now become cosmic principle in its own right and immanent physical law. But after we have locked it up in the very depths of reality, it is not possible to isolate it once again in order to make it the new absolute Law of the universe. *Disorder exists only in relation and relativity.*

The Disorder of Order

Order is no longer king.

One order has died: the order-principle of supra-temporal and supra-spatial invariance, namely, the order of the Laws of Nature. These supreme laws were in reality "simplified laws invented by scholars" (Brillouin, 1959, p.190), abstractions taken for the concrete (Whitehead, 1926).

One order has shrunk: universal order, stretching out boundlessly in time and space, has henceforth been born in time, sandwiched in space between micro-physical chaos and diaspora. It is no longer general, but provincial. It is no longer unalterable, but degradable. Nevertheless, if it loses as an absolute, it gains as a process [Fr. *devenir*]. It is capable of development.

Fallen as evidence, order is raised as problem. How was it born? How, starting from zero, did it develop? How does one conceive it, despite, with, and in disorder? How could it have seemed to us the sole sovereign of the universe, now that it is so difficult to justify its existence?

To understand order, we must trace its genealogy. Its birth is indistinct from that of the universe: order is born with and in the initial, singular conditions of the universe, those *boundary conditions* which delimit and restrict the field of the possible, which eliminate possible digressive or transgressive universes, and which thereby constitute themselves as negative determinations or constraints. In other words, order carries the irremediable mark of the initial happenings of a singular universe! Order, which emerges, therefore, under the form of initial determinations, constraints, is going to develop through materializations, then interactions and organizations. The first determinations take shape and multiply in conditional necessities with the constitution of material particles: in fact, among all the possible or created particles, a limited number, endowed with singular properties, is both viable (capable of survival in a chance environment) and operational (capable of interactions which produce transforming effects). Therefore, the materiality and the finite diversity of the particle elements are going to determine different types of interactions from which the great laws of the Universe will flow. Thus, we see at the origin of laws: the singular, the happenstance, the conditional, the fortuitous.

In fact, by a paradox inconceivable in the old order, there are general laws in the universe only because the latter is singular, that is to say its origin and originality constitute determinations. These laws are conditional, that is, dependent not only on the singular characters of the universe, but on the nature of these interactions and on the conditions in which they operate. The idea was already in Newton for whom nature always obeys the same laws in the same conditions. But Newton focused on the idea of law, whereas we must

henceforth focus on the idea of conditions, which, haphazard, do not obey laws but, precisely, condition them. Every law depends, in a sense, on chance: the encounter is by chance, the effect is by necessity. The necessity of the effect, or law, has one foot in chance, or disorder...

Order, I have already said, develops truly at the stage and level of organization. Order, says Layzer, is "a property of systems made of several particles." (Layzer, 1975) In fact, it finds its footing, so to speak, after the "strong" interactions have bonded protons and neutrons into a stable nucleus; that done, it will be able to consolidate and extend itself once the electro-magnetic interactions have bonded electrons to cores, constituting atoms, then atoms among themselves, constituting molecules. Developing in "chemical" order, it becomes more and more supple, multiple, until that moment when the most complex order that we know will be born: the biological order.

But already and since long ago, order has founded its cosmic realm in and by gravitational interactions which find their home in the stars. Thenceforth, it radiates to phenomenal distances, becomes master of planetary ballets, shepherd of suns... How can we be astonished to have believed it sovereign of the universe!

Between stars, atoms, planets, molecules, etc., interactions weave and multiply, developing organized phenomena. Orders diversify, complexify, as we shall see.

This is to say, prematurely at this point but already necessary, that the real and multiple developments of order are brought about correlatively to organization: order of assemblage (structure); order of internal and external constraints; order of symmetry; order of stability; order of regularity, of cycle; order of repetition; order of doubling (crystals); order of exchanges; order of regulations; order of homeostasis; order of control; order of command; order of program; order of reparation and regeneration; order of identical reproduction; *order of multiplication which is multiplication of the said order.*

Thus, order presents an interesting, rich, ambiguous, strange face, completely absent from the old, simple, clear, evident, obtuse notion.

Order has ceased to be one. There is some order in the universe, there is not *one* order. Without respite and without success, Einstein had sought to unify gravitational and electro-magnetic interactions. He dreamt of a single keystone of order. But unity in the universe must be sought elsewhere than in order. Is not the order of a shattered cosmos necessarily plural, dislocated? There are orders, that is to say disorder, in order...

Order has ceased to be external. It is constructed, produced from genic chaos, and it is not really separate from it, since as I have said, we are still not separate from it.

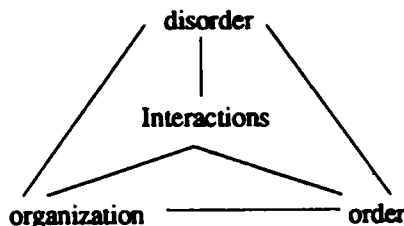
Order has ceased to be exterior to things: it is henceforth contextual, inseparable from the specific materiality of the elements in interactions and from these interactions themselves; it is ordered by the phenomena which it orders: each of the atoms of our body depends on gravitational order, which depends on the interactions of each atom of our body with its environment. Order is no longer king, nor is it a slave; it is interdependent.

Order has ceased to be absolute; it has become relative and relational. Order has become provincial, but its zone of influence, especially gravitational, stretches very far. It knows, in and by organization, how to resist disorder, how to gain on disorder.

It is capable of progress, and this progress transforms it. The more the organization is rich, the more it is rich in disorder, the more order includes disorder, which becomes an ingredient of organizational order, which in turn becomes more and more refined, but also regional and fragile... Living order is so refined and delicate that it would be extremely fragile if, precisely, its refinement did not allow it to manipulate the disorder to its benefit, and especially to reorganize itself continuously.

Thus, the more we consider its origin, the more we consider its development towards complexity, the more order reveals its mysterious dependence and illegitimacy with respect to disorder, with and against which, like Jacob with the angel, it is *corps à corps* simultaneously copulating and fighting to the death. But also, the more we consider its origin, and the more we consider its development, the more we are struck that in it, by it, extraordinary improbability is transformed into necessity and probabilities, indeed conditional, provincial, but *real* (which will oblige us to complexify, a little further on, the stiff-necked idea of improbability).

Thus, order, in losing its absolute character, obliges us to consider the most profound mystery which, like all great mysteries, is hidden by the most obtuse evidence: *the disappearance of the Laws of Nature finally poses the question of the nature of laws*. We are once again returned to the tetralogue:



The Co-production of Order and Disorder

Order which tears and transforms itself, the omnipresence of disorder, the upsurge of organization give rise to fundamental demands: every theory must henceforth bear the mark of disorder and disintegration, every theory must relativize disorder, every theory must nucleate the concept of organization.

We can indeed conceive disorder and order in a Manichean fashion in a universe subject to these two opposed principles. As L. L. Whythe says:

We must indeed oppose but also link these two tendencies. This signifies, first of all, that order and disorder are not absolute, substantial concepts. Both

Two great opposite tendencies appear in natural processes, one towards local order and the other towards uniformity of general disorder. The first manifests itself in all the processes by which a zone of order aims at differentiating itself from a less orderly environment. That is what we see in crystallization, in chemical combination, and in most organic processes. The second tendency manifests itself in the process of radiation and diffusion; it leads to a uniformity of thermic disorder. The two tendencies act normally in opposite directions, the first producing differentiated zones of order and the second dispersing them. (Whythe, 1949)

are born together and probably have roots, in an evidently inconceivable manner, in the Pre-Beginning. They are reborn unceasingly of a genésic indistinction here named chaos. They are relative and relational.

They are relative and relational to each other, and this introduces logical complexity into the heart of these notions: we must put disorder in the notion of order; we must put order in the notion of disorder. Pushed further, the extreme complexity of disorder would contain order, the extreme complexity of order would contain disorder. The relation between order and disorder necessitates mediating notions; we have seen three indispensable notions appear and impose themselves in order to establish the relation order/disorder:

—the crucial idea of interaction, real Gordian knot of chance and necessity since an aleatory interaction triggers, in given conditions, necessary effects (like the encounter in the same millionth of a millionth of a second of three helium nuclei constituting a carbon nucleus);

—the idea of transformation, notably the transformations of dispersive elements into an organized whole, and inversely of an organized whole into dispersed elements;

—the key idea of organization (to which this Volume I is devoted).

We need, then, a fundamental linking of the notions of order and disorder within the "tetralogue" disorder/interactions/order/organization.

The fundamental linking must be of dialogic nature. I will be able to really define this term only later (v.II, ch.7); let us say here that dialogic signifies the symbiotic unity of two logics, which simultaneously nourish each other, compete against each other, live off each other, oppose and combat each other to death.

I say dialogic, not to put aside the idea of dialectic, but to have it derive from it. The dialectic of order and disorder is situated at the level of phenomena; the idea of dialogic is situated at the level of principle, and already I am daring to promote it (but I will be able to demonstrate it only much later, in v.III) to the level of paradigm. In fact, in order to conceive the dialogic of order and disorder, we must suspend the logical paradigm in which order excludes disorder and inversely in which disorder excludes order. We must conceive a fundamentally complex relation between these two notions, a relation which is simultaneously complementary, antagonistic, and uncertain. Thus, order and disorder, from a certain angle, are not only distinct, but in absolute opposition; from a different angle, in spite of distinctions and oppositions, these two notions are one.

We must, then, conceive that the relation order/disorder is simultaneously:

—one (that is to say, indistinct in its genesic source and in its formative chaos);

—complementary: *everything physical, from atoms to stars, from bacteria to humans, needs disorder to organize itself*; everything organized or organizing works, in and by its transformations, *also* for disorder (increase of entropy);

—concurrent: from another point of view, disorder on the one hand, order/organization on the other, are two concurrent processes, that is to say they flow at the same time, one of generalized dispersion and the other of archipelagic development of organization;

—antagonistic: disorder destroys organizational order (disorganization, disintegration, dispersion, death of living beings, thermic equilibration), and organization represses, dissipates, annuls disorders.

Thus, disorder and order simultaneously merge with, call forth, necessitate, combat, contradict each other. This dialogic is at work in the great phenomenal

game of interactions, transformations, organizations, where everybody works for himself, one for all, all against one, all against all...

Given this, one can envisage a theory. It would start, not from zero, nor from the initial "point," but from the genesis, from chaos, namely, from the tetralogical loop. It should not rest on order or disorder as on an ontological or transcendent pillar, but produce correlatively the notions of order, disorder, and organization.

The Improbable and the Probable

What precedes does not dissipate, rather it reveals, the mystery of the conjoined origin of disorder and order. And it poses, without being able to resolve it, the mystery of the becoming of order and disorder.

For, the polylogic game order/disorder/organization cannot be considered a perpetual game. It is a game in which the data are transformed, and we must consider the two antagonistic orientations which the transformations take: one is the "progress" of organization and order, ever more complex, hence ever soaking up and encompassing more disorder in their sphere; the other, indicated by the fatal prediction of the second law, is the triumph of dispersion, the thermic death of the universe.

As we have seen, order and organization are improbable, that is to say minority, in the great cosmic diaspora. But this notion of improbability must be considerably softened and relativized.

In fact, if all birth of organization is improbable, the very constitution of organization is improbable; the very constitution of organization establishes a transformation of the local conditions in which it operates. Organization is a phenomenon of relative scope (Varela, 1975), which is protection against the risks of the environment; organization constitutes its own constraints, its own stability, which can be very strong (as for certain atomic nuclei) or very supple, permitting thenceforth multiple associations (electronic links between atoms constituting molecules) or exchanges (metabolism of the living being). In other words, organization and the order afferent to it constitute a *law of selection* which decreases the possible occurrences of disorder, increases in space and time their possibilities of survival and/or development, and permits building on a foundation of general, diffused, and abstract improbability a *local, concentrated, temporary, and concrete probability*.

On the basis of such a local and temporary probability a new, improbable, minority organization can be created, which, benefiting from the stable, organizational base, will itself be able to constitute its own probability, and so forth. Let us call to mind, in a completely ephemeral fashion, living

organization. It is extremely improbable in its origin (perhaps there has been only one single cell-ancestor of all the living¹⁶) and it is improbable as physico-chemical organization. This improbability holds concerning the arrangement of molecules which constitute every cell, and of course every multicellular organism: the physico-chemical probability, namely, the dispersion of the molecular components, appears finally at death. Now, in spite of death, and at the heart of death, that is to say the crushing and always victorious pressure of the physico-chemical probability, living organization has developed its own probabilities of survival, but evidently in the extremely narrow limits not only of the conditions of existence, rotation, and solar watering of the small planet, but also of the atmospheric, geo-climatic, and ecological conditions which are indispensable to it.

Thus, we see that there are, in improbability, some holes where spheres of necessity, islets of probability nestle. We must, then, dereify the absolute opposition between the notions of probability and improbability. These antithetical concepts also have their dialectical communication and permutation. And although we know, with regard to our sun irremediably promised to death, that this dialectic is only provisional, we do not know what the cosmic future of the organized world is...

We are returned to the fundamental uncertainty already encountered: is the disorder of the world a part of the order of the world, or is the order of the world a part of the disorder of the world? In the first case, the production of order and organization constitutes the only true process, immersed in a bath of disorder, needing enormous waste in order to pursue itself, and capable of pursuing itself to infinity. In the second case, everything organized must perish, since it was born, and the universe as order and organization is condemned to death by its very improbability.

In our uncertainty, we have no choice but to uphold the two conflicting orthodoxies, each aberrant to the other, and to consider the phenomena of organization simultaneously as nuclei and as deviances. Again the problem of the observer arises, of his point of view, his logic, his desire, his fear, the limits of his understanding, uncertain of his very uncertainty, since he does not know if it is his uncertainty that he is projecting on the universe or if it is the uncertainty of the universe reaching his consciousness.

Thus, the new world opening up is uncertain, mysterious.¹⁷ It is more Shakespearian than Newtonian. There is staged some epic, some tragedy, some buffoonery, and we do not know which is the principal scenario, if there is a principal scenario, if there is a scenario even...

VI. Towards the Galaxy Complexity

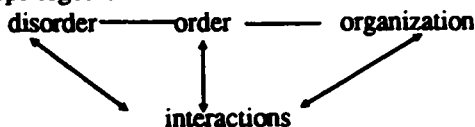
A Theoretical Genesis

The concept of order, in classical physics, was Ptolemaic. As in Ptolemy's system, where suns and planets rotated around the earth, everything rotated around order. Now, we are led to make a simultaneous, double revolution, Copernican and Einsteinian, in the concept of order. The Copernican revolution provincialized and satellized order in the universe. The Einsteinian revolution has relativized order and disorder.

These revolutions in the concept of order are revolutions in the universe. The universe has not only lost its sovereign order, it no longer has a center. Einstein has removed it from any center of privileged reference. Hubble takes away any astral or galactic center. And that brings us to the great meta-Copernican, meta-Newtonian revolution, which had been making its way subterraneanly from Carnot and Boltzmann to Planck, Bohr, Einstein, and Hubble. There is no longer a center of the world, be it the earth, the sun, the galaxy, a group of galaxies. There is no longer a non-equivocal axis of time, but a double, antagonistic process stemming from the same and only process. The universe is, therefore, simultaneously polycentric, acentric, decentric, disseminated, diasporating...

This is of capital importance henceforth for every theory of *physis*. There can no longer be a sovereign master-concept whence all others flow, derive, subsist. But theory cannot tolerate a disorderly scattering of concepts. Everything does not lead back to disorder. But everything does not include immergence in disorder.

What we have seen, in the course of this first chapter, is that the foundation on which thought takes shape is indistinct and unthinkable: is that primary concepts are no longer isolated, substantial, self-sufficient. They are bound and relativized to each other. We have even seen rapprochement at work, a curving towards each other, and finally the junction between seminal notions, and which, precisely because they are seminal, were not only disjointed, but disjunctive, that is to say: order/disorder/organization, and: chaos/cosmos/*physis*. We have seen the problem of their association and articulation posed in a complex way which cannot be a juxtaposition or an assemblage. We have even seen that a sort of conceptual circuit had been formed which loops together:



We have seen finally that the idea of catastrophe cannot be considered a pure beginning, not only because it plunges into an unfathomable "forward" but also because, to assume its meaning, it needs notions which correspond to the processes it has generated; the idea of genetic catastrophe thus takes on meaning through the "tetralogical loop" and the ideas of chaos/*physis*/cosmos.

Therefore, we will have to interrogate, explicate, develop the complex inter-solidarity of these notions, namely, the basis of unsimplifiable, irreducible complexity in every theory concerning our physical universe, namely, consequently, our biological and anthropo-sociological universe.

What we have seen appear, here, is a kind of nebulous genetic spiral of "conception of the world" in the sense that this term signifies simultaneously the principles of the organization of intelligibility (paradigm, *episteme*) and the very organization of theory. And the whole adventure of this work, in the course of these three volumes, will be to pursue, to develop this genesis in generativity and productivity—namely: method.

In the nebulous spiral, we have seen appear, coming out of the underworld and the ghettos of theory, flickering, bewildered, key notions that the kingdom of order had hounded out of science; these notions will be necessary to our interrogation because they themselves will be interrogated by this very interrogation. Thus it is with the ideas of event, game, expenditure, singularity...

Universe A-borning

The old universe had no singularity in its obedience to general laws, it had no event-ness [Fr. *évémentialité*] in its repetitive clockwork movements, no play in its inflexible determinism... The Universe which is born here is singular even in its general character; the paradigm of classical science, "there is no science except science of the general," obliged us to empty the singularity in all things, beginning with the universe. Now then, what appears absurd to us is not the junction between the idea of the singular and that of the general; it is, on the contrary, the alternative which excludes one by the other. We have seen that it is the singularity of the universe which establishes the generality of the principles and laws which apply to its nature (*physis*) and to its globality (cosmos). Which signifies that henceforth we are going to be able to hope to find, in all things, all beings, all life, concomitant with its concrete individuality (singularity), its generativity and its generativity (generality).

This universe a-borning is born in Happening and is generated in cascades

of happenings. Happening, triply excommunicated by classical science (since it was simultaneously singular, aleatory, and concrete), re-enters by the cosmic front door, since the world is born in Happening. It is not the birth which is a happening, it is Happening which is birth, in the sense that, conceived in its root meaning, it is accident, rupture, that is to say catastrophe... Hereon in, we imagine cosmic development as a series of happenings, accidents, ruptures, morphogeneses. And this character is reflected in every organized thing, star, atoms, living being, which has, in its origin and its end, something to cause a happening [Fr. *quelque chose d'événementiel*]. Much more, from the substratums of micro-physics to the immense vaults of the cosmos, every element can appear to us henceforth as a happening. Whence the necessity of the principle of complexity which, instead of excluding the event, includes it (Morin, 1972) and pushes us to look at the events of our earthly, living, and human scale, to which an anti-event science had blinded us.

This universe a-borning is a game. The idea of game had already been philosophically thrown onto the world (from Heraclitus¹⁹ to Finck, 1960, and Axelos, 1969). It made its entry into science with Von Neumann (Von Neumann and Morgenstern, 1947) in a limited sector and in a limited way at first, then spread (spread of game theory to biological evolution), and it has recently known its first elaboration intrinsically founded on *physis* (Sallantin, 1973). I am not going to go here into the game of the game. I simply want to point out that we cannot escape the idea of game in *physis* in the sense that this idea unites in itself on the one hand the idea of an aleatory win-lose process, obeying constraints and rules and elaborating configurations, on the other hand the idea of looseness in the articulations of organized phenomena, of a weak tightening up through which the disorder of encounters, interferences, contaminations, etc., infiltrates and operates.

This universe of game is at the same time a universe of fire. Fire has become genestic (thermic catastrophe) and generative of order and organization (stars, fire-machines on fire), which is why heat rules as master in the universe, all the more so because it accompanies all work, all transformation, therefore is inseparable from the least activity, organizational or not. This universe of fire, substituting for the old universe of ice, makes the wind of madness blow in classical rationality, in which the ideas of simplicity, functionality, and economy were linked. Heat always comprises agitation, dispersion, that is to say loss, expense, dilapidation, hemorrhage.

Expense was ignored when order ruled supreme. This order signified economy. Cosmic, physical, and political economy was founded on a general law of least effort, of least detour from one point to another, of least cost from one transformation to another. The very truth of a theory is always judged by

its economical character compared to its rivals, more costly in concepts, postulates, theorems.

Now, a universe created and creating by heat, transformed and transforming with heat, makes us reject as idealistic abstraction every conception which would hide expense, not only as cost, price, fee, share, but also as dissipation, loss, deficit. Consequently, even in the favorable hypothesis of a Teilhardian universe which develops its own richness in an ascensional way, there is hemorrhage, waste, mess of which we must be conscious. The encounters produce more destruction and dispersion than organization. To constitute an organization, erect an order, keep a life alive, so many "useless" agitations, so many "fruitless" expenses, so many squandered energies, so many dispersive hemorrhages are needed! There have to be so many billion agitations for a single carbon nucleus to be formed, there has to be a loss of so many billions of spermatozoa (180 million per ejaculation in *homo sapiens*) for a single mortal being to be born, there have to be so many Sisyphean efforts not to let ourselves be destroyed! What a loss, what a waste, what a mess, what an exorbitant price we must pay for an atom, a star, a life, the least ounce of existence, a kiss!

Rationalist thought includes an aspect of mad rationalization in its hiding of absurd expense. Religious thought used to explain that "liberty" demanded risk, therefore allowed loss. Rationalist thought remained blind to loss. We had to wait for Georges Bataille in order to finally discover this "accursed part." (Bataille, 1949) Now, behold, a tearing, lacerating, "absurd" idea appears, asserts itself, and will no longer let us go.

Complex Time

Physical order was unaware of the irreversibility of time until the second law of thermodynamics. Cosmic order was unaware of the irreversibility of time until 1965, when the universe entered into becoming. The eternity of the Laws of Nature was thus liquidated. There is no more frozen *physis*. Everything was born, everything appeared, everything began, once upon a time. Matter has a history.

But it is insufficient to rehabilitate only time; the new universe, in being born, makes us discover its complexity. Time is one and multiple. It is simultaneously continuous and discontinuous, that is to say, as we have seen, it is event-full [Fr. *événementiel*], shaken by ruptures, jolts, which break its thread and perhaps recreate threads elsewhere. This time is, in the same movement, the time of drifts and dispersions, the time of morphogeneses and developments.

Now, each of these two times had arisen at the same moment, in the middle of the nineteenth century.

The first, that of the second law, drew *physis* toward degradation, the first rumble announcing the great cosmic diaspora. The second, on the contrary, was that of ascensional evolution, or progress. It had penetrated society since 1789 and burst upon biology. (Darwin, *The Origin of Species*, 1859) But biological time was going inversely to entropic time, and as they had each arisen in a sphere hermetically closed to the other, people were blind (with few exceptions, among them Bergson) to the extraordinary problem that their confrontation posed (cf. Grinevald, 1975), and they were split according to the classical alternative of exclusion.

Now, we can finally break the schizophrenia between these two times which are unaware of and flee each other. They are simultaneously one, complementary, concurrent, and antagonistic; they have a common trunk, they are in symbiosis, mutual parasitism, and they fight to the death...

To this already very complex time, we will have to integrate, when we examine the problem of organization, the time of reiterations, repetitions, loops, cycles, repeated beginnings, and we will see that these repetitive times are nourished and contaminated by irreversible time (cf. Part II, ch.2), just as they are perturbed by event-full time: their movement is always spiraloid and always subject to the risk of rupture...

The great time of Becoming is syncretic (and that is what the great philosophies of becoming had been unaware of, beginning with the greatest, that of Hegel). It mixes in itself diversely, in its flux, its overlaps, these diverse times, with temporary islets of immobilization (crystallization, stabilization), whirlwinds and cycles of reiterative times. The complexity of real time is in this rich syncretism. All these diverse times are present, acting and interfering in the living being and, of course, in man: every living being, every human carries in itself the time of event/accident/catastrophe (birth, death), the time of disintegration (senescence, which *via* death, leads to decomposition), the time of organizational development (ontogenesis of the individual), the time of reiteration (the daily, seasonal repetition of cycles, rhythms and activities), the time of stabilization (homeostasis). In a refined way, catastrophic time and the time of disintegration are inscribed in reiterative, ordered/organizing cycles (births and deaths are components of the cycle of new beginning, of reproduction). And all of these times are inscribed in the irreversible hemorrhage of the cosmos...

Thus, from the start, the new universe gives rise, not only to irreversible time, but to complex time.

The Complex Nature of Nature

So then, around the tetralogical loop a polycentric constellation of notions in interdependence is set. This conceptual constellation has only general values. It brands with its presence every phenomenon, every reality to be studied. It constitutes the first foundation of the complexity of the nature of nature. But there would be, in this principle of complexity, a serious deficiency if it lacked the presence of him who sprang up with cosmic uncertainty: the observer/conceiver.

VII. The Observer of the World and the World of the Observer

All knowledge, whatever it may be, supposes a knowing mind, whose possibilities and limits are those of the human brain, and whose logical, linguistic, and informational support comes from a culture, therefore from a society, *hic et nunc*.

Classical science had succeeded in neutralizing this problem: the "scientist"—observer/conceiver/experimenter—, like a photographer, was always out of focus. The limits of the mind were suppressed because the mind was suppressed. Observations were therefore the reflection of real things, and all subjectivity (erroneously identified) could be eliminated by the concordance of observations and the verification of experiences.

The Loss of Certainty

The cosmological problem was, however, the first to come up against the limits of the human observer, incapable of inferring the past and the future of a universe still absolutely deterministic. The problem was resolved, that is to say hidden away, by the postulate that an ideal observer or daimon, situated in the best observation post possible and in possession of the master-formula (conceived at the time as a vast system of differential equations), "would embrace...the movements of the largest bodies of the universe and those of the lightest atom; nothing would be uncertain (for his intelligence), and the future like the past would be present before his eyes." (Laplace, 1812)

Cosmic order could invent only an abstract observer. Disorder alone could reveal to its own eyes the concrete observer. In fact, whereas order is precisely what eliminates uncertainty, thus erases the human mind (because all

subjective certainty is taken as objective reality), disorder is precisely what, in an observer, gives rise to uncertainty, and uncertainty tends to make the uncertain return to itself and be examined, and that all the more so because, when order is an objective, disorder is first of all taken as a deficiency of subjectivity. Thus, faced with any disorder, we inevitably ask the question: is it appearance or reality? Is it not the provisional form of (our) ignorance? Is it not the irrationalizable form of a complexity beyond the reach of our understanding? Thenceforth, the problem not only of the insufficiencies of our knowledge, but also of the limits of our understanding tends to be inscribed in every vision of the world which allows for disorder.

Uncertainty, namely, the problem of the limits of the understanding of the observer/conceiver and perhaps of human understanding itself, is amplified here on the scale of the universality of disorder. It even attacks the foundations of logic when the aporias which watch over the primal mysteries of origin and finitude appear. Finally, uncertainty definitively implants itself in the discourse which follows the path of complexity, where notions which should logically exclude each other, starting with order and disorder, automatically hug each other. And that way, under the revealing effect, in the quasi-photographic sense of the term, of uncertainty, the face of the observer/conceiver stands out superimposed on the infinite image of the cosmos he is contemplating.

The Loss of Sirius

Uncertainty is increased with the loss of Sirius, that is, the irremediable loss of the idea that there could exist a supreme point of view whence at least one demon could have contemplated the universe in its nature and its becoming. *Thenceforth the absence of an objective point of view gives rise to the presence of the subjective point of view in every vision of the world.* And we are forced to examine the subject, to look back on the hidden observer and on what is hidden behind him. And we must ask ourselves the inevitable question: who are we in this world? Whence do we observe? How do we conceive that world, how do we describe it? And these questions cannot be enclosed in a strictly physical framework. It is not enough to say that we are on the third planet of a suburban sun on the periphery of a galaxy called the Milky Way, itself peripheral, that we are beings made of atoms forged in our sun or one of its predecessors. It must also be said that we are beings organized biologically, having a very useful cerebral apparatus for considering our local environment, but which can conceive the infinitely small subatomic and infinitely vast macro-cosmic only with great difficulty. We are cultural and social beings, who have developed an activity of knowledge called science,

and it is the developments (both progress and crisis) of this science which today lead us to change universes, and also perhaps to change sciences.

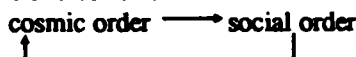
Thenceforth, the problem of the subject imposed on us is not a problem of "subjectivity" in the weakened sense in which this term signifies contingency and affectivity; it is the fundamental inquiry of oneself on oneself, on reality and truth. And this inquiry gives rise, not only to the problem of the bio-anthropological determination of knowledge, but also to that of the socio-cultural determination.

The Celestial Rorschach

The sky is the great projective test of humanity. With death, it is the sovereign catalyst and crystallizer of mythologies and religions. Debunking myths and gods has not for all that emptied the sky of all anthropo-social projections, and I do not speak here of the persistence and resurgence of astrology (Morin, 1975, pp.149-150), but rather of the scientific theories projected therein. The very elimination of the cosmos, at the beginning of this century, in favor of a physical extension spreading out infinitely, corresponds even to a negative mythology, proper to classical science, which eliminated global forms and units to ontologize only elementary units. This apparent absence of conception of the world was nothing but the triumph of the atomized conception of the world. The polemics which subsequently opposed the theory of the *steady state* to that of the *big bang* have been overdetermined by the secular conflict between lay rationalization, which tends to constitute a self-sufficient and uncreated universe, and religious belief, which has found the opportunity for a cosmic *reconquista* by introducing a divine flick in the triggering of the *big bang*, and by discovering in the inconceivable and improbable infinite the very name of the *Deus absconditus*. (cf. the "lay" point of view, in H. Alfvén, 1976)

Still more profoundly, the fierce cosmological resistance of the static paradigm of order, while everywhere else for a century everything had been in evolution and subjected to disorder, is undoubtedly significant. Is it only because classical science saw the collapse of the Newtonian keystone under which it had prospered? Must we not look beyond for a more obscure and hidden relation between cosmic and social order?

In ancient societies, there was not only a game of mirrors, but a recursive relation between cosmic and social order:



Thus, to be regenerated, social organization was supposed to obey, in a

mimetic way, through ceremonies, rites, and sacrifices, the cosmic organization on which it depends, but those ceremonies, rites, and sacrifices were themselves necessary for the regeneration of cosmic order. In our societies, only residual forms of this relation subsist. There is no longer any direct relation cosmos-society, but there is an indirect relation, mediated notably by science, and whose paradigm of order, curled up in the shadow, perhaps holds the thread... Here, we can only mark time in front of this problem, but if the reader is patient he will see in volume III that it is far from forgotten...

Contagious Heat

In any case, the collapse of cosmic order cannot be dissociated from the collapse of the principle of absolute order in classical science and the latter, from the collapse of an old social order. Since the eighteenth century the development of the physical sciences, of technology, of industry, is part of a formidable multi-dimensional transformation of society. In the course of the nineteenth century, Western societies become "hotter and hotter," (according to the very precisely thermodynamic expression used by Lévi-Strauss). Carnotian heat (1824), at first peripheral, a minor form of energy, raised in the "fire-machines," is going to spread through the bins of society, to constitute its boilers in perpetual and increasing activity; in fact, social heating does not correspond only to industrialization, but also to the growth and acceleration of all exchanges, transformations, combustions, movements in the social body, including the accentuation of Brownian agitation in the movements of individuals, their encounters, conflicts, friendships, loves, coitions, circulations, displacements... Shuddering, ferment, bubbling, boiling seize the entire fabric of economic, social, political life... It is in and by this heat that a "Thomian catastrophe" takes place in society, in which the disintegration of old forms and the gestation of new forms constitutes one and the same banged up, antagonistic, and uncertain process. And it is in the same movement that science enters into its own transforming catastrophe, precisely with the introduction, in and by heat, of agitation and disorder in every theory; this is the very movement which passes through Clausius, Boltzmann, Planck, which sows disorder in micro-physics, and finally shakes up the cosmos. Henceforth, this very heat, having made the old cosmos burst, is installed in its most ardent and irradiant form at the origin of the world and at the heart of billions of suns!

And thus, it will have been necessary that all society be in heat, that is to say both in chaos and in becoming, it will have been necessary that society become hotter and hotter, it will have been necessary that many conceptual

beams fall in ruin and in ashes, it will have been necessary that science itself be revolutionized by heat, so that the world finally stretch, yawn, loosen up, get going, and finally plunge into becoming, rise up in chaos, drink up disorder, go into labor...

And here, how can we not be struck by the homology of the catastrophes of science, society, the cosmos? By the astounding coincidence between the crisis of social order and the crisis of cosmic order? And even between the crisis of the cosmos on the whole and the crisis of humanity on the whole? Both becomings seem to suffer the same radical ambiguity. We do not know if the cosmic diaspora is going to submerge the organized archipelagoes, or if these are headed toward superior developments which will allow them to overcome the generalized diaspora. We do not know if humanity is promised to dispersion, or will find an organizing communication; we do not know if the ever more profound and multiple aspirations for a radically new and different society will be swept away and dispersed... In either case, the crisis of the old order is very profound, but the new organization is uncertain. In either case, what is dying is dying, and what is being born is not being born. In either case, the worst is statistically probable, but in either case, what has been creator and founder has always been statistically improbable...

Now, I am uncertain even about the nature of this uncertainty; is it the uncertainty of our social becoming which is projected on the cosmos? Is it the pace of cosmic becoming which is accelerated and panic-stricken locally today in and by our anthropo-social becoming? Is it not rather my mind, which, uncertain by nature and culture, projects thus its own uncertainty both on society and on the cosmos? *And, is it not, especially, all of this simultaneously?*

Here in an apparently solidary and inextricable way, the cosmic and anthropo-social dimensions and the dimension of consciousness proper to the subject are joined.

The subject emerges fully in this very conjunction; the subject, with all that this term signifies of insufficiency, limitation, egocentrism, ethnocentrism, but also of will, consciousness, interrogation, and research: the subject emerges not only with disorder, uncertainty, contradiction, bewilderment in face of the cosmos, loss of the privileged observation post, but also and simultaneously with the awareness of his cultural and social rooting *hic et nunc*.

And his first awareness is this: *it is not only humanity which is a by-product of the becoming, it is also the cosmos which is a by-product of an anthropo-social becoming.*

Knowledge of the heavens does not fall from the heavens. The very conception of the universe is in dependent relation with the development of the

means of production of knowledge—today, science—itself in interdependence with the productive developments of society. Whence the socio-solipsistic tendency, which consists of inverting—that is to say preserving in its unilateral character—the old paradigm of “objective science” and making it only a social production of ideological character. Now, such a vision, which preserves very precisely what the old paradigm had as reductive and simplifying, removes all interest in the problem of knowing, not only the universe, but everything that is not social; at the same time, it deprives social knowledge of all foundation; in isolating and absolutizing the anthropo-social sphere, it enclosed itself in the absolute solipsism, since it ceases to possess the least exterior referent on which to base itself.

Now, to conceive science we cannot eliminate the problem of *observations*, which sort of constitute the cryptic message received from the exterior universe by the mind locked up in itself and in its society *hic et nunc*, a mind which can find in itself and in its culture, not only the ideology of illusion, but some ideas of elucidation.

Our key problem thenceforth is unveiled: it is the problem of paradox, enigma, the complexity of the Gordian knot with the two ties:

1. the tie between the cosmos-object and the knowing subject where the cosmos encompasses and generates the knowing subject, who appears as a minute and fugitive element/event in cosmic becoming, but in which at the same time the knowing subject encompasses and generates the cosmos in his own vision;

2. the tie between the cosmo-physical universe and the anthropo-social universe where each in its own way produces the other while being dependent on the other.

One sees then what my first purpose is: the search for the “nature of Nature” cannot do without the search for a method to grasp the key articulations object/subject, nature/culture, *Physis/Society*, which simple facts hide and break. *The unknown, the uncertain, the complex are found precisely in these articulations.*

Will we know how to make uncertainty the leaven of complex knowledge? Will we know how to encompass the knower in knowledge and grasp knowledge in its multi-dimensional roots? Will we know how to elaborate the method of complexity? I know: the risks of failure in such an undertaking are highly probable...

2. Organization

(from the object to the system)

In all physical science, there is not one thing that is a thing. James Key.

The object denotes us more than we denote it. Bachelard.

All reality is complex unity. A.N. Whitehead.

If I find some other person capable of seeing things in their unity and in their multiplicity, there is the man that I will follow as I would follow a God. Plato (*Phaedra*).

The Enigma of Organization

Organization is the marvel of the physical world. How does it happen that from an incandescent deflagration, that from a soup of photons, electrons, protons, and neutrons at least 10^{73} atoms can be organized; that millions of billions of suns swirl about in the 500 million known galaxies (and beyond the 2-3 billions of light years, we no longer understand much)? How could these billions of fire-machines arise out of fire? And of course: how could life?

We know today that everything that ancient physics conceived as simple element is organization. The atom is organization; the molecule is organization; the star is organization; life is organization; society is organization. But we know nothing at all of the meaning of this term: organization.

Legendary problem. Always deviant in its origin (catastrophic, schismatic, aleatory), it is for us what constitutes the central core of *physis*, what is endowed with being and existence (for us non-organized particles have hardly any being, any flavor of existence).

It is because there is organization that we speak of *physis*. However, it is the absentee concept of physics. Order was the notion which, in suppressing all the others, had also suppressed the idea of organization. After the upsurges of disorder and the first refluxes of order, we have finally seen interaction become a central idea in modern physics. Interaction is in fact a necessary, crucial notion; it is the turntable where the idea of disorder, the idea of order, the idea

of transformation, and finally the idea of organization meet. Physics is being converted to the idea of interaction. But we still have to have the idea of organization emerge.

Now, this cannot take shape from a principle which would be the complementary antagonist of the second law of thermodynamics. The generating source of organization is, as we have seen, the complexity of cosmic disintegration, the complexity of the idea of chaos, the complexity of the relation disorder/interaction/encounters/organization.

Whereas it is sufficient to raise the temperature of an environment to melt a cube of ice, or to beat eggs to scramble them, it is not sufficient to cool the environment once again to have the ice retake its form, to beat in an inverse direction to have the eggs unscramble; organization is not disorganization reversed. And it is also by reason of all these difficulties that organization, the fundamental question to which all the avenues of modern science lead, could not be treated by classical science:¹ it was a complex question. To reduce it to a simple question is to disorganize organization.

The science of order repressed the problem of organization. The science of disorder, the second law, reveals only the shell, *negatively*. The science of interactions leads us only to its antichamber. Organization is the absentee principle of physics, the paradox of thermodynamics, the enigma of the suns, the mystery of micro-physics, the problem of life. But what is organization?

What is this enigma, in this universe of catastrophe, turbulence, dispersion, and which appears in catastrophe, turbulence, dispersion: organization? It is this question that I am going to address, not in the illusion of defining an "organizing force" of the type "dormitive virtue of opium," a false solution which thickens the mystery, but with the intention of recognizing its mode of existence and development. This is going to necessitate questioning beforehand the notion of object which was obstructing by its opaque and homogeneous mass the access to any idea of system or organization.

I. From the Object to the System; from Interaction to Organization

A. From the Object to the System

The Royalty of the Substantial Object and Elementary Unity

In a physical universe which we know starting from our perceptions and our representations, under the species of liquid or solid matter, of fixed or

changing forms, on our planet where appearances are infinitely diverse and entangled, we grasp objects which seem to us autonomous in their environment, outside our understanding, endowed with their own reality.

Classical science was founded under the banner of *objectivity*, namely of a universe constituted of isolated *objects* (in a neutral space) governed by laws *objectively* universal.

In this vision the object exists in a positive fashion, without the observer/conceiver participating in its construction by the structure of his understanding and the categories of his culture. It is substantial; constituted of matter having ontological fullness, it is self-sufficient in its being. The object is thus a closed and distinct entity, which is defined by isolation in its existence, its characteristics and properties, independently of its environment. We determine so much more readily its "objective" reality as we isolate it experimentally. Thus, the objectivity of the universe of objects resides in their double independence with regard to the human observer and the natural environment.

The knowledge of an object is the knowledge of its situation in space (position, speed), of its physical qualities (mass, energy), of its chemical properties, of the general laws which govern it.

What characterizes an object can and must be brought back to measurable dimensions; its material nature itself can and must be analyzed and decomposed into simple substances or elements, of which the atom becomes the basic unit, indivisible and irreducible before Rutherford. In this sense, phenomenal objects are conceived as compounds or mixtures of primary elements which hold their fundamental properties.

From that moment the explanation said to be scientific by its promoters, reductionist by its contesters, must be accepted. The description of any composed or heterogeneous phenomenal object, including its qualities and properties, must decompose this object into its simple elements. To explain is to discover the simple elements and the simple rules based on which the various combinations and complex constructions are worked out.

Since any object can be defined according to the general laws which govern it and the elementary units which constitute it, all references to the observer or to the environment are excluded, and reference to the organization of the object can only be accessory.

In the course of the 19th century "reductionist" research triumphed on all fronts of *physis*. It isolated and inventoried the chemical elements constituting all objects, discovered the smallest units of matter, conceived first as molecules then as atoms, recognized and quantified the fundamental characteristics of all matter, mass, and energy. The atom thus glittered as the object of objects, pure,

full, indivisible, irreducible, the universal component of gases, liquids, and solids. Every movement and state, every property could be conceived as a measurable quantity by referring to the primary unit proper to it. Thus, physical science at the end of the 19th century had at its disposal a battery of measurements permitting it to characterize, describe, define any object whatsoever. It brought both the rational knowledge of things and the questioning of things. The method of decomposition and of measurement permitted experimenting, manipulating, transforming the world of objects: the objective world!

The success of classical physics pushed the other sciences to establish likewise their object in isolation from any environment and any observer, to explain it by virtue of the general laws which it obeys and the simplest elements which constitute it. Thus, biology conceived its own object in isolation, first the organism, then the cell, once it had found its elementary unit: the molecule. Genetics isolated its object, the genome: it recognized the elementary units in it, first the genes, then the four basic chemical elements whose combination furnishes the reproduction "programs" which can vary infinitely. The reductionist explanation triumphed there also, it seems, since we could explain all living processes by the interplay of a few simple elements.

Decay at the Base

Now, beginning with physics, a strange reversal takes place at the start of the 20th century. The atom is no longer the primary unit, irreducible and indivisible: it is a system constituted of particles in mutual interaction. Would the particle from that moment on take the place prematurely assigned to the atom? Indeed it seems undecomposable, indivisible, substantial. However, its quality as elementary unit and its quality as object are going to be very rapidly blurred.

The particle not only is in a crisis of order² and a crisis of unity (we number today more than two hundred particles), it is undergoing especially a crisis of identity. We can no longer isolate it in a precise way in space and time. We can no longer isolate it totally from the interactions of observation. It wavers between the double and contradictory identity of wave and corpuscle.³ It occasionally loses all substance (the photon at rest has no mass). That it is a primary element is less and less plausible; at one moment we think of it as a system composed of *quarks* (and the *quark* would be still less reducible than the particle to the classical concept of object), at another we envisage it as a "field" of specific interactions. Finally, it is the idea of elementary unit itself which has become problematic: perhaps there does not exist any ultimate or

primary reality individualizable or isolable, but a continuum (*bootstrap* theory), even a unitary root outside time and outside space. (d'Espagnat, 1972)

Thus, no longer being a true object nor a true elementary unit, the particle opens up a double crisis: the crisis of the idea of object and the crisis of the idea of element.

As object, the particle has lost all substance, all clarity, all distinction, sometimes even all reality; it becomes a Gordian knot of interactions and exchanges. To define it, we must appeal to the interactions in which it participates, and, when it is part of an atom, to the interactions which weave the organization of this atom.

In these conditions, not only is the reductionist explanation no longer suitable for the atom, none of whose characteristics or qualities can be induced starting from the characteristics proper to its particles, but it is the traits and characteristics of the particles which, in the atom, can only be understood in reference to the organization of this system. *The particles have the properties of the system much more than the system has the properties of the particles.* We cannot understand, for example, the cohesion of the nucleus, composed of associated protons and stable neutrons, starting from the specific properties of the protons, which in free space mutually repel each other, and of neutrons, which, very unstable in free space, each spontaneously decompose into protons and electrons.

Likewise, the behavior of electrons around the nucleus cannot flow from their individual laws of mechanics. Each electron, by itself, would tend to place itself at the most profound energy level, and we would expect all the electrons to place themselves simultaneously at this fundamental level. But as Pauli's exclusion principle has shown, "it is precisely then that the constraint of totality acts to limit to two electrons of opposite spins the maximum number which can occur at the same level, and this exigency has the effect of filling a large number of levels in the atom, independently of the fact that they are more or less deep. Of course, the atom thus constituted is qualitatively quite different from what it would have been if each electron had gone to lodge itself at the lowest level." (N. Dallaporta, 1975)

Since then, the atom steps forward as a new object, the organized object or system whose explanation can no longer be found solely in the nature of its elementary components, but is found also in its organizational and systemic nature, which transforms the characteristics of the components. Now, because this system, the atom, constitutes the true texture of what is the physical universe, gases, liquids, solids, molecules, heavenly bodies, living beings, we see that the universe is founded, not on an indivisible unity but on a complex system!

The Universe of Systems

The universe of systems emerges, not only at the ground level of *physis* (atoms) but also at the cosmic keystone. The old astronomy saw only a solar system, namely a clockwork rotation of planets around the sun. The new astro-physics discovers myriads of sun-systems, organizing sets which self-maintain by spontaneous regulations.

From its side, modern biology *gives life* to the idea of system by ruining simultaneously the idea of living matter and the idea of vital principle, both of which used to anesthetize the system idea enclosed in the cell and the organism. Since then the idea of a living system inherits simultaneously the animation of the ex-principle of life and the substantiality of living ex-matter. Finally, sociology since its foundation had considered society as a system, in the strong sense of an organizing whole irreducible to its components, the individuals.

Therefore, on all horizons, physical, biological, anthropo-sociological, the system-phenomenon must henceforth be accepted.

The System Archipelago

All the key objects of physics, biology, sociology, astronomy, atoms, molecules, cells, organisms, societies, stars, and galaxies constitute systems. Outside systems, there is only particle dispersion. Our organized world is an archipelago of systems in the ocean of disorder. All that was object has become system. All that was even an elementary unit, including and especially the atom, has become system.

We find in nature masses, aggregates of systems, unorganized flows of organized objects. But what is remarkable is the polysystemic character of the organized universe. The latter is an astonishing architecture of systems built one on the other, one between the other, one against the other, implicating and dovetailing one with the other, in a grand game of masses, plasmas, fluids of micro-systems circulating, floating, enveloping the architectures of systems. Thus, the human being belongs to a social system, in the heart of a natural eco-system, which is in the heart of a solar system, which is in the heart of a galactic system: it is constituted of cellular systems, which are constituted of molecular systems, which are constituted of atomic systems. There is, in this chain, overlapping, mortising, superpositioning of systems; and in the necessary dependence of some with respect to others, in the dependence, for example, which ties a living organism, on the planet earth, to the sun which floods it with photons, to the exterior life (eco-system) and interior life (cells

and perhaps micro-organisms), to the molecular and atomic organization, there is a key phenomenon and a key problem.

The phenomenon is what we call *Nature*, which is nothing but extraordinary solidarity of mortised systems building one on the other, by the other, with the other, against the other: Nature is systems of systems in chaplets, clusters, polyps, bushes, archipelagoes.

Thus, life is a system of systems of systems, not only because the organism is a system of organs which are systems of molecules which are systems of atoms, but also because the living being is an individual system which is part of a system of reproduction, because both are part of an eco-system, which is a part of the biosphere...

We were so taken by dissociative and isolating thought, that this evidence was not, with exception, noticed: "There exist really only systems of systems, the simple system being only a didactic abstraction." (Lupasco, 1962, p.186) Nature is a polysystemic whole: we will have to draw here all the consequences of this idea.

The problem, highlighted by Koestler with the idea of *holon* (Koestler, 1968), is one of the aptitude proper to systems to interdesign themselves, to construct themselves on and by others, each able to be at the same time part and whole.

Let us tie the phenomenon to the problem: we have to interrogate the nature of the system and the System of Nature. We can start with these initial remarks: *the system has replaced the simple and substantial object, and it rebels against being reduced to its elements; the chain of systems of systems breaks the idea of the closed and self-sufficient object. We have always treated systems as objects; it is a matter henceforth of conceiving objects as systems.* Henceforth, we must conceive what a system is.

Presence of Systems, Absence of the System

The phenomenon of systems is today evident everywhere. But the idea of system has still hardly emerged in the sciences which treat systemic phenomena. Certainly chemistry conceives the molecule *de facto* as a system, nuclear physics conceives the atom *de facto* as a system, astrophysics conceives the star *de facto* as a system, but nowhere is the idea of system explained or explaining. Thermodynamics resorts fundamentally to the idea of system, but it is to distinguish the closed from the open, and not to recognize in system a proper reality. The idea of living system vegetates and is not developing. The idea of social system remains trivial: sociology, which uses and abuses the term system, never elucidates it: it explains society as a system

without knowing how to explain what a system is.⁴

Thus, a bit everywhere, the term system is seen, to be avoided, to be emptied. System appears as a root concept, and as such, from Galileo⁵ until the middle of this century, had not been studied or reflected upon. We can understand why: at one time, the twofold and exclusive attention to the constitutive elements of objects and to the general laws which regulate them prevent any emergence of the idea of system; at another, the idea emerges flabby, subordinated to the character *sui generis* of objects disciplinarily considered. Thus, in its general sense, the term system is an all-embracing word; in its particular sense, it adheres unstickably to the matter which constitutes it: no relation is therefore conceivable between the diverse uses of the word system: solar system, atomic system, social system; the heterogeneity of both the components and the laws of organization between stellar systems and solar systems is so evident and striking that it annihilates all possibility of tying into one the two meanings of the term system.

Thus, in the sciences, systems are everywhere, the system is nowhere. The notion is diasporated, deprived of its principle of unity. Implicit or explicit, atrophied or emerging, it was never able to lift itself to the theoretical level, at least not before Bertalanffy. Is it because of an insufficiency in science or an insufficiency in the concept of system? Does science need to develop a systems theory, or is the concept of system not developable theoretically? In other words, is it worth the trouble to disengage and autonomize the notion of system? Is it too general in its universality, too particular in its diversities? Is it trivial and only trivial?

We need to interrogate the notion of system. Are there systemic laws at once fundamental, original, not trivial? In other words, do these laws have some interest for the study of particular systems and for the general comprehension of *physis*?

During the fifties, Bertalanffy worked out a *General System Theory* which finally revealed the systems problematic. This theory (Bertalanffy, 1968) spread to all points of the globe, with diverse fortunes, in the course of the sixties. Although it contains radically innovating aspects, general systems theory has never attempted the general theory of *the* system; it has omitted deepening its own foundation, reflecting on the concept of system. Thus, the preliminary work still remains to be done: interrogate the idea of system.

First Definition of System

We have along the way furnished a quick definition of system: an interrelation of elements constituting an entity or a global unit. Such a

definition has two principal characters; the first is the interrelation of the elements, the second is the global unity constituted by these elements in interrelation. In fact, most of the definitions of the notion of system, from the 17th century up to the systematists of *General Systems Theory*, recognize these two essential traits, stressing at one time the trait of totality or globality, at another the relational trait. They complete and overlap each other without really ever contradicting each other. A system is "a set of parts" (Leibniz, 1666), "any definable set of components" (Maturana, 1972). The most interesting definitions tie the global character to the relational trait: "A system is a set of unities with relationship among them" (Bertalanffy, 1956); it is "the unity resulting from parts in mutual interaction" (Ackoff, 1960); it is "a whole which functions as a whole by virtue of the parts which constitute them" (Rapoport, 1968). Other definitions indicate to us that a system is not necessarily or principally composed of "parts;" certain ones among them can be considered a "set of states" (Mesarovic, 1962), indeed even a set of events (which holds for every system whose organization is active), or of reactions (which holds for living organisms). Finally, the definition of Ferdinand de Saussure (who was a systematist rather than a structuralist) is particularly well articulated and evokes especially the concept of organization by linking it to that of totality and interrelation: the system is "an organized totality, made up of interdependent elements holding together and not able to be defined except one by the other in function of their place in this totality." (Saussure, 1931)

In fact, it is not sufficient to associate interrelation and totality; one must tie totality to interrelation by the idea of organization. In other words, as soon as the interrelations between elements, events, or individuals⁶ have a regular or stable character, they become organizational⁷ and constitute a "furnace."

Organization, the concept absent from the majority of the definitions of system, was until now almost stifled between the idea of totality and the idea of interrelations, when actually it ties the idea of totality to that of interrelations, the three notions becoming undissociable. Thenceforth, we can conceive system as *a global unity organized by interrelations between elements, actions, or individuals.*

From Interaction to Organization

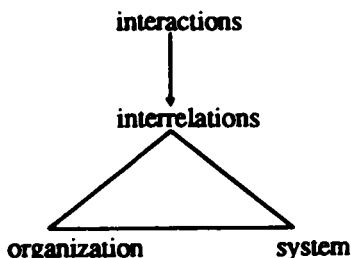
The aptitude to self-organization is the fundamental property, surprising and evident, of *physis*. Yet it is the great absentee in physics.

The problem of organization has been repressed and concealed in the same way the problem of system has (evidently, since they are the two sides of the same problem). The sciences met it, partially treated it, always in terms of the

particular point of view of the disciplines. Certain ones treated it poorly, under the term of structure. Modern physics advances towards the problem of organization when it transforms the law of nature into interactions (gravitational, electromagnetic, nuclear, weak and strong), but it has not yet conceived the passage, the transformation of certain interactions of relational character into organization. As often happens, the thing emerges before the concept, which waits for its niche to form before being able to occupy it. But henceforth the idea that there is a general problem with organization is "in the air." "Whatever the levels may be, the objects of analysis (of science) are always organizations, systems" (Jacob, 1970, p.344⁸); and Chomsky: "Scientific method...is interested in givens, not in themselves but as witness to the laws of organization." (Chomsky, 1967) The idea of entity properly organizational is suggested or looked for with *holon* (Koestler, 1968), *org* (Gérard, 1958), *integron* (Jacob, 1971). It is Henri Atlan who finally really disengages the concept as concept. (Atlan, 1968, 1974)

B. From Interaction to Organization

I recall what was said in conclusion to the preceding chapter: there is not, in Nature, a law *sui generis* of organization or organotropy, which, like a *deus ex machina*, would provoke the reunion of elements which should constitute the system. There is no systemic law anterior and exterior to the interactions between elements. On the other hand, there are physical conditions of formation wherein certain phenomena of interaction, taking the form of interrelations, become organizational. If there is an organizing principle, it is born from chance encounters, in the copulation of disorder and order in and by catastrophe (Thom, 1972), namely the change of form. The morphogenetic marvel is precisely that: the upsurge of interrelation, of organization, of system are three aspects of the same phenomenon.



What is organization? As a first definition: organization is the arrangement of relations between components or individuals which produces a complex unity or system, endowed with qualities unknown at the level of components or individuals. Organization interrelationally ties⁹ diverse elements, events, or individuals which henceforth become the components of a whole. It assures relative solidarity and solidity to these ties, thus assures the system a certain possibility of duration despite chance perturbations. Organization, therefore: *transforms, produces, binds, maintains.*

The Trinitarian Concept: organization  *system*
interrelation

The idea of organization and the idea of system are still, not only embryonic, but dissociated. My aim here is to associate them, since system is the phenomenal and global character which interrelations take, whose arrangement constitutes the organization of the system. The two concepts are tied by that of interrelations: any interrelation endowed with some stability or regularity takes on an organizational character and produces a system.¹⁰ There is, therefore, a circular reciprocity among these three terms: interrelation, organization, system.

These three terms, though inseparable, are relatively distinguishable. The idea of interrelation returns to the types and forms of union between elements or individuals, between these elements/individuals and the Whole. The idea of system returns to the complex unity of the interrelated whole, its characters and its phenomenal properties. The idea of organization returns to the arrangement of parts in, as, and by a Whole.

The relative autonomy of the idea of organization is verified in the simplest way in the case of isomers having the same chemical formula, the same molecular mass, but whose properties are different because there is a certain difference in the arrangement between the atoms in the molecule. We sense immediately the considerable role of organization, if it can modify the qualities and characters of systems constituted by similar elements, but arranged, that is to say organized, differently. We know from elsewhere that the diversity of atoms results from variations in the number and arrangement of three types of particles, that the diversity of living species depends on variations in the number and arrangement of four basic elements forming a "code."¹¹

Therefore, we need one concept in three, three concepts in one, each constituting a definable aspect of the same common reality.

The construction of this trinitarian concept can be of primordial interest, since it would concern the organized *physis* that we know, from the atom to the star, from bacteria to human society.

Primordial interest or primary banality? We cannot see what "common" elements could emerge from an empirical confrontation between molecule, society, star. But it is not in that direction that we must work: *it is in our way of organizationally perceiving, conceiving, and thinking of what surrounds us, and which we call reality.*

II. Organized Complex Unity.

The Whole and the Parts. Emergences and Constraints.

Unitas Multiplex

It is not possible to give a system a substantial, clear, simple identity. A system presents itself at first as *unitas multiplex* (Angyal, 1941), namely as paradox: considered in respect to the Whole, it is one and homogeneous; considered in respect to the components, it is diverse and heterogeneous. Atlan has very clearly stated the organizational character of this paradox: organization is a complex of variety and of repetitive order (redundance); it can even be considered a compromise, or a conjunction between the maximum of variety and the maximum of redundance. (Atlan, 1974)

The first and fundamental complexity of a system is to associate in itself the idea of unity on the one hand, of diversity or multiplicity on the other, which in principle repel and exclude each other. And we must understand the characters of complex unity: a system is a global unity, not elementary, since it is constituted by diverse interrelated parts. It is an original unity, not there initially: it possesses its own irreducible qualities, but it has to be produced, constructed, organized. It is an individual unity, not indivisible: we can decompose it into separate elements, but then its existence decomposes. It is a hegemonic, not a homogeneous, unity: it is constituted by diverse elements, endowed with their own characters which it holds in its power.

The idea of complex unity is going to take on density if we vaguely sense that we can reduce neither the whole to the parts nor the parts to the whole, neither the one to the multiple nor the multiple to the one, but that we must try to conceive together, in a way simultaneously complementary and antagonistic, the notions of whole and parts, of one and diverse.

We begin to understand that this complexity has had an allergic effect on a science that was looking to found itself precisely on the reducible, the simple, the elementary. We begin to understand that the concept of system has been

skirted, neglected, ignored. Even in the work of the systematists, very rare are those who have introduced complexity in the definition of system. I have found it only in the works of Jean Ladrière: "A system is a complex object, formed of distinct components connected with each other by a certain number of relations." (Ladrière, 1973, p.686) Now, if we want to attempt a theory of system, we have to face the problem of complex unity, beginning with the relation between the whole and the parts.

A. Emergences

1. *The Whole Is More Than the Sum of Its Parts.*

A system possesses something more than its components considered as separate or juxtapositioned:

- its organization,
- the global unity itself (the "whole"),
- the new qualities and properties emerging from organization and from global unity.

Let us note immediately that it is very abstractly that I separate these three terms, for organization and global unity can be considered as qualities and new properties emerging from the interrelations between parts; the organization and the new qualities can be considered as traits proper to the global unity; the global unity and its emergent qualities can be considered as the very products of organization.

It is especially the notion of emergence which can be confused with that of totality, the whole being emergent, and emergence being a trait proper to the whole.

The idea of totality, is, therefore, crucial here. This idea, which had often surfaced in the history of philosophy, had blossomed in romantic philosophy and especially in Hegel. It has sometimes arisen in the contemporary sciences, as in the theory of form or *Gestalt*.¹² From the point of view of the construction of the concept of system itself, Foerster indicated that the rule for the composition of components in interaction in the coalition is superadditive (*superadditive composition rule*). (Foerster, 1962, pp.866-867) It is now necessary to single out the new qualities or properties which emerge with globality.

2. *Global Emergences*

We can call emergences the qualities or properties of a system which present a character of newness in respect to the qualities or properties of the

constituents considered separately or arranged differently in another type of system.

Every global state presents emergent qualities. The atom, we have seen, is a system possessing original properties, notably stability, in respect to the particles which constitute it, and it retroactively confers this quality of stability on the unstable particles which it integrates. As for the molecules, "the newly appeared type has no relation at all with the primitive components, its properties are not at all the sum of theirs, and it behaves differently in all circumstances. If the mass, the quantity of total substance stays the same, its quality, its essence is brand new." (Auger, 1966, pp.130-131) Thus, the mixture of the two gases, ammonia and hydrochloric acid, produces molecularly solid ammonium chloride. The example, apparently banal, in fact very complex, of water shows us that its liquid character (at ordinary temperatures) is due to the properties, not of the atoms, but of the molecules of H_2O to link up with each other in very supple fashion.¹³

Qualities are born of associations, combinations; the association of an atom of carbon, in a molecular chain makes stability emerge, a quality indispensable to life. In what concerns life, "it is clear that the properties of an organism go beyond the sum of the properties of its components. Nature makes more than additions: it integrates," (Jacob, 1965) and it is clear that the living cell has emergent properties (Monod, 1971)—to nourish itself, to metabolize, to reproduce.

These emergent properties, whose cluster is precisely called life, imbibe the whole as whole and retroact on the parts as parts. From the cell to the organism, from the genome to the genetic pool are constituted systemic totalities with emergent qualities.

Finally, the implicit or explicit postulate of all human sociology is that society cannot be considered as the sum of the individuals that compose it, but that it constitutes an entity endowed with specific qualities.

It is quite remarkable that the apparently elementary notions that are matter, life, meaning, humanity, correspond in fact to the emergent qualities of systems. (Serres, 1976, p.276) Matter has consistence only at the level of the atomic system. Life, we have just seen, is the emanation of living organization; it is not organization which is the emanation of a vital principle. Meaning, which linguists grope for in the depths or the dark corners of language, is nothing but the very emergence of discourse, which appears in the deployment of global unities, and retroacts on the basic unities which have made it emerge. The human, finally, is an emergence proper to the hyper-complex cerebral system of an evolved primate. Thus, to define man as opposed to nature is to define him exclusively in function of his emergent qualities.

3. *Micro-emergences (the Part Is More Than the Part)*

Emergence is a product of organization which, although inseparable from the system insofar as whole, appears, not only at the global level, but eventually at the level of the components.

Thus, qualities inherent to the parts within a given system are absent or virtual when these parts are in an isolated state; they can be acquired and developed only by and in the whole. As we have seen, the neutron acquires qualities of duration within the nucleus; electrons acquire qualities of individuality under the organizational effect of Pauli's exclusion principle. The cell creates conditions of full use of molecular qualities under-utilized in the isolated state (catalysis). In human society, with the constitution of culture, individuals develop their aptitudes for language, craftsmanship, art, that is to say that their richest individual qualities emerge within the social system. Thus, we see systems where macro-emergences retroact as micro-emergences on the parts. Thenceforth, not only is the whole more than the sum of the parts, it is the part that is, in and by the whole, more than the part.

4. *The Reality of Emergence*

The phenomena of emergence are clearly evident, as soon as they are noticed. But this evidence is dispersed, singularized; it has not been meditated or theorized.

In the idea of emergence there are, closely linked, the ideas of:

- quality, property,
- product, since emergence is produced by the organization of the system,
- globality, since it is undissociable from global unity,
- newness, since emergence is a new quality in respect to the anterior qualities of the elements.

Quality, product, globality, newness are, therefore, notions which we must link up in order to understand emergence.

Emergence has something relative (with respect to the system which produced it and on which it depends) and absolute (in its newness); it is under these two apparently antagonistic angles that we must consider it.

a) New Quality

Emergence is a new quality in respect to the components of the system. It has, therefore, the force of *event*, since it surges up discontinuous once the system has been constituted; it has of course the character of *irreducibility*: it

does not allow itself to be decomposed and one cannot deduce it from nterior elements.

We have just said that emergence is *irreducible*—phenomenonally—and undeducible logically. What do we mean by this? First of all, that emergence imposes itself as *fact*, a phenomenal given which understanding must first of all recognize. The new properties which arise at the level of the cell are not deducible from the molecules considered in themselves. Even when we can predict emergence based on knowledge of the conditions of its rise, it constitutes a logical jump and opens in our understanding the breach through which the irreducibility of the real penetrates...

b) Between Epiphenomenon and Phenomenon

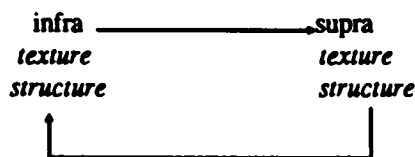
How to situate emergence? It seems to us at times to be an epiphenomenon, a product, a resultant; at other times it seems to be the very phenomenon which makes the originality of the system.

Let us take the example of our consciousness. Consciousness is the global product of cerebral interactions and interferences inseparable from the interactions and interferences of a culture on an individual. We can effectively conceive it as epiphenomenon, a flash bursting and dying immediately, a will-o'-the-wisp incapable of modifying behavior commanded or "programmed" apart (genetic apparatus, society, "pulsions." etc.). Consciousness can also very precisely appear as a superstructure, resulting from depth organization, and which manifests itself in a superficial and fragile fashion, like all that is second and dependent. But such a description would omit noticing that this fragile epiphenomenon is at the same time the most extraordinary global quality of the brain, the self-reflection by which the "I myself" exists. This description would also ignore the retroaction of consciousness on ideas and on behavior, the upheavals which it can bring about (consciousness of death). Finally, this description would ignore the dimension quite new and sometimes decisive which the self-critical aptitude of consciousness can bring to personality itself. The retroaction of consciousness can be more or less uncertain, more or less modifying. And, according to the moments, according to the conditions, according to the individuals, according to the problems confronted, according to the pulsions challenged, consciousness will appear to be at various times pure epiphenomenon, or superstructure, or global quality; at times capable, at other times incapable of retroaction...

Thus, the concept of emergence does not allow itself to be reduced by concepts of superstructure, epiphenomenon, or globality; but it does contain necessary relations, oscillating and uncertain, with those concepts. It is precisely both its irreducibility and that imprecise and dialecticable relation

which imposes it as a complex notion. Consequently, characterizing emergence only as superstructure becomes ridiculous. Emergence is too tied to globality, and globality is too tied to organization, to be superficialized.

We have just seen that consciousness is a quality endowed with organizing potentialities, capable of retroacting on the being itself, of modifying it, of developing it. At this point, we must abandon the simple hierarchy between *infra* (texture, structure) and *supra* (texture, structure) in favor of an organizational retroactivity where the ultimate product retroacts by transforming that which produces it.



Thus, emergence constrains us to complexify our systems explanation of systems. Fruit of the organizational/systemic ensemble, emergence can certainly be decomposed into its constitutive elements. But, as with fruit this decomposition decomposes emergence. Like fruit, emergence is always ultimate (chronologically) and always first (by quality). It is both the product of synthesis and the force of synthesis. And in the same way that the fruit, ultimate product, is at the same time the ovary-bearing reproductive power, likewise emergence can contribute retroactively to producing and reproducing what produces it.

5. The Emergence of Reality

a) Phenomenal Reality

Emergences, new qualities, are at the same time phenomenal qualities of the system. As I have said, they are logically undeducible and physically irreducible (they are lost if the system dissociates). But, by that very fact, they constitute the sign and the indication of a reality exterior to our understanding. We will meet this idea again along our way: the real is not what allows itself to be absorbed by logical discourse, but what resists it. It seems to us here, therefore, that the real is found not only hidden in the depths of "being" [Fr. *l'être*]; it springs also to the surface of the "active being" [Fr. *l'étant*] in the phenomenality of emergences.

b) Material Architecture

We noted earlier: nature is polysystemic. From the nucleus to the atom, from the atom to the molecule, from the molecule to the cell, from the cell to

the organism, from the organism to society, a fabulous systemic architecture grows. It is not a question here of noting this architecture, but of indicating that it is conceivable only by introducing the notion of emergence.

In fact, the global emergences of the basic system, the atom, become materials and elements for the systemic level encompassing the molecule, whose emergent qualities, in their turn, will become the primary materials of cellular organization, and so on... The emergent qualities rise one on the other, the heads of some becoming the feet of others, and systems of systems of systems are emergences of emergences of emergences.

6. *The Emergence of Emergence*

The notion of emergence hardly emerges. And already we sense its polyvalent necessity. Emergence allows us to understand better the profound meaning of the proposition according to which the whole is more than the sum of the parts. Though organization and globality can also be considered as emergence, we can understand that this *more* is not only the organization which creates globality, it is also the emergence which globality causes to flourish.

Emergence opens up to us a new understanding of the phenomenal world; it proposes to us a conducting thread through the arborescences of organized matter. At the same time, it poses problems for us; we need to situate it in a complex fashion in the relations between whole and parts, between structurality (super-, infra-structure) and phenomenality, and this obliges us to go further into systems theory.

In another way, it also leads us to the most surprising aspects of *physis*: the leap of newness, synthesis, creation... This notion, precisely in the logical and physical leap from the qualities of the elements to the qualities of the whole, also carries its mystery, like all notions bearers of intelligibility. This mystery of emergence, the very mystery of life and of consciousness, already appears "in the physical mystery of the atom, of the molecule, or even of a resonant circuit." (Stewart)

We can finally better sense what weaves and unravels our own lives. If it is true that emergences constitute, not native virtues but virtues of synthesis, if it is true that, always chronologically second, they are always first by quality, if it is true therefore that the most precious qualities of our universe can only be emergences, then we need to reverse the vision of our values. We want to see these exquisite virtues as unalterable essences, as ontological foundations, whereas they are ultimate fruits. In fact, basically, there are only components, mold, fertilizer, chemical elements, the work of bacteria. Consciousness,

liberty, truth, love are fruits, flowers. The most subtle charms, perfumes, the beauty of faces and of the arts, the sublime goals to which we devote ourselves are the efflorescences of systems of systems of systems, of emergences of emergences of emergences... They represent what is most fragile, most alterable: a nothing will deflower them, feebleness and death will strike them first, just when we think them immortal, or would want them so.

B. Constraints: The Whole Is Less Than the Sum of the Parts

As soon as we conceive a system, the idea of global unity imposes itself to such a point that it blinds us, which means that, instead of reductionist blindness (which sees only the constitutive elements), there follows "holistic" blinding (which sees only the whole). Consequently, if it has been very often noticed that the whole is more than the sum of the parts, the contrary proposition: the whole is less than the sum of the parts, has been very rarely formulated. And nobody at all, to my knowledge, has thought of linking the two propositions:

$$\begin{aligned} S &> S_1 + S_2 + S_3 + S_4 + \dots > S \\ S &< S_1 + S_2 + S_3 + S_4 + \dots < S \end{aligned}$$

This is a formulation by Jacques Sauvan which made me conceive the second proposition; I linked it to the first in an apparently absurd fashion, that is to say $S = S$ or $S > S$, and I looked for the organizational foundation of the paradox.

1. Constraints

The whole is less than the sum of the parts: this means that qualities, properties attached to the parts considered isolatedly disappear inside the system. Such an idea is rarely recognized. Yet, it is deducible from the idea of organization, and lets itself be conceived much more logically than emergence.

Ashby had noted that the presence of an organization between variables is equivalent to the existence of constraints on the production of possibilities. (Ashby, 1962) We can generalize this proposition and consider that every organizational relation exercises restrictions or constraints on the elements or parts which—the word is accurate—are subject to it.

It is, in fact, when its components cannot adopt all of their possible states that there is a system.

The internal determinism, the rules, the regularities, the subordination of components to the whole, the adjustment of the complementaries, the specializations, the retroaction of the whole, the stability of the whole, and, in living systems, the mechanisms of regulation and control, systemic order in a word, are translated into so many constraints. Every association implies constraints: constraints exercised by parts interdependent one on the other, constraints of the parts on the whole, constraints of the whole on the parts. But, whereas the constraints of the parts on the whole stem primarily from the material characters of the parts, the constraints of the whole on the parts stem primarily from organization.

2. The Whole Is Less Than the Sum of the Parts

All organization has diverse degrees of subordination at the level of the components (we will see that the development of organization does not necessarily mean increase of constraints; we will even see that the progress of organizational complexity is founded on the "liberties" of the individuals constituting the system).

Always, and in every system, and even in those that give rise to emergences, there are constraints on the parts, which constraints impose restrictions and servitudes. These constraints, restrictions, servitudes make the parts lose their qualities or properties or they inhibit them. The whole is, therefore, in this sense, *less* than the sum of the parts.

The example previously cited can be read in reverse. A chemical union determines constraints on each element joined, and, for example, the acquisition of solid quality by joining two gaseous molecules is paid for evidently by the loss of the gaseous quality. But these physico-chemical examples are very little serious and very little convincing. *It is, in fact, where organization creates and develops active regulations, controls, and internal specializations*, that is to say starting from the first living organizations—cells..—up to anthropo-social organizations, that is manifested conspicuously the law of emergence as well as the law of constraint.

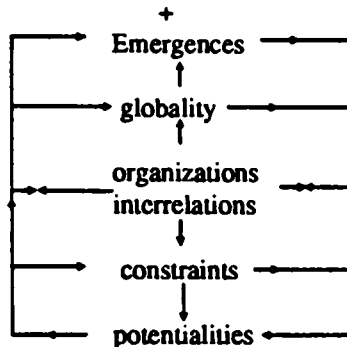
Thus, the regulation of enzyme activity, within the cell, includes an inhibiting constraint when the final product of a chain of enzyme reactions fixes on the site (called allosteric) of an enzyme from the other end of the chain and consequently blocks all reactions which should have followed. Likewise, genetic regulation is carried out by a specific molecule—significantly named "repressor"—which attaches itself to a gene and prevents it from being expressed. In fact, as we shall see, there is a complex play of

blocking/unblocking in circuits, through which organization is effected by constraints which at certain moments inhibit the play of relatively autonomous processes.

As we shall see, every organization which determines and develops specializations and hierarchizations determines and develops constraints, subjections, and repressions. We know today that each cell of an organism carries in it the genetic information of the entire organism. but the biggest part of this information is repressed; only the minuscule part corresponding to the specialized activity of the cell can be expressed.

The constraints which inhibit enzymes, genes, even cells do not diminish liberty inexistant at this level, liberty emerging only at a level of individual complexity where there are possibilities of choice; they inhibit *qualities*, possibilities of action or of expression. It is only at the level of individuals having possibilities of choice, of decision, and of complex development that constraints can be destructive of liberty, that is to say become oppressive. Thus, this problem of constraints poses itself in a way both ambivalent and tragic at the level of societies, and particularly of human societies.

THE WHOLE IS MORE THAN



AND LESS THAN THE SUM OF THE PARTS

It is certainly culture which allows the development of the potentialities of the human spirit. It is certainly society which constitutes a solidary whole protecting the individuals who respect its rules. But it is really also society which imposes its coercions and repressions on all activities, from the sexual to the intellectual. Finally, and especially, in historical societies, hierarchic domination and specialization of work, oppressions and enslavements inhibit and prohibit the creative potentialities of those who are subjected to them.

Thus, the development of certain systems can come at the expense of a formidable underdevelopment of the possibilities which they hold.

On the most general level, we arrive at a vision of complexity, ambiguity, systemic diversity. We must thenceforth consider in any system, not only the gain in emergences, but also the loss by constraints, subjections, repressions. A system is not only enrichment, it is also impoverishment, and the impoverishment can be bigger than the enrichment. This shows us likewise that systems are differentiated, not only by their physical components or their class of organization, but also by the type of production of constraints and emergences. Within the same class of systems, there can be a fundamental opposition between systems where the production of micro- and macro-emergences predominates and those where repression and subjection predominate.

C. The Formation of the Whole and the Transformation of the Parts

A system is at the same time more, less, other than the sum of the parts. The parts themselves are less, perhaps more, in any case other than what they were or would be outside the system.

This paradoxical formulation shows us immediately the absurdity there would be in reducing the description of a system to quantitative terms. It signals us not only that the description must be qualitative, but especially that it must be complex.

This paradoxical formulation shows us at the same time that *a system is a whole which is formed at the same time as its elements are transformed.*

The idea of emergence is inseparable from systemic morphogenesis, that is to say from the creation of a new form which constitutes a whole: complex organized unity. It is really a question of morphogenesis, since the system constitutes a topologically, structurally, qualitatively new reality in space and time. Organization transforms a discontinuous diversity of elements into a global form. Emergences are the properties, global and particular, flowing from this formation, inseparable from the transformation of the elements.

The acquisitions and the qualitative losses indicate to us that the elements which participate in a system are transformed, *and first of all into parts of a whole.*

We arrive at a key systemic law: the link between formation and transformation. *Everything which forms transforms.* This law will become active and dialectical at the level of living organization, where transformation and formation constitute an uninterrupted recursive circuit.

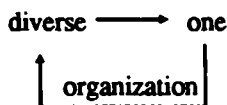
III. Organization of the Difference. Complementarities and Antagonisms.

A. Difference and Diversity

Every system is one and multiple. Multiplicity can concern only similar and distinct components, like the atoms of a crystal group. But that difference suffices to allow organization among those atoms to be constituted, which imposes its constraints (on the disposition of each atom) and produces its emergences (crystal properties). Nevertheless, such systems are "poor" in respect to those systems which, from atoms to suns, from cells to societies, are organizers of, in, by the diversity of the components.

These systems are not, therefore, only one/multiple; they are also one/diverse. Their diversity is necessary to their unity, and their unity is necessary to their diversity.

One of the most fundamental traits of organization is the aptitude to transform diversity into unity, without annulling diversity (association of protons, neutrons, electrons in the atom, association of diverse atoms in the molecule, of diverse molecules in the macro-molecule), *and also, to create diversity in and by unity*. Thus, Pauli's exclusion principle imposes, within the atom, a quantic individualization which singularizes each of the identical electrons. Cellular organization produces and sustains the diversity of its molecular components. The constitution of an adult organism from an egg is a process of the intraorganizational creation of millions or billions of cells which remain differentiated, diversified, and individualized (possessing organizing autonomy). All that is living organization, that is to say not only the individual organism, but also the cycle of reproduction, ecosystems, the biosphere illustrate the chain circuit of this double proposition: diversity organizes unity which organizes diversity:



Thus, diversity is required, maintained, sustained, indeed created and developed in and by the systemic unity which diversity itself creates and develops.

There is certainly a problem of complex relation, that is to say complementary, concurrent, antagonistic, between diversity and unity, namely between repetitive order and deployment of variety, which dissolves, as Atlan

indicates (Atlan, 1974), the trustworthiness of the organization, namely its fitness to survive. The predominance of repetitive order stifles all possibility of internal diversity, and is translated into poorly organized and poorly emergent systems, as the example of crystal groups indicated. At the other limit, extreme diversity risks making organization explode and be transformed into dispersion. There is no abstract optimum, no "happy medium," between repetitive order and variety. As I see it, every increase in complexity is translated by an increase in variety within a system; *this increase, which tends to dispersion in the type of organization where it is produced, requires thenceforth a transformation of organization in a more supple and complex direction.* The development of complexity requires, therefore, both a greater richness in diversity and a greater richness in unity (which will be founded for example on inter-communication and not on coercion). Thus, in principle, the developments in internal difference, diversity, and individuality within a system, the richness of emergent qualities, internal (proper to the constitutive individualities) and global, and the qualities of the global unity go together.

B. Double Identity and Complementarity

In these conditions, oneness has a complex identity (multiple and one at the same time). The parts have a *double identity*, which has hardly been noticed. They have their own identity, and they participate in the identity of the whole. However different they may be, the elements or individuals constituting a system have at least a common identity of belonging to the global unity and of obedience to its organizational rules.

In human societies, the individual has from the moment of birth a double identity, personal and familial (he identifies himself individually from the rest as "son of"); he is going to develop, in and by culture, his own individual originality and acquire correlatively his social identity.

Every system allows, therefore, a relation, very variable according to the classes and types of systems, between difference and identity. We can extrapolate well beyond language what Ferdinand de Saussure said: "The linguistic mechanism revolves completely on identities and differences, the latter being only the counterpart of the former." (Saussure, 1931)

The Organization of Difference

The organization of a system is the organization of difference. *It establishes complementary relations between the different and diverse parts,*

as well as between the parts and the whole.

The elements and parts in a whole are complementary. This idea is trivial, flat, false. The non-trivial idea is: the parts are organized in a complementary fashion in the constitution of a whole. For the idea leads us to question the conditions, the modalities, the limits, and the problem which this complementarity poses.

Organizational complementarity can be instituted in diverse fashions, as for example:

- interactions (gravitational interactions between stars and planets constituting a solar system, electrical interactions between nucleus and electrons constituting an atomic system);

- bonds instituting a common part; thus, one or several electrons are common to the atoms which form a molecule;

- associations and combinations of complementary activities (functional specializations);

- informational communications; in this case, the common identity between the different parts, beings, individuals can be limited to participation in one and the same code.

It is at the biological stage that the organization of difference knows its original developments. These are going to follow two tracks:

- the development of specialization, namely of organizational, anatomical, functional differentiation of elements, individuals, or sub-systems; such an organization is associated with strong constraints and with the development of apparatuses of control and command;

- the development of the competences and of the autonomy of the individualities composing the system, which goes with an organization developing intercommunications and internal cooperations. (Changeux, Danchin, 1976)

We will tackle these problems head-on in their time and place (v.II). But we guess that there will be as many combinations as antagonisms between these two types of organization. We know from our anthropo-social experience that the imposition of specializations on individualities endowed with rich organizing competences reduces and inhibits the diversity which the organizational development itself created.

As of now, on the plan of the most general systemic principles, we are going to see that the organization of difference, in instituting complementarities, creates antagonisms, be it only virtually; we are going to see that apposition carries in itself a potentiality for opposition.

C. Organizational Antagonism

1. *Interrelation and Antagonism*

Every organizational interrelation supposes the existence and the play of attractions, affinities, possibilities of bonds or of communications between elements or individuals. But the maintenance of differences equally supposes the existence of forces of exclusion, repulsion, dissociation, without which everything would be confounded and no system would be conceivable.¹⁴ It is necessary, therefore, in systemic organization, that the forces of attraction, affinities, bonds, communications, etc., predominate over the forces of repulsion, exclusion, dissociation; it is necessary that they inhibit, contain, control, in a word *virtualize*.

The most stable interrelations suppose that forces which are antagonistic to them be simultaneously maintained, neutralized, and surmounted. Thus, electrical repulsions between protons are neutralized and surmounted by the interactions called strong which include the presence of neutrons, and more widely the group of the organizational nuclear complex. The stabilization of bonds between atoms at the core of the molecule brings a sort of equilibration between attractions and repulsions. Unlike thermodynamic equilibriums of homogenization and disorder, organizational equilibriums are equilibriums of antagonistic forces.

Thus, every organizational relation, therefore every system, includes and produces antagonism at the same time as complementarity. Every organizational relation necessitates and actualizes a principle of complementarity, necessitates and more or less *virtualizes* a principle of antagonism.

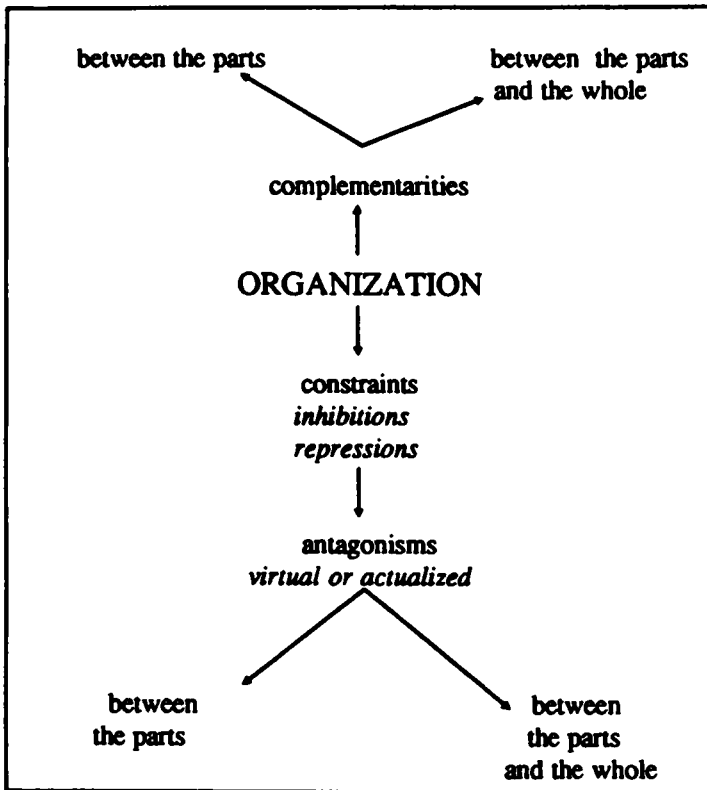
2. *Antagonism in Complementarity*

To the antagonisms which every bond or integration supposes and virtualizes there are coupled antagonisms which the organization of complementarities produces.

As we have seen, the organization of complementarities is inseparable from constraints or repressions; the latter virtualize or inhibit properties which, if expressed, would become anti-organizational and would threaten the integrity of the system.

Thus, complementarities which are organized between parts secrete antagonisms, virtual or not; the double and complementary identity which co-exists in each part is by itself virtually antagonistic. It is, therefore, the very principle of complementarity which fosters in itself the principle of

antagonism.



Every system presents, therefore, an emerged diurnal face, which is associative, organizational, functional, and a shadow face, immersed, virtual which is its negative. There is latent antagonism between what is actualized and what is virtualized. The solidarity manifest at the heart of the system and the functionality of its organization simultaneously create and dissimulate this antagonism which bears potentiality of disorganization and disintegration. We can, therefore, state the law of systemic antagonism: *the complex unity of a system simultaneously creates and represses antagonism.*

3. The Organization of Antagonisms

Suns and living beings are systems whose organization integrates and utilizes antagonistic activities. The star is an untamed machine, a motor in

flames, which exists and subsists, as we have seen, only in and by the organizational conjunction of two antagonistic processes, one of implosive nature, the other of explosive nature, *which simultaneously provoke each other, support each other, inhibit each other, balance off each other, and whose association, simultaneously complementary, concurrent, and antagonistic, becomes regulation and organization.* In such conditions, antagonisms are not at all virtual; they are active, and not merely active; it is they which create the fundamental organizational complementarity of the star.

Every system whose organization is active is in fact a system where antagonisms are active. Regulations suppose a minimum of antagonisms on guard. Retroaction which maintains the constancy of a system or regulates a performance is called *negative* (negative feed-back), a very enlightening term: triggered by the variation of an element, it tends to annul this variation. Organization tolerates, therefore, a margin of fluctuations which, if they were not inhibited on this side of a certain threshold, would develop disintegratingly into *positive* retroaction. Negative retroaction is, therefore, an antagonistic action which itself actualizes anti-organizational forces. We can conceive retroaction as an antagonism, as an anti-disorganization or an anti-anti-organization. Regulation as a whole can be conceived as a coupling of antagonisms where the activation of an anti-organizational potential triggers its antagonist which is reabsorbed when the anti-organizational action is reabsorbed.

Thus, active organization links, in a complex and ambivalent fashion, complementarity and antagonism. Complementarity acts antagonistically to antagonism, and antagonism acts complementarily to complementarity.

To any growth of complexity in organization correspond new potentialities of disorganization. Living organization (as we will see in v.II) bases its own complexity on the union simultaneously complementary, concurrent, and antagonistic of uninterrupted disorganization and reorganization. It gives rise (by consumption of energy, transformations) to degradation and disorganization (disorders which awaken antagonisms, antagonisms which entail disorders) but this degradation and this disorganization are inseparable from its reorganizing activities; it integrates them, without, however, their losing their disintegrating character. We will see later that relations simultaneously complementary, concurrent, and antagonistic are constitutive of eco-system. (v.II, ch.1) We will see likewise how organizational/anti-organizational antagonism is at the heart of the problematic of human societies, where complementarities and antagonisms are unstable, oscillating unceasingly between actualization and virtualization.

4. *The Law of Systemic Antagonism*

Systems theory, although it conceived the very concept of system in a simplistic ("holistic") way, has nevertheless often met the idea of antagonism. "Open systems theory has no fundamental difficulties in including harmony and conflict in the same system." (Trist, 1970) Bertalanffy even proclaims, Heraclitus-like, that "every totality is based on competition between its elements and presupposes struggle between its parts." (Bertalanffy, 1968, p.66) But systems theory has not formulated the intrinsically organizational character of the law of antagonism.

Let us recapitulate the different levels of antagonisms which have been noted:

- the level of bonds and integrations which suppose, virtualize, and neutralize antagonistic forces;

- the level of the organization of difference and diversity where organizational constraints create and repress antagonisms;

- finally the level of the complexity of active, therefore reorganizing, organizations; antagonistic actions and processes intervene in the dynamic of internal and external interactions and retroactions, and, in this way, contribute to organization.

Thus, the idea of system is not only harmony, functionality, higher synthesis; it includes, necessarily, dissonance, opposition, antagonism.

Let us formulate, therefore, the law: *there is no organization without anti-organization*. Let us state as corollary: *anti-organization is both necessary and antagonistic to organization*. In fixed organization, anti-organization is virtual, latent. In active organization, anti-organization becomes active.

5. *Anti-organization and Organizational Entropy*

The idea of antagonism includes the potentiality to disorganize.

Now, as we have just indicated, disorganization is coupled with reorganization in stellar systems and in living systems.

At the same time, such systems are subject to crises. Every crisis, whatever be its origin, is manifested by a weakness in regulation, that is to say in the control of antagonisms. Antagonisms erupt when there is a crisis; they cause a crisis when they erupt. The crisis reveals itself by transformations of differences into opposition, of complementarities into antagonisms; and disorder permeates a system in crisis.¹⁵ The richer the organizational complexity, the greater the possibility, hence danger, of crisis; the more also

the system is able to overcome its crises, indeed to benefit from them for its development. We cannot, therefore, conceive organization without antagonism, that is to say without potential anti-organization included in its existence and its functioning.

Thenceforth, *the increase of entropy, seen organizationally, is the result of the passage from virtuality to actualization of anti-organizational potentialities, a passage which, beyond certain thresholds of tolerance, control, or utilization, becomes irreversible.* The second law of present-day science means that sooner or later anti-organization will shatter organization and scatter the elements. Systems whose organizations are non-active, immobilize energies of bonding, which allow them to counterbalance the forces of opposition and dissociation. The increase of entropy corresponds to an energetic/organizational degradation, either because antagonisms unblock energies, or because degradations of energies release antagonisms. Non-active systems can gain neither energy nor restorative organization from the outside. This is why they can only evolve towards disorganization.

The only possibility of fighting against the disintegrating effect of antagonisms is action; for example:

- to integrate and utilize antagonisms organizationally to the utmost;
- to renew energy by drawing it from the environment, and to regenerate organization;
- to defend itself efficaciously against aggressions and to correct internal disorders;
- to multiply itself in such a way that the rate of reproduction exceeds the rate of disintegration.

This is what living systems do, and life has so well integrated its own antagonist—death—that it carries it in itself, constantly and necessarily.

Every system, therefore, whatever it be, carries in itself the internal ferment of its deterioration. Every system carries in itself the announcement of its own ruin when at a given moment external aggression and internal regression connect. Deteriorations, ruin, disintegration do not come only from the outside, they also come from the inside. Chance death from the outside comes to take the hand of death crouched inside the organization. Thus, every system is from birth condemned to death. Non-transactional systems last without living, disintegrate without dying. To a half-life, only a half-death. Only the tragic complexity of living organization corresponds to beings which undergo the fullness of death. For them, antagonism signifies complementarily, concurrently, antagonistically, and uncertainly: life, crisis, development, death.

IV. The Concept of System

Objects give way to systems. Instead of essences and substances, organization; instead of simple and elementary units, complex unity; instead of aggregates forming bodies, systems of systems of systems.

The object is no longer an essence-form and/or a substance-matter. There is no longer any form mold which sculpts the identity of the object from the outside. The idea of form is preserved, but transformed: form is the totality of the complex organized unit which is manifested phenomenally insofar as whole in time and space; the *Gestalt* form is the product of catastrophes, of interrelations/interactions between elements, of internal organization, of the conditions, pressures, constraints of the environment. Form ceases to be an idea of essence in order to become an idea of existence and organization. Likewise, materiality ceases to be a substantial idea, an opaque and full ontology and enclosed in form. But materiality has not evaporated; it has been enriched by being dereified: every system is constituted of elements and *physical* processes (including, as I will show, ideological systems): the idea of organized matter takes on meaning in the idea of an organizing *physis*.

Thus, the Aristotelian model (form/substance) and the Cartesian model (simplifiable and decomposable objects), both subjacent to our conception of objects, do not constitute principles of intelligibility of the system. The system can be grasped neither as pure unit, nor as absolute identity, nor as decomposable compound. We need a systems concept which expresses simultaneously multiplicity, totality, diversity, organization, and complexity.

A. Beyond "Holism" and Reductionism: the Relational Circuit

We have already said and repeated: neither the description nor the explanation of a system can be given at the level of the parts, conceived as isolated entities, tied only by actions and reactions. The analytical decomposition into elements also decomposes the system, whose rules of composition are not additive, but transforming.

Thus, the reductionist explanation of a complex whole into the properties of simple elements and the general laws which command these elements disarticulates, disorganizes, decomposes, and simplifies what makes the very reality of the system: articulation, organization, complex unity. It is unaware of the transformations which are brought about on the parts, it is unaware of the whole insofar as whole, it is unaware of the emergent qualities (conceived as simple effects of conjugated actions), it is unaware of the latent or virulent antagonisms. Atlan's remark concerning living organisms applies to all

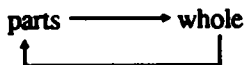
systems: "The simple fact of analyzing an organism starting from its components entails a loss of information about this organism." (Atlan, 1972, p.262)

It is not a question of underestimating the startling success obtained by the "reductionist" view: research for the primary element led to the discovery of the molecule, then the atom, then the particle; research for manipulable units and verifiable effects has in fact permitted us to manipulate every system, by manipulating its elements. *The counterpart is that a shadow has been extended on organization*, obscurity has covered over the complexities, and the elucidations of reductionist science have been paid for by obscurantism. Systems theory has reacted to reductionism, in and by "holism" or the idea of the "whole".¹⁶ But, believing to go beyond reductionism, holism has in fact brought about a reduction on the whole: whence, not only its blindness on the parts insofar as parts, but its myopia on organization insofar as organization, its ignorance of the complexity at the heart of global unity.

The whole, thenceforth, becomes a euphoric notion (since we do not know the internal constraints, the losses of qualities at the level of parts), a functional notion, oiled (since we do not know the internal antagonistic virtualities), a foolish notion.

Reductionist or "holistic" (globalist), the explanation, in either case, seeks to simplify the problem of complex unity. One case reduces the explanation of the whole to the properties of the parts conceived in isolation. The other reduces the properties of the parts to the properties of the whole, likewise conceived in isolation. These two explanations, which reject each other, both stem from the same paradigm.

The conception stated here places us directly beyond reductionism and "holism," by calling on a principle of intelligibility which integrates the partial truth included in both: there must not be an annihilation of the whole by the parts, nor of the parts by the whole. It is important, therefore, to highlight the relations between parts and whole, where each term returns to the other: "I hold it equally impossible to know the parts without knowing the whole, as to know the whole without knowing each term in particular," said Pascal.¹⁷ In the 20th century, reductionist and "holistic" ideas have not yet been raised to the level of such a formulation. In truth, still more than mutual return, it is interrelation which ties the explanation of the parts to that of the whole and reciprocally is, in fact, invitation to a recursive description and explanation: the description (explanation) of the parts depends on that of the whole which depends on that of the parts, and it is in the circuit:

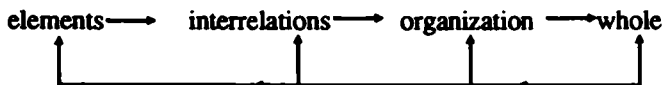


that the description or explanation is formed.

That means that neither of the two terms is reducible to the other. Thus, if the parts must be conceived in function of the whole, *they must be conceived also in isolation*: a part has its own irreducibility in relation to the system. Moreover, we have to know the qualities or properties of the parts which are inhibited, virtualized, therefore invisible at the heart of the system, not only in order to correctly know the parts, but also in order to better know the constraints, inhibitions, and transformations which the organization of the whole brings about.

It is important also to go beyond the purely globalizing and enveloping idea of the whole. The whole is not only emergence; it has, as we will see, a complex visage, and, here, the idea of a macroscope (de Rosnay, 1975) or conceptual glance imposes itself, which allows us to perceive, recognize, describe global forms.

The explicative circuit whole/parts cannot, as we have just seen, hide the idea of organization. It must be thus enriched:



Elements have to be defined, therefore, both in and by their original characters, in and with the interrelations in which they participate, in and with the perspective of the organization wherein they are arranged, in and with the perspective of the whole wherein they are integrated. Inversely, organization has to be defined in reference to the elements, the interrelations, the whole, and so forth. The circuit is *polyrelational*. In this circuit, organization plays a nucleating role which we must attempt to recognize,

This circuit, in a sense, is closed; it is looped necessarily since the system is a relatively autonomous entity. But we must also open it, because this autonomy is precisely relative: we will have to conceive the system in its relation with its environment, in its relation with time, in its relation finally with the observer/conceiver.

Thus, the system must be conceived according to a conceptual constellation where it will be able finally to take on complex form. Consequently, we are going to consider now:

- the problematic of the whole (the whole is not whole),
- the problematic of organization,
- the physical *dasein* of the system (its situation in an environment and in time),
- the relation of the system to the observer/conceiver.

B. The Whole Is Not the Whole

1. *The Whole is More Than the Whole. The Whole Is Less Than the Whole.*

The whole is much more than global form. It is also, we have seen, emergent qualities. It is still more: the whole retroacts inasmuch as whole (organized totality) on the parts. Inasmuch as it is totalities which organize, the atom or cell retroacts on the components which form them and every discourse retroacts on the elements which constitute it. Thus, for words to take on a definite meaning in the sentences which they form, it is not sufficient that their meanings be inventoried among others in the dictionary; it is not sufficient that they be organized according to grammar and syntax; it is necessary moreover that there be retroaction of the sentence on the word, in the course of its formation, up to the definitive crystallization of the words by the sentence and of the sentence by the words.

It is, therefore, because the whole is hegemonic on the parts, because its organization can be conceived very precisely as over-determination, that the whole is much more than the whole.

But the whole cannot be hypotized. The whole alone is only a hole. The whole can function as whole if the parts function as parts. The whole must be related to organization. The whole, finally and especially, carries in it scissions, shadows, and conflicts.

2. *Scissions in the Whole (the Immersed and the Emergent, the Repressed and the Expressed)*

While emergences develop into phenomenal qualities of systems, organizational constraints immerse in a world of silence the characters inhibited, repressed, compressed at the level of parts. Every system includes, thus, its immersed, secret, obscure zone where suppressed virtualities stir. The duality between the immersed and the emergent, the virtualized and the actualized, the repressed and the expressed is a source of scissions and dissociations in great living and social polysystems, between the universe of the parts and the universe of the whole, indeed between multiple internal spheres and the sphere of the whole itself. Thus, although there is interrelation and interdependence, there is non-communication between what happens at the global level of the exterior behavior of an animal and what happens in each of its cells. None of Anthony's thirty billion cells knows that Anthony is declaring his love to Cleopatra, and Anthony does not know that he is

constituted by thirty billion cells. A great empire is a social being which does not know the needs, the loves, the sufferings, the hunger, the consciousness of the millions of individuals which constitute it, and for these individuals the degree of existence and presence of this being seems to be an exterior and distant fatality. The Freudian idea of the psychic unconscious, the Marxist idea of the social unconscious already reveal to us the bottomless gulf which has been opened in identity and totality. The problem of the unconscious finds its source—and only its source, because we will see it is not a question in this work of reducing everything to systemic terms—in this deep scission between the parts and the whole, between the world inside and the world outside...

The duality between the inside and the outside carries in germ, not only the scission between the universe of the whole and the universe of the parts, but also a scission between the phenomenal universe, where the system exists in an extroverted fashion with its emergent qualities, and the introverted universe of organization, notably organizational rules that we call structures. Thus, the phenomenal whole can stay at the surface, unaware of organization and parts, although it can control them globally and retroact on their actions or movements.

We acknowledge this duality in our own fashion when we distinguish, in a system, its "structure" from its "form," and our reductionist logic tends, besides, to reduce the phenomenal characters to structural characters as mere effects.

There is great accuracy, in what concerns not only social systems but also biological systems, to conceive them under the angle of a coupled infra/superstructure relation, where the second is unaware of or forgets the other. We need to note, moreover, that the first likewise is unaware of and forgets the second, and especially to conceive that this mutual unawareness is situated at the heart of an indissoluble solidarity, where the "superstructure" is not only a vague epiphenomenon, returning on the infrastructure by a feeble retroaction, but participates recursively in the structuration of the infrastructure. We need, therefore, to conceive the biological and sociological complexity of what, while being fundamentally one, includes several levels of organization, of being, of existence, becomes multiple, dissociated, and, at the limit, antagonistic to itself.

The Insufficient Whole

I have just indicated problems which come alive only with life, since they emerge as problems only among living and social beings. At the same time, they are beings which, although we cannot enclose them in the notion of system, allow us to truly reveal all the latent riches and complexities which are

found at the heart of this notion.

At this point, I want to highlight the complexity of the idea of totality, too often homogenized. We have only seen the lighted face of totality, that is to say half of its reality and of its unreality. Totality, and I know that I have indicated it very/too summarily, is much more, much less than we think. There are black holes in totality, blind spots, shadow zones, ruptures. Totality carries in itself its internal divisions which are not only divisions between distinct parts. They are scissions, possible sources of conflict, even of separations. It is very difficult to conceive the idea of totality in a universe dominated by reductionist simplification. And, once conceived, it would be derisive to conceive totality in a simple and euphoric fashion. True totality is always cracked, fissured, incomplete. The true conception of totality recognizes the insufficiency of totality. It is the great progress, still unperceived and unknown in France, of Adorno over Hegel whose faithful continuer he is: "Totality is non-truth."

The Uncertain Whole

Finally—and I will come back to this idea under another angle—, the whole is uncertain. It is uncertain because we can isolate only with great difficulty, and we can never truly close, a system among the systems of systems of systems to which it is tied, and where it can appear, as Koestler has very well said, both as whole and as part of a greater whole. It is certain, for systems of higher biological complexity, in the relation individual/species, and especially for this trisystemic monster which is *homo sapiens*, constituted by the interrelations and interactions among species, individual, society. Where is the whole? The answer can only be ambiguous, multiple, and uncertain. We can assuredly see society as a whole and the individual as a part, species as a whole and society as well as the individual as parts. But we can also conceive the individual as the central system and society as its eco-system or its organizing placenta, and all the more so as the emergence of consciousness is effected on the scale of the individual, not on the scale of the social whole. Likewise, we can invert the hierarchy species/individual and consider the individual as a concrete whole, species being only a mechanical cycle of reproduction of individuals. To tell the truth, we cannot absolutely decide, that is to say we must, not only through prudence but also through a sense of complexity, conceive that these terms finalize each other, return each other in a circuit which itself is the "true" system:



But such a system is a multiple totality, a polytotality, whose three inseparable terms are at the same time concurrent and antagonistic...

It results from the above that at certain moments, under certain angles, in certain cases, the part can be richer than the totality. Whereas a simplifying "holism" privileges every totality over its elements and the vastest of totalities over the others, we know as of now that we do not have to necessarily privilege every totality over the components. "The most profitable control system for the parts must not exclude the bankruptcy of the set." (Stafford Beer, 1960, p.16) The bankruptcy of imperial mega-systems can allow the constitution of federal polycentric systems...

Finally, we do not have to privilege the totality of totality of totality. What is the cosmos but a totality in polycentric dispersion, whose riches are disseminated in little archipelagoes? It really seems that "little parts of the universe have a bigger reflexive power than the set." (Gunther, 1962, p.383) It seems even, as Spencer Brown audaciously indicated (1969), that reflexive power can only be effected in a small part half-detached from the whole, by the virtue and the vice of its remoteness, its distance, its open finitude with respect to totality... Thenceforth, it appears to us anew that the point of view of *only* totality is partial and mutilating. It appears to us not only that "totality is non-truth" but that the truth of totality is in (or passes through) parcelled *individuality*. The idea of totality becomes so much the more beautiful and rich as it ceases to be totalitarian, as it becomes incapable of enclosing on itself, as it becomes *complex*. It shines more in the polycentrism of relatively autonomous parts than in the globalism of the whole.

C. The Organization of Organization

Organization is the crucial concept, the knot which ties the idea of interrelation to the idea of system. To jump directly from interrelations to the system, to retrocede directly from the system to interrelations, as those systematists do who are unaware of the idea of organization, is to mutilate and devertebrate the very concept of system.

The idea of organization is in this work the concept which I will take up again, develop, transform, from the system to the machine, from the machine to the automaton, from the automaton to the living being, from the living being to society, to man, to theory, which is an organization of ideas.

Organization binds, transforms, produces, maintains. It binds, transforms the elements into a system, produces and maintains that system.

1. *The Relation of Relations*

Organization, which can combine in a diversified fashion diverse types of bonds,¹⁸ binds the elements among themselves, the elements into a totality, the elements to the totality, the totality to the elements, that is to say binds all the bonds together and constitutes *the bond of bonds*.

2. *The Transforming Formation and the Forming Transformation*

Organization is both transformation and formation (morphogenesis). It is really a matter of transformations: elements transformed into the parts of a whole lose some qualities and gain new ones; organization transforms a discrete diversity into a global form (*Gestalt*). It creates a continuum—the interrelated whole—where there was the discontinuous; thereby it brings about a change of form: it forms (a whole) starting from the transformation (of the elements).

It is really a matter of morphogenesis: organization gives form, in space and time, to a new reality: complex unity or system.

Thus, organization is what transforms transformation into form; in other words, it forms form by forming itself; it produces itself from itself by producing the system, and this makes its fundamentally *generating* character apparent to us.

3. *The Maintenance of What Maintains*

Organization is, at the same time, the ordering principle which insures permanence.

Permanence in the being of atoms, molecules, heavenly bodies does not correspond to inertia but to active organization. Organization is morphostatic: it maintains the permanence of the system in its form (*Gestalt*), its existence, its identity.

This permanence appears at two levels which we must both distinguish and link:

—the level of structures (organizational rules) and generation (producer of forms and phenomenal being);

—the level of the phenomenon, where the whole maintains the constancy of its forms and qualities despite fortuities, aggressions, and perturbations, in the midst of possible fluctuations (corrected by regulations).

Let us repeat: permanence is not a consequence of inertia, of weightiness,

of the "force of things." We have seen that every system is threatened by outside and inside disorders. That is to say that every system is also an organization against anti-organization or an anti-anti-organization. When, moreover, the system works without stopping, like the human system, it produces by that very fact degradation and disorganization; therefore, it must consecrate an enormous part of its organization to repairing the degradations and the disorganizations that its organization provokes, in other words to regenerating its organization. Thus, formidable living organization includes expenses, works, unheard-of refinements vowed exclusively to maintaining its maintenance, that is to say to this tautological finality of permanence: survival.

4. The Order of Organization and the Organization of Order

The transformation of disordered diversity into organized diversity is at the same time transformation of disorder into order.

Invariances, constancies, constraints, necessities, repetitions, regularities, symmetries, stabilities, repeats, reproductions, etc., are conjugated in a determinism which constitutes the autonomous order of the system. This order can, as the case may be, radiate over a vast zone, sometimes even to very great distances (thus, our planet lives under the reign of solar order).

The relation order/organization is circular: organization produces order which maintains the organization which produced it, that is to say co-produces organization. This organizational order is an order built on, conquered over disorder, protecting against disorders: it is in the same movement that order transforms the "improbability" of organization into local probability, safeguards the originality of the system, and constitutes an islet of resistance against the disorders of the outside (fortuities, aggressions) and the inside (degradations, unleashing of antagonisms).

Organizational order is, therefore, this structural (Thom, 1972), stratified (Bronowski, 1969) "invariance" or "stability," which not only is like the armature or skeleton of every system, but which allows us to build on this base new organizations, which will also constitute their own order, on which in turn still other organizations will rest, and so on, allowing, therefore, the appearance, the deployment, the development of systems of systems of systems, or organizations of organizations of organizations...

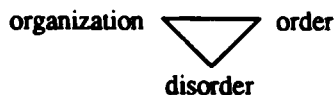
5. Organization, Order, and Disorder

Disorder is not driven away by organization: it is transformed in it,

remains virtualized in it, can be actualized in it, secretly prepares its victory.

We cannot conceive the birth of organization outside of chance encounters. According to Atlan's very striking expression, there is an "organizational chance." But this bastard son of chance or disorder is anti-chance, anti-disorder, constitutes an islet, an isolate which its determinism protects against outside and inside disorders.

Once again we find in the systems framework, in an original fashion, the trinitarian relation:



Internal disorder has two faces: the first, potentialized in latent antagonisms, restrained in and by constraints, we have named here anti-organization. The second is entropy. One of these two faces is the organizationist expression, the other the thermodynamic expression, of the same reality, the reality of a principle of disorganization, inherent to every organization, that is to say to any system. This principle means that every system is perishable, that its organization is disorganizable, that its order is fragile, relative, mortal.

We see, therefore, that organizational order is besieged and undermined by disorder. In non-active systems, fragments of negentropy created by encounter, this order is a forgotten sentinel, lost in the torrent of time. In active systems, order, indefatigable Sisyphus, unceasingly repels on-going disorganization by on-going reorganization.

Now, it is in systems founded on permanent reorganization that disorder is "detoured," fixed (disorganization becoming a component of reorganization), without, however, being reabsorbed or excluded, without its having ceased to carry in itself its fatality of dispersion and death.

The more it becomes complex, the more its order is mixed more and more intimately with disorders, the more antagonisms, uninhibitions, fortuities play their role in the being of the system and its organization.

Thus, the triad disorder/order/organization takes on an original character at the heart of systems. Organizational order is a relative order, fragile, perishable, but also, we will see, evolutive and constructive. Disorder is not only anterior (interactions by chance) and posterior (disintegration) to organization, it is present in a potential and/or active fashion. The exclusion of disorder characterized the classic vision of the physical object; the complex organizationist vision includes disorder.

Organization can only be organized and organize by incorporating the

relation order/disorder, not only in the virtualization/inhibition of disorder, but also, as it appears in the suns and in living phenomena, in its actualization.

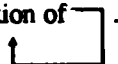
6. The Structure of Organization and the Organization of Structure

The notion of structure, very useful and integrable in the idea of organization, cannot in itself summarize this idea. Structure is all the more integrable as it is under its cover, or rather in its gavage, that organizational realities have begun to emerge to theoretical consciousness. (Piaget, 1970)

It is in general the set of rules of assemblage, linkage, interdependence, transformations which we conceive under the name of structure; and structure, pushed to its limits, tends to be identified with the formal invariant of a system.

Already, the reduction of the system to organization would entail a loss of phenomenality and complexity. But organization is a richer and more complex notion than that of structure. Therefore, neither the phenomenal system (the whole insofar as whole, its emergent properties), nor organization in its complexity can be deduced from structural rules. Every purely structuralist conception, that is to say purely interested in reducing systemic phenomena and organizational problems to terms of structure, would entail a great decrease in intelligibility, a natural loss of phenomenality, a destruction of complexity.¹⁹ In fact, the idea of structure conceives only a conjunction of necessary rules manipulating and combining basic units. It remains, therefore, dependent on the paradigm of order (here intrasystemic) and of simple objects. It is blind to the complex object, the system; it is blind to the complex, and nonetheless fundamental, relations between organization and anti-organization...

The idea of organization, on the other hand, must be referred necessarily to complex unity and, we will see better and better further on, to a paradigm of complexity; it must be conceived necessarily in function of the trinitarian macro-concept system/interrelation/organization in which it belongs; it must be thought of, not in a reductionist fashion but as articulating, not as simplifying but as multi-branched; it includes in a nuclear fashion the ideas of reciprocity of action and of retroaction; the latter, which loops the system on itself in a whole returning on its parts, at the same time loops organization on itself; thenceforth, organization appears as a reality quasi-recursive, that is to say whose final products are looped on the initial elements; whence the idea that organization is also always simultaneously organization of



It is a circular notion, which, in returning to the system, is returned to itself; in fact, it is constitutive of relations, formations, morphostases, invariances, etc., which circularly constitute it. Organization must, therefore, be conceived as organization of its own organization, which also means that it closes in on itself by closing the system in reference to its environment.

7. Organizational Closing and Opening: a System Must Be Opened and Closed

Systems theory, following thermodynamics, opposes open systems (which effect material, energetic and/or informational exchanges with the outside) to closed systems (which do not effect exchanges with the outside). Systems theory has quite pertinently highlighted the idea that opening is necessary to maintenance, to renewal, in a word to the survival of living systems, but it has not really noted the organizational character of opening, and it has posited the idea of opening as exclusive of the idea of closing.

Now, we are going to see that opening and closing, on condition that we consider these terms organizationally and not only thermodynamically, are not in absolute opposition.

First of all, a system called "closed" (not bringing about matter/energy exchanges) is not a hermetic entity in a neutral space. It is neither isolated nor isolable. Apparently intrinsic characters, like mass, can only be defined in function of the gravitational interactions linking it to the bodies which constitute its environment. That is to say that the tissue of a system, even closed, is founded on external relations; if it is not really "open," it is not totally "closed."

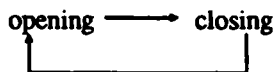
If every closed system is not really closed, every open system includes its closing. We can even say: there is truly organizational closing where there is truly organizational opening.

Every organization, in the sense that it prevents both the hemorrhaging of the system into the environment and the invasion of the environment into the system, constitutes a phenomenon of closing. And organizational closing is all the more necessary since, as always, every internal threat opens the door to external threat.

The idea of closing appears in the key idea of retroaction of the whole on the parts, which loops the system on itself, traces its form in space; it appears in the recursive idea of organization of organization, which loops organization on itself. Both complete conjointly the autonomy of the complex unity in this looping/closing, which not only is compatible with the opening of open systems, but which becomes active loop only in these systems.

The looping of organizationally non-active systems (called closed) is not a true looping; it is a blockage. It is, if we may say so, a blocked loop, or a looped block. This blockage preserves by immobilization an original negentropy which, more or less long, is going to resist the forces of internal and external disintegration. Organization is fixed, it does not work. The closing is, therefore, passive.

On the other hand, active organizations of systems called open insure the exchanges, the transformations which nourish and effect their own survival: the opening allows them to ceaselessly form and reform themselves; they are reformed by closing, by multiple loops, negative retroactions, recursive uninterrupted cycles (cf. Part II, ch.2). Thus, the paradox imposes itself: an open system is opened in order to be closed, but is closed in order to be opened, and is closed once again by opening. The closing of an "open system" is the loop on itself. I will attempt to demonstrate this proposition further on (p.197). Thus, looped organization is distinguished radically from blocked organization; it is active reclosing which insures active opening, which insures its own closing:



and this process is fundamentally organizational. Thus, living organization is opened in order to be closed again (to insure its autonomy, to preserve its complexity) and is closed again in order to be opened (to exchange, communicate, enjoy, exist...).

We need, therefore, to go beyond the simple idea of closing which excludes opening, beyond the simple idea of opening which excludes closing. The two notions can and must be combined; necessary together, each becomes relative to the other, as in the idea of frontier, since the frontier is what both forbids and authorizes the passage, what closes and what opens. But this link can only be established at the heart of a complex organizationist principle. We will see, besides, that the more a system is complex, the more its opening is ample, the more its closing is strong.

8. *The Organ*

Organization is a polyphonic, polyscopic concept. Organization bonds, forms, transforms, maintains, structures, orders, closes, opens a system.

This is to say that it organically connects what bonds, forms, transforms, maintains, structures, orders, closes, opens the system.

Which has brought us to consider organization as a concept of second

order or recursive, whose products or effects are necessary to its own constitution: organization is the relation of relations, it forms what transforms, transforms what forms, maintains what maintains, structures what structures, closes its opening and opens its closing; it is organized by organizing and organizes by being organized. It is a concept which is looped on itself, closed in that sense, but open in the sense that, born of anterior interactions, it maintains relations with, indeed brings about changes with, the exterior.

These features are pertinent, I believe, for all systems and by this fact they constitute organizational universals. The following chapters and volumes will show us their developments, diversifications, and complexifications.

D. Physical *Dasein*: Relation with Time

The old physical object was, at first, outside time. It was by perennial postulate perishable only by accident. The second law showed that it could, that it should be degraded, that is was perishable by nature and probability, but only its degradation became temporal; its formation remained intemporal, as if the system had been given from all eternity or had been brought by a *deus ex machina*.

We can, henceforth, conceive the birth of the system in and by interactions becoming interrelations, and its existence in given outside conditions. Therefore, every physical system is a *dasein* (finite honor that we believed reserved to man)—a *being there*, dependent on its environment and subject to time.

Every physical system is fully a being of time, in time, which time destroys. It is born (of interactions), it has a history (the external and internal events which perturb and/or transform it), it dies by disintegration. It is evidently when life takes form that birth and death will take on a deep meaning.

Systemic time is not only that which goes from birth to dispersion, it is also the time of evolution. What is evolutive, in the universe, what develops, proliferates, complexifies, is organization.

A system is evolutive in its existence since, in reference to its components, it is a new form, a new organization, a new order, a new being endowed with new qualities. It constitutes the basis of new morphogeneses, which will utilize its emergences as primary elements.

The modification in the arrangement of its components can make it evolve. Finally, and especially, it is the interrelations and intercombinations between systems which will be evolutive. Actually, there is an *evolution of matter*, as we henceforth recognize. It goes from the constitution of the first

nuclei in the primitive cloud to the formation of stars and to the formation of atoms at the heart of the stars; then, more locally come the molecules and the macro-molecules; finally, at one point, perhaps alone, perhaps one among others in the universe, a living cell is created. This evolution from matter is in fact the evolution of organization, which is going to continue, after the living cell, with organisms, societies, and, lastborn, ideas, noological forms of organization...

The Law of Physical Selection

The idea of encounters is necessary, but insufficient, to understand the evolution of organized *physis*, starting from atomic nuclei and astral concentrations, towards more complex systems of systems. We must also, given the improbability and ever greater fragility of what becomes complex, understand evolution starting from the consolidation of fragility and improbability in and by organizational order, in and by the acquisition of emergent qualities (among them, more subtle organizational qualities, more and more apt to resolve phenomenal problems), in and by the aptitude to form organizational relations with other systems. Thus, the universe of organization, born by chance encounters, is maintained by order, necessity, but also *qualities*, making what otherwise should have been dissolved and dispersed survive and perdure.

All that is stabilized becomes both an organizational citadel, protecting the system against fortuities, and a base of departure for new adventures.

Organizational closing, structural stability, internal order, phenomenal permanence or constancy constitute an undissociable conceptual constellation which explains the system's resistance to destructive pressures from the inside and the outside.

Selection does not work only for what passively, pantingly, imperturbably resists outside perturbations and aggressions. It also works for what is complex, the advantages of a complexity which counterbalances its fragility. Resistance to fortuities can be effected, not only by insensitivity to the fortuities, but also by response to the fortuities. Thus, adapting to the fortuities and integrating it into the organization are going to constitute equally a premium of selection. What the organization loses in cohesion and rigidity by being complexified it gains in suppleness, aptitude to regenerate, to turn the table on event, chance, perturbations.

Likewise, selection does not work only for what is solitary (particles and atoms scattered in the universe), it works also for what is solidary, namely coalitions, associations, systems of systems. In other words, physical selection

does not work for one form of organization, it works for very diversified forms of organization, it works for organization itself. It is not only by chance that everything has not been dispersed.

E. Beyond Formalism and Realism: From *Physis* to Understanding, from Understanding to *Physis*: the Subject/System and the Object/System

The notion of system is submitted to double pressure, on one side by an assured realism that the notion of system reflects the real characters of empirical objects, on another side by a formalism for which the system is an ideal heuristic model that we apply to phenomena without prejudicing their reality.

The reader encounters here a fundamental problem, which is posed for all phenomena and physical objects, perceived and conceived by the human mind. In one sense, every description on which diverse observers are agreed returns to an objective exterior "reality." But, inversely, the same description returns to mental and logical categories, to perpetual structures without which there would not be any description. This problem, which is the problem of the knowledge of knowledge, will be treated head-on at its own time (v.III). Yet, we can already inscribe the notion of system, not in the alternative realism/formalism, but in a perspective wherein these two terms are presented as simultaneously complementary, concurrent, and antagonistic.

1. *Rooting in Physis*

All systems, even those which we isolate abstractly and arbitrarily from sets to which they belong (like the atom, which is, besides, a partially ideal object, or like the molecule) are necessarily rooted in *physis*.

The conditions of formation and of existence are physical: gravitational, electro-magnetic interactions; topological properties of forms; ecological conjunctures; energy immobilizations and/or mobilizations. "A system can only be energy," said Lupasco; which is like saying: *a system is necessarily physical*. An ideal system, like the theory which I am attempting to elaborate, pays its tribute in energy, provokes chemico-electrical modifications in my brain, corresponds to the stabilizing and morphogenetic properties of the neuron networks...

Finally, the inscription of the notion of emergence, at the very heart of systems theory, is the inscription of the non-reducible and non-deducible of what, therefore, in physical perception, resists our understanding and our

rationalization, namely that aspect of the real which is at the antipodes of the ideal.

There is, therefore, in the systems theory I am outlining, something irreducibly tied to physical phenomenality by the base (innate interactions and interrelations which maintain the system), by the sides (the physical thresholds of existence beyond which it is disintegrated and transformed), by the top (the emergences).

2. The System Is an Abstraction of the Mind

As every system escapes in some way the mind of the observer to be based in *physis*, every system, even one which seems phenomenally most evident, like a machine or an organism, is based also in the mind in this sense that the isolation of a system and the isolation of the concept of system are abstractions brought about by the observer/conceiver.

Ashby called attention to the fact that "objects can represent an infinity of systems equally plausible which differ from each other by their properties." (Ashby, 1958, p.274) Who am I? I can think of myself as a physical system of billions upon billions of atoms; as a biological system of thirty billion cells; as an organismic system of hundreds of organs; as an element of my family system, or city, or profession, or society, or country, or ethnic group.

Certainly, distinctions have been established which allow systems to be categorized. Thus we will say:

—*system*, for any system which manifests autonomy and emergence in reference to what is exterior to it;

—*sub-system*, for any system which manifests subordination with regard to a system in which it is integrated as a part;

—*supra-system*, for any system controlling other systems, but without integrating them in itself;

—*eco-system*, for the systemic set whose interrelations and interactions constitute the environment of the system therein encompassed;

—*meta-system*, for the system resulting from interrelations mutually transforming and encompassing two systems previously independent.

In fact, the boundaries between these terms are not clear, and these terms themselves are interchangeable according to the framework, the framework, the angle of the viewpoint which the observer takes on the systemic reality being considered. The determination of systemic, sub-systemic, eco-systemic, etc. character is based on cultural and social conditions where the observer/conceiver is inscribed. Is system: that which an observer considers from the point of view of its autonomy and emergences (hiding by that very fact the

dependences which, from a different angle, would define it as sub-system). Is sub-system: that which an observer considers from the point of view of its integration and dependences. And so on. Thus the same "holon" can be considered as eco-system, system, sub-system, according to the focus of the observer. If the observer studies the *Escherichia coli* bacteria of our intestines as living system, the human intestine becomes the eco-system supporting the bacteria; if he studies the intestine as system, the bacteria becomes a more or less parasitic element, integrated in the functioning of the said system; evidently the intestine becomes sub-system when we consider the organism in its entirety. *Thus, not only is there no clear boundary between these notions (in reality), but they are interchangeable (by the observer).*

They are equally variable according to the observers; an atomic bomb, for the mechanic, is the grouping of solid elements including two blocks of uranium; for the atomist, it is a system of nuclei and neutrons; for the chemist, it is a system of uranium atoms; for the Secretary of Defense, it is an element of the National Defense system; and for everyone, the potential destruction of living systems.

Finally, and these are the most important, there are cases where uncertainty dominates any characterization: is society the eco-system of the individual, or is the individual the perishable and renewable component of the social system? Is the human species a supra-system or is it the system? We cannot get out of uncertainty, but we can ponder it and conceive the concept of man as a trinitarian poly-system whose terms:



are simultaneously complementary, concurrent, and antagonistic. This concept also requires a theoretical construction and a complex conception of system, that is to say, again, the active participation of the observer/conceiver.

There is always, therefore, in the extraction, isolation, definition of a system, something uncertain or arbitrary: there is always decision²⁰ and choice, which introduces into the concept of system the category of the *subject*. The subject intervenes in the definition of a system in and by his interests, selections, and finalities; this is to say that he brings into the concept of system, by his subjective overdetermination, cultural, social, and anthropological overdetermination.

Thus, a system requires a subject, who isolates it in the poly-systemic swarm, cuts it up, qualifies it, hierarchizes it. The system returns us, not only to physical reality in what it has of irreducible to the human mind, but also to

the structures of this human mind, to the selective interests of the observer/subject, and to the cultural and social context of scientific knowledge.

From the subjective character of systematism flow two extremely important consequences.

The first is a principle of uncertainty as to the determination of the system in its context and its polysystemic complex.

The second consequence is a principle of art. In fact, the systemic cutting up can be either a clumsy butchering of the phenomenal universe, which will flow out in arbitrary systems, or on the contrary the art of the skillful butcher who cuts up his beef by following the outline of the joints. The systemic sensibility will be like that of the musician's ear which perceives the competitions, symbioses, interferences, overlappings of themes in the same symphonic flow, where the brutish mind will recognize only one theme surrounded by noise. The systemist ideal cannot be the isolation of system, the hierarchization of systems. It is in the art, aleatory and uncertain but rich and complex like all art, of conceiving the polysystemic interactions, interferences, and dovetailing. The notions of art and science, which oppose each other in the dominant techno-bureaucratic ideology, must be associated here as wherever there is true science.

Thus, the concept of system requires the full use of the personal qualities of the subject in his communication with the object. It is radically differentiated from the classical concept of object. The latter returned, either solely to the "real" or solely to the "ideal." The system does not return very profoundly to the real; it is more real, because much more rooted in and tied to *physis* than the former object, quasi-artificial in its pseudo-realism; at the same time, it returns very profoundly to the human mind, that is to say to the subject, himself culturally, socially, historically immersed. It requires a physical science which is at the same time a human science.

3. Phantom-concept, Pilot-concept

System is, therefore, really a concept with a double entrance: the first physical, phenomenal, empirical; the other formal, ideal. Bertalanffy started from a concrete, phenomenal totality, the living organism; he ended up at a general systems theory. Inversely, Ashby started from the ideal systems whose typology he made. The two aspects are the two faces of the new concept of system. The latter partakes of phenomenally localizable objects and ideal objects without being totally identified with either. At its organizational heart physical interrelation and relation proper to mathematical formalization can meet.

System is physical by its feet, mental by its head. It needs to be conceived logically, but the logic must start from the physical base of the parts, and faced with emergence, it can only gape.

In its double nature, system is a phantom-concept. Like the phantom it has the form of material beings, it is their spectre; but like the phantom it is immaterial. It links idealism and realism, without allowing itself to be enclosed in one or the other. In fact, it concerns neither the "form," nor the "contents," nor the elements conceived isolatedly, nor the whole alone, but all of that tied in and by the organization which transforms them. System is a model, which also allows itself to be modeled by the qualities proper to phenomenality. The idea of organization is a logical simulation, but since it includes illogical elements (antagonism, emergences), it is also a reflection of what it simulates, which stimulates it.

Thus, system oscillates between the ideal model and the descriptive reflection of empirical objects, and it is really neither one nor the other. The two poles of antagonistic apprehension are complementary here, while remaining antagonistic. For us, we will see better if we continue to read this work, the most physical system is also in some aspect mental and the most mental system is in some aspect physical.

This is to say that the concept of system is not a recipe, a carriage which transports us towards knowledge. It offers no security whatsoever. We must ride it, correct it, guide it. It is a pilot notion, but on condition of being piloted.

4. *The Transaction Subject/object*

The concept of system can only be constructed in and by the transaction subject/object, and not in the elimination of one by the other.

The naive realism which takes a system as a real object eliminates the problem of the subject; the naive nominalism which takes a system for an ideal schema eliminates the object. But it also eliminates the problem of the subject, since it considers in the ideal model, not its subjective structure, indeed cultural, but its value of efficacy in manipulation and prevision.

In fact, the object, be it "real" or "ideal," is also an object which depends on a *subject*.

By this systemic path, the observer, excluded from classical science, the subject, enucleated and returned to the trashcans of metaphysics, make their re-entrance at the very heart of *physis*. Whence this idea, that we will follow strictly: there is no longer any *physis* isolated from man, that is to say isolable from his understanding, his logic, his culture, his society. There is no longer an object totally independent of the *subject*.

The notion of system, thus understood, leads the subject therefore, not only to verify the observation, but to integrate self-observation therein.

5. *The System Observing and the System Observed*

Here there intervenes a curious novelty. The relation between the observer and the system observed, between the subject and the object, can be enveloped and translated into systemic terms.

In fact, any system observed in nature is tied to a system of systems, which is tied to other systems of systems, and, step by step, is connected to organized *physis* or Nature which is a polysystem of polysystems. At the same time, this observed system is perceived and conceived by a cerebral system, which is part of a living system of the type *homo*, which is inscribed in a socio-cultural polysystem, and, step by step, is connected to the entire anthropo-social universe.

Thus, the observation and the study of a system link physical organization and the organization of ideas to each other *in systemic terms*. The observed system, and consequently the organized *physis* of which it is a part, and the observer-system, and consequently the anthropo-social organization of which it is a part, become interrelated in a critical manner: the observer is *also* a part of the definition of the observed system, and the observed system is *also* a part of the intellect and culture of the observer-system. A new systemic totality is created in and by such a relation which encompasses both.

The new systemic totality which is constituted by associating the system-observed and the observer-system can, thenceforth, become meta-system in reference to both, if it is possible however to find the meta-point of view, which allows us to observe the set constituted by the observer and his observation.

We can have a simplifying view of this relation, and reduce to the extreme either the importance of the observer or the importance of *physis*. In the first sense, the observer will be only a supra-system, whose theory lets us see autonomous phenomenal systems.

In the second sense, the accent will be put on the ideological, cultural, and social character of the theoretical system (systems theory) where the conception of physical system is inscribed.

The systemic relation between observer and observation can be conceived in a more complex fashion, where the mind of the observer/conceiver, his theory, and more widely his culture and society are conceived as so many eco-systemic envelopes of the physical system studied; the mental/cultural eco-system is necessary to have the system emerge as concept; it does not

autonomy. This is the point of view I am adopting here provisionally.

We can and must also go beyond in the search for a meta-systemic point of view: we can no longer escape the key epistemological problem which is the relation between, on one hand the polysystemic group constituted by the conceiver-subject and his anthropo-social grounding, on the other hand the polysystemic group constituted by the object-system and its physical grounding. Henceforth, it is a question of elaborating the meta-system of reference from which we might embrace simultaneously both groups which could communicate and interorganize therein. It is in this perspective, both impossible and forbidden by classical science, that the path of new theoretical and epistemological development is opened; *this development necessitates not only that the observer observe himself observing systems, but also that he make an effort to know his knowledge.*

Finally, the systemic articulation which is established between the anthropo-social universe and the physical universe, via the concept of system, suggests to us that an organizational character is fundamentally common to all systems. The possibility of posing, in systemic terms, the organization of *physis* as well as the organization of knowledge, supposes a preliminary organizational homology. This homology would allow the organizing retroaction of our anthropo-social understanding on the physical world, an understanding which has come about by evolution. In this sense, the organization of *physis* and mental organization would not be absolute strangers to each other (each playing a co-producer role in regard to the other), without our being able nevertheless to have the unheard-of richness of *physis* enter into the systemic frameworks of the human mind, without our any longer being able to reduce the richness and originality of the human mind to the first systemic principle examined in this chapter. I want only to indicate, as of now, that *the theory of organization, as it develops, and in its intimacy, is going to concern more and more the organization of my theory. We are going to see that the concept of system lends itself to theoretical elaborations which permit going beyond it. We are going to see that complex systems theory transforms the theoretical system which forms it.*

I hope that we have understood: it is not a question here of a Hegelian plan looking to dominate the world of systems by the System of Ideas. It is a question of searching for the articulation, secret and extraordinary, between the organization of knowledge and the knowledge of organization.

V. Complexity as the Base

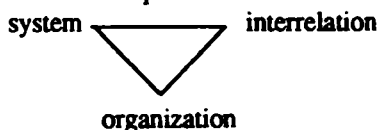
A. The Complexity of Complex Unity

Simplification isolates, that is to say hides the relationism consubstantial to the system (relation, not only with its environment, but with other systems, with time, with the observer/conceiver). Simplification reifies, that is to say hides the relativity of the notions of system, sub-system, supra-system, etc. Simplification dissolves organization and system.

It is certainly necessary to know the *simple* laws of interaction whence flow innumerable, rich, and complex combinations. Thus, we know, henceforth and profitably, that the great diversity of atoms, the infinite diversity of molecules is constituted starting from combinations between protons, neutrons, electrons, obeying a few laws of interaction. We know that a few simple rules permit the infinite diversity of the genetic combinations of living beings. We know that the laws of language organization permit infinite combinations of phonemes in discourse. But, to be content with this type of explanation is to hide complexity at departure (the play of order/disorder/interactions) and complexity at arrival: the complex organization of such combinations into systems of systems. To know life is not only to know the alphabet of the genetic code: it is to know the organizational and emergent qualities of living beings. Literature is not only grammar and syntax; it is Montaigne and Dostoevsky. We must, therefore, be capable of perceiving and conceiving organized complex unities. Unfortunately and fortunately the intelligibility of complexity necessitates a reform of understanding.

Unitas Multiplex: *the Macro-concept*

We must first of all be capable of conceiving plurality in oneness. While we easily conceive that atoms group together to form a molecule, that grouped molecules constitute a macro-molecule, we have not yet raised ourselves to the molecular level of ideas where concepts are grouped into a macro-concept. Now, we cannot conceive organized complex unity except in the form of a trinitarian macro-concept, around which is positioned an entire satellite constellation. This macro-concept:



is, let us repeat one last time, undissociable. The organization of a system and the system itself are constituted by interrelations. The notion of system completes the notion of organization as much as the notion of organization completes that of system. Organization articulates the notion of system which phenomenalizes the notion of organization, by tying it to building elements and to a phenomenal whole. Organization is the interiorized visage of system (interrelations, articulations, structure), system is the exteriorized visage of organization (form, globality, emergence).

Unitas Multiplex: *the Unity of, in Diversity*

It is still more difficult to mentally conceive oneness and diversity together: whoever favors *Oneness* (as fundamental law) devaluates diversity (as phenomenal appearance); whoever favors diversity (as concrete reality) devaluates *oneness* (as abstract law). Classical science was founded on reductionist and imperialist *Oneness*, which rejects diversity as epiphenomenon or scoria. Now, without the principle of intelligibility which seizes *oneness* in diversity and diversity in *oneness*, we are incapable of conceiving the originality of a system. A system is a *complexion* (a set of diverse interrelated parts); the idea of complexion leads us to the idea of complexity when we associate oneness and diversity. A system is a unity which comes from diversity, ties in diversity, carries diversity in itself, organizes diversity, produces diversity. From the Pauli exclusion principle to the principle of differentiation and biological multiplication, systemic organization creates, produces, maintains, develops interior diversity at the same time as it creates, maintains, develops unity. We must, therefore, grasp oneness and diversity as two notions which are not only antagonistic or competitive, but also complementary.

Oneness Is Complex

We arrive here at the question of complex identity. Already, cosmogenic reflexion has shown us that *Oneness* was in crumbs (while remaining probably *one*); here systemic reflection puts us face to face with the logical paradox of *unitas multiplex*. The unity of the system is not the unity of *One* is *One*. One is both *one* and non-*one*. There is breach and shadow in the logic of the identity. We have seen that there is not only diversity in *oneness*, but also relativity of *oneness*, alterity in *oneness*, uncertainties, ambiguities, dualities, scissions, antagonisms.

The One has become relative in reference to the other. It cannot be

defined only in an intrinsic fashion. To emerge, it needs its environment and its observer. Given that it belongs to a polysystemic totality, its definition as a system or sub-system, supra-system or eco-system varies according to the way we situate it among other systems. There is, therefore, in fact relativity of the one in reference to the other. There is, likewise, alterity at the heart of the one. The formula $S \subset S$ shows us that the one is other than the grouping of parts considered in addition or juxtaposition. Likewise, every modification in the arrangement of the same components, as we have seen, creates another system, endowed with different qualities, although nothing has changed in the composition of these elements. The one is double, and multiple double. Each part has a double identity, and the whole itself has a double identity: it is not a whole and it is a whole. It has unity and also scission.

Antagonism in Oneness

The inclusion of antagonism at the heart of complex unity is probably the most grievous attack on the paradigm of simplicity, and the most evident call to the elaboration of a principle and a method of complexity.

Anti-organization is part of organization, since there is no organization which does not determine internal antagonisms, be it only virtually; the most complex organizations even include in their principle and in their activity antagonistic interplays. But at the same time, antagonism remains the deadly menace. Antagonism cannot, therefore, be simplified, that is to say either defused and totally integrated in organization, or be only the carrier of disintegration.

It is Heraclitus who expressed with the most intense sense of complexity the complementary/antagonistic bond between "what is complete and what is not, what accords and what discords, what is in harmony and what is in disharmony." Since then, the idea which links complementarity to antagonism while maintaining their opposition has returned ceaselessly to haunt Western thought, from Heraclitus to Hegel and passing through Nicholas of Cusa (the *coincidentia oppositorum*), and relentlessly Western tradition has exorcised the idea of *antagonism internal to unity*.

The nuclear idea, common to Heraclitus, Hegel, Marx is that antagonism, latent or working at the heart of Oneness, plays a role not only as destroyer, but as builder. The constructivity of negativity in fact appeared to us in the preceding chapter (where disorder, which is the opposite of order, is necessary to its elaboration while remaining destructive). The negativity of constructivity appeared to us in this chapter and is installed at the heart of organization theory.

The idea of antagonism, devaluated by its philosophical origins and dialectical farfetchedness, has not obtained right of entry in scientific thought. Nevertheless, micro-physics has, henceforth, installed in the shadow of each particle its anti-particle, both therefore complementary and antagonistic, and it has come to conceive an anti-matter. But the association of these antagonistic terms has always remained tied to their specific context. Only Stéphane Lupasco has dared a theory of *physis* founded on the idea of antagonism (Lupasco, 1951, 1962); unfortunately antagonism has become for him a master-word, a *deus ex machina*, and the notion, endlessly repeated and remouthed, has not been, as such, developed, relationed, relativized.

Cybernetics, we will see, carries in itself an internal principle of antagonism (positive *feed-back*), but it has atrophied, anesthetized, integrated it in a quasi-mechanistic theory of regulation; everything which gives rise to deviances and antagonism is "noise" which the system must eliminate, whereas it is also a question of its necessary negative part. Biology, likewise, has by-passed the principle of antagonism, as much in its organism phase of harmonies and complementarities as in its new cybernetico-molecular phase.

Therefore, nowhere in the sciences has the sometimes empirically recognized idea of antagonism been able to take root.

We clearly see the problem therefore: to integrate in scientific theory an idea which has previously emerged in philosophy; this must entail, not only the modification of the philosophical idea into a scientific idea, but a modification of the idea of science itself. That is to say, a repudiation of the master-idea of simplification (which could only eliminate all antagonism in Oneness) in favor of a matrix idea of complexity.

Complexity emerges, therefore, at the heart of Oneness simultaneously as relativity, relationality, diversity, alterity, duplicity, ambiguity, uncertainty, antagonism, and in the union of these notions which are each in reference to the others complementary, concurrent, and antagonistic. System is the complex being which is more, less, other than itself. There is no organization without anti-organization. There is no functioning without dysfunction...

Things Are Not Only Things

It is, henceforth, impossible to lock up the richness of system in simple and closed notions. The new type of intelligibility must be able to associate antagonistic notions and integrate ambiguity, to understand the real complexity of objects and their relation with the thought which conceives them. A universe of entities is disintegrating: the universe of simple unities, of very distinct object-things in a theater setting, subject to the laws of the universe.

The homogeneous and uniform universe of objects dressed in black no longer exists. There is internal and external diversification. The substantial object no longer exists; there is the organized system. Simple unity no longer exists; there is complex unity. For the closed object a system both open and closed is substituted. Where it was closed, it is opened to the environment, to time, to evolution, to the observer. Where it was empty, it is organizationally closed. Closed, it keeps its autonomy; opened, it offers its possibility to communicate and be transformed.

Objects and concepts lose their Aristotelian and Cartesian virtues: substantiality, clarity, distinction... But these virtues were vices of simplification and perversion.

We had wound up ignoring that objects are very slightly objects. The idea of object is only a cut, a fragment, an appearance, a face, the simplifying and unidimensional face of a complex reality which takes root both in physical organization and in the organization of our anthropo-socio-cultural representations. Things are not only things, Robert Pagès said, one day long ago, and that sentence which had so impressed me had to wait fifteen years before being able, finally, to bring forth its meaning, here, for me.

B. Complexity as the Base

We can now attempt a new definition of system. The first definition, "an interrelation of diverse elements constituting an entity or global unity," carried in itself riches, complexities, and difficulties which its trivial evidence did not allow us to foresee and which have appeared along the way. Henceforth, system, or organized complex unity, appears to us as a pilot-concept resulting from the interactions between an observer/conceiver and the phenomenal universe; it allows us to represent and conceive complex unities, constituted from organizational interrelations between elements, actions, or other complex unities. Organization, which binds, maintains, forms, and transforms a system, has its own principles, rules, constraints, and effects; the most remarkable effect is the constitution of a global form retroacting on the parts, and the production of emergent qualities, as much at the global level as at the level of the parts. The notion of system is neither simple nor absolute; it includes, in its unity, relativity, duality, multiplicity, scission, antagonism. The problem of its intelligibility opens up a problematic of complexity.

It is now no longer a question of a definition, properly speaking, of a system, but of a critical examination of conjoined and articulatable traits necessary to allow the concept of system to be *pilot*, that is to say a reading guide for all phenomena of physical, biological, anthropological, ideological

organization, including the theoretical system which I am beginning to elaborate here. This pilot-definition, concerning the common denominator of everything organized, has, therefore, universal value. *System is, therefore, conceived here as the basic complex concept concerning organization.* It is, if we may say so, the most simple complex concept. In fact, *there are no longer, there will be no longer any basic simple concepts for any physical object whatsoever, ergo for the universe.*

System is the basic complex concept because it is not reducible to elementary units, simple concepts, general laws. System is the unity of complexity. It is the basic concept because it can be developed into systems of systems of systems, where natural machines and living beings will appear. These machines, these living beings, are also systems, but they are already something else. Our goal is not to generate reductionist systemism. *We are going to use our conception of system universally, not as the master-word of totality, but at the root of complexity.*

In our first chapter, complexity invaded the universe. In the course of this chapter it has been installed at the heart of organization, at the heart of system. Contrary to the over-simple idea which made man the only complex being (and this idea was so simplistic that it made us incapable of conceiving the complexity of man), contrary to the more liberal idea which granted complexity to living matter as against the simplicity of physical nature, *complexity is everywhere.* In the beginning was complexity: genesis is the other side of disintegration. On the horizons there was complexity, since all our concepts twist and bend in cosmological relativity, all our concepts break up as soon as they are carried beyond the speed of light. At the very base complexity triumphs: *the simple matter of classical physics was complex organization!* Much more. Where we thought we held the most simplistic elementary unity we see emerge the most unbelievable of all complexities. We have seen that the particle is not only a particle, and perhaps it is not even a particle. At this level, the problems of complexity are not attenuated, but aggravated: the uncertainty in knowledge, the dereification of the notion of object and matter, the irruption of local contradiction in description, the interaction between object and observer. The particle is perhaps only the local phenomenalization of an unknown complexity which returns us to the problem of the being of *physis*. Which means finally and especially that at the base of *physis* there is not simplicity, but complexity itself. And yet we continue to remain moles, unaware that the simplicity of our porcelain cosmos and phony *physis* have just been broken. We still believe we are on the firm rock of simplicity. But our island is made of systems of systems of systems. There also complexity reigns. System creates complexity, maintains complexity, develops

complexity. It is born and it dies because it is complex. There is no longer, therefore, a simple empirical base anywhere, a simple logical base for considering the physical substratum. The simple is only an arbitrary moment of abstraction, a means of manipulation torn from complexity.

C. Complexity at the Helm; Ever Greater Utility and Insufficiency of Systems Theory

System is basal complexity. On this base we are going to try to follow the developments of the complexity of organized phenomena, that is to say the developments of diversity in unity, of the autonomy of individuals, of forms of interrelation, more and more supple, of polysystems more and more emergent and rich.

There is no linear development in complexity; complexity is complex, that is to say unequal and uncertain. There is no superior excellence in the complexity of a macro-system over the micro-system which it integrates: thus the atom is of a much more complex organization than the molecule; the organization of unicellulars is much more complex than the first multi-cellular organizations; human individuals, by their reflexive aptitude and their consciousness, are on this plane more complex than the societies to which they belong. Ideas, born in the societies of *homo sapiens* are still much less complex in their organization as theoretical systems than the organization of the least living being. They are still, we shall see, very barbarous in their stiffness, stupidity, coarseness. And what this study is trying to do is, by revealing the complexity of *physis* and life, to complexify somewhat the system of ideas, that is to say to civilize theory and intelligence...

The developments of complexity are going to go beyond the notion of system. Thus, when we broach the organization of machine-beings and of existents, we will see that these beings and existents, without ceasing to be systems, are much more than systems. We will see that being, existence, life go beyond the notion of system everywhere; they envelop it, but are not enveloped by it. We suspect already that to reduce life to the notion of system is to make life a skeleton-concept, necessary like any skeleton, but without flesh, without brain, without life. We have to speak, not only of the living polysystem, but of *living beings*, evident term, nonetheless unknown to systemic and even biological vocabulary. Though the living being is a system, we cannot reduce the living to the systemic. To reduce to a system is to drive out existence and being. The term "living systems" is a demential abstraction if it makes any sense of life disappear. I will use the term "living system" here, but only to evoke the systemic aspect of the living, never in order to see,

in the living, only a system. What terrifying poverty to perceive, in a living being, only a system! But what foolishness not to see also a system! I know that my attitude, however evident it appears to me, will not be understood, because the majority of those who will read me still obey a paradigm of simplification which enjoins alternative where we need transcendence by integrating opposed points of view. Therefore, my struggle will be difficult, because it must be fought on two fronts. I will commit myself to the task, apparently pompous and nonsensical, in fact dialectical, of defending systems and, if need be, of combatting them. The systems theory that I propose is also anti-systemic.

I will say even more: the more we go beyond system, the more we need it. *It is when systems theory is less and less sufficient that it becomes more and more necessary.* In fact, systems theory takes on life where there is active play of interactions, retroactions, emergences, constraints; where the antagonisms between parts, between the parts and the whole, between the emergent and immersed, the structural and the phenomenal start up. Systems theory takes on life where there is life, and its greatest theoretical interest is deployed at the level of human societies, which on the other hand it would be gross and mutilating to reduce to the notion of system.

Therefore, we must clearly understand that my aim, though integrally systemic, is opposed to the majority of systemist positions which, believing they have overcome the paradigm of simplification by refusing to reduce the system to its components, succumb to the paradigm by reducing all things and all beings to the notion of system.

The idea of system is a two-sided idea; on the one side, there is unification and reduction under the guise of a general and abstract conceptual grab-bag; on the other, the universality of systems invites us to transform our view and restructure our thought. Yves Barel has very well seen and said: "The idea of system is a Problematic in the strong or exact meaning of the term, that is to say a way of discovering problems which would not be perceived otherwise." (Barel, 1976, p.7) We must go towards system as problem, not towards system as solution. My purpose is not to undertake a systemic reading of the universe; it is not to cut up, classify, hierarchize the different types of systems, from physical systems to *homo* as system. *My purpose is to change the way we look at all things, from physics to homo.* Not to dissolve being, existence, life in system, but to understand being, existence, life with the added help of system. That is to say, first of all, to put a *circumplex accent* on all things! This is what I have attempted to point out: complexity at the hold, complexity at the helm.

Part 2

Organization

(active organization)

1. Machine-beings

Carnot speaks of his machine, he speaks of the world, meteors, seas, and suns, he speaks of human groups, of the circulation of signs. Michel Serres.

In the Beginning Was Action

As far back as we can conceive the cosmic past, it is movements and interactions. As far down as we can conceive the depths of *physis*, we find particle agitations and interactions. Immobility, fixity, repose are local and provisional appearances, for certain states (solids), on the scale of our human lives and perceptions. *Physis* is active. The cosmos is active.

What does action signify? Action does not signify only movement having an application and an effect. We have seen that action signifies *interactions*, key and central term.¹ which includes diversely *reactions* (mechanical, chemical), *transactions* (actions of exchanges), *retroactions* (actions which act in return on the process which produces them, and, as the case may be, on their source and/or their cause).

These interactions, reactions, transactions, retroactions have generated the fundamental organizations which populate our universe, atoms and stars. These billions upon billions of beings are not at all assemblages of fixed elements, organizations at rest. They are all in permanent activity. They are themselves constituted of interactions, reactions, transactions, retroactions, and as we will see, retroactions play therein a fundamental role, overdetermining, accentuating, inhibiting, modifying, transforming the actions and interactions.

The atom is a quasi-vortex of particles. Everything in the sun is turbulences, fluxes, flames, collisions. Everything under the sun is in action. The earth rotates, quakes, cracks, hardens, softens, moistens, dries, the depths of the sea become mountains, leveled mountains become marine foundations; the surface is watered, irrigated by running waters, encircled by ascending, descending, whirling winds, and all life which is immobilized, on this earth,

becomes a corpse.

Thus, the major and fundamental fact of *physis* is not only the idea of organization, but the idea of *active organization*. Systems at rest or fixed are second and secondary.

This means that action has created organization which creates action. This means that interactions, transformations, generations take place in organization by organization, and they constitute that organization. This signifies that *the wild processes of genesis are transformed into organizational processes of production*.

I. Organization, Production, Praxis: The Notion of Machine-being

To say that an organization is active is to say that it generates actions and/or that it is generated by actions. At the same time, it is to say much more. The term action, become organizational, is itself going to tug along a first constellation of notions: praxis, work, transformation, production.

Every physical being whose activity includes work, transformation, production can be conceived as a machine; I am going to show that every active organization constitutes in fact a machine organization. When I evoked the stars, in Chapter I of Part One, I said "machines/motors on fire." It was not only an image by which I projected into the sky fiery reflections of our boilers, crucibles, and forges. It was already to suggest that its prodigious *organization* made it the mother-machine, of which our industrial earthly machines are ultimate abortees.

A. A Physical Being Which Organizes

What is a machine? We can and must consider our artificial machines as instruments invented (by man, society) and performing mechanical operations. We generally dissociate these two traits, returning the instrument-machine to *homo faber* and the industrial society, the mechanical-machine to the practice of the engineer.

Nevertheless, the progress effected by these machines, notably with cybernetics, in operational autonomy, has allowed us to question, not only what produces the machine, but also what it is. It was certainly evident that the machine is a phenomenal object. But it is Wiener who brought a new way to conceive of a machine, not as a social product or material instrument, but as a *physical being which organizes*. Certainly, in highlighting the physical being

of the machine, he hid its sociological being; in proposing a physical, autonomous concept, he hid the total dependence of the machine in regard to the society which created it. But, in limitation and insufficiency, for better and for worse, the first physical science having organization as object had been born.

B. Praxis, Transformation, Production

1. From Action to Praxis

Unlike the wild actions which are effected haphazardly by encounters between separate processes, the actions of a machine-being, even when they are of chance character,² are produced in function of organizational properties. In order to distinguish actions/transformations/productions which are effected in, by, and for an organization from actions/transformations/productions which are effected by chance encounters (which, I repeat, by no means excludes on principle the chance character of actions at the heart of an organization), I call *competence* the organizational aptitude to condition or determine a certain diversity of actions/transformations/productions, and I call *praxis* the set of activities which effect transformations, productions, performances starting from *competence*. Praxis concerns actions which always have an organizational character, and this is why I term praxic systems those in which organization is active. I add that it is not in all innocence that I take, as primary notions concerning machine-beings, both competence and praxis, terms which seem to belong only to the anthropo-social sphere. I hope to show that we can and must give these terms a very archaic, physical foundation. In any case, they are justified here in the definition I have given them. *A machine is, thus, a praxic physical being, that is to say effecting its transformations, productions, or performances by virtue of an organizational competence.*

2. Renovation of the Notion of Production

To produce means, in its original sense which is ours here: *to lead to being and/or existence*. The universe of wild actions is also that of wild productions, where interactions of encounter, in creating organization, create being and existence.

Now, this term production has been considerably weakened in our artificial machine, although essentially conceived to produce and enslaved to productivity. Thus, these machines produce movement by transforming chemical, electrical, atomic energies, etc., into mechanical energy; they are

motors. They produce performances, that is to say actions having a precise and finalized form, generated by virtue of a competence;³ they produce things. But all these productions are reduced, either to the repetitive fabrication of material goods, or to the generation of movement or performances. The idea of production, imprisoned in its techno-economic connotation, has become antinomic to the idea of creation. Now, it is necessary to restore to the term of production its full and diverse meaning. To produce, which fundamentally means, as we have just recalled to mind, to lead to being or to existence, can alternately or simultaneously mean: to cause, to determine, to be the source of, to breed, to create.

The term production, in these cases, keeps the genésic character of creative interactions. Thus, stars and living beings are poietic beings (I will use the term *poiesis* each time I give a creative connotation to the term production): they produce being and existence from raw materials. The generation of a being by another being is the consummate biological form of *poiesis*.

Therefore, the idea of production cannot be only identified with the industrial idea of standard fabrication. To create and to copy (to reproduce a model, a program) are two poles, opposed and on occasion linked, of the concept of production. The idea of production must take root in the ideas of genesis and of generativity. It is only in derived forms that it degenerates, that is to say, literally, stops being generative, to be merely fabricative.

3. Transformations and Meta-morphoses

The idea of transformations, conceived outside of organization, is reduced and fragmented: one speaks then of chemical transformations, of transformations of physical states, of mechanical transformations (producing movement). Certainly natural and even artificial machines involve transformations simultaneously physical *stricto sensu*, chemical, energetic. But we forget that the idea of transformation signifies change of form, that is to say: de-formation, formation (morphogenesis), meta-morphosis, and that we must consider the term form in its strict meaning, namely *Gestalt*, globality of a system and of a being. Thus, a machine is a praxic organization where forms are made, unmade, remade, and in living machines as in the solar arkhe-machine the work of transformation simultaneously destroys, constructs, meta-morphoses.

A machine, therefore, can produce, by dissociation, cracking, disintegration, shearing, reduction into elements, the raw from the composed, the less organized from the organized. Such a disintegration or decomposition can be productive of movement, of pure bodies, of raw materials which perhaps will

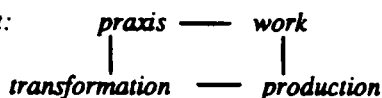
be assigned to formative productions.⁴

In the other sense, the more important one, transformations give birth to new forms of organizations. Thus, a machine can produce organized or organizing matter from the non-organized, better organized matter from the less organized. From that moment, the transformation appears as *fabrication* (a term which gives preponderance to the idea of work as organizer and to the idea of multiplication of the same) or appears as *creation* (a term which gives preponderance to the generativity of the system and the newness of the product). Here again, we must note that the idea of creation is far from being antinomic to that of production: all production is not necessarily creation, but all creation is necessarily production.

Thus, the idea of praxic organization or machine leads, not only to a repetitive fabrication of the same, but to the creation of a very great diversity of actions, processes, phenomena, things, beings. It leads to the development of variety and newness in the universe. We will even see that productive organizations or machines can produce not only other organizations, but organizations which, themselves, produce. New stage in generativity: living beings associate poietic generation and multiplying copy of the same in the process called reproduction, namely, a productive organization can reproduce its own productive organization.

Thus, machine-beings participate in the process of growth, multiplication, complexification of organization in the world. Through them genesis is prolonged, pursued, metamorphosed, in and by production.

4. The Praxic Circuit:



The ideas of production, work, transformation, when they enter the organizational field, are no longer isolable. The idea of work must be conceived no longer as the product of a force by displacement of its point of application, but as praxic activity which transforms and produces. Neither can it be isolated from the energy supply which permits the work, nor from the organizational degradation which all work provokes.

The idea of transformation becomes reciprocal to the idea of production: a transformation is not only the product of reactions or of modifications; it is also productive either of movement (motors) or of forms and performances. The notions of praxis, work, transformation, production are not only interdependent in the organization which encompasses them: they are transformed into each other and produce each other, since praxis produces

transformations, which produce performances, physical beings, movement. This rotation between the terms of production and transformation is well expressed in the *duction* of production and the *trans* of transformation... The *duction* (circulation and movement) becomes transformation, and the *trans* preserves and continues the idea of circulation and movement. And thus, we come back to the primary character of action: movement. An active organization includes transformation and production in its very logic.⁵

5. The Rise of the Concept of Machine

In order to formulate for ourselves a first notion of machine, we had to go through the Wienerian revolution and consider the machine as a physical being. But we already see that, to truly autonomize this notion, we need another revolution to deliver us from the cybernetic model of artificial machine.

Just like the concept of production, today mechanized and industrialized, the concept of machine today is seriously weighed down by its techno-economic narrowness and heaviness. In its current acception, it denotes only an artificial machine and connotes its industrial environment. And so, to properly conceive the machine as basic concept, we must dehypnotize ourselves of machines populating the civilization in which we are immersed. We must not be prisoners of those images which rise up in us: axes, bars, bolts, cams, casings, chains, faucets, gears, handles, hooks, levers, pinions, pistons, rods, safety valves, scales, screws, springs, spindles, straps, steering wheel, switches, trusses, universal joints, valves, vents, wagons, wheels... Let us not be prisoners of the idea of mechanical repetition, of the idea of standard fabrication. The word machine must be "felt" also in the pre-industrial or extra-industrial meaning where it designated complex sets or arrangements whose functioning is nonetheless regular and regulated: the "round machine" of LaFontaine, the political machine, the administrative machine...

Above all, we must feel it in its poetic dimension, a term which combines creation and production, practice and poetry. We must not erase the possibility of creation in the idea of production. Let us think that the idea of production goes much beyond its dominant techno-economistic meaning, that it can also mean, as I said at the very beginning: to give existence, to be a source of, to compose, form, procreate, create. In the machine, there is not only the *mechanical* (repetitive), there is also the *machining* (inventive). The idea of active organization and the idea of machine (which gives it flesh and form) must not be seen in the coarse image of our artificial machines (although it is thanks to the artificial machine, as I am going to show, that they emerged into

our consciousness). We must dream of producing diversity, alterity, one's self... Thus understood in the strict sense of the term production, the machine is a fabulous concept. It takes us to the heart of stars, of living beings, human societies. It is a solar concept; it is a concept of life. The key ideas of work, praxis, production, transformation run through *physis*, biology, and come to ferment at the heart of our contemporary societies.

II. The Machine Families

I want to show now that our first notion of machine, praxic/transforming/producing, conceived as a physical being, has universal value, that is to say applies (except perhaps to atoms) to all the active organizations known in the universe (which organizations are nonetheless all constituted of atoms). We are going to see that this notion applies to the stars, to living beings, to societies.

The Arkhe-machine: the Sun

We had never imagined, we who have dreamed so much while looking at the stars, that their fire was so very artist and artisan. We had never dreamed that, though they were balls of fire, they were also organizing beings in integral and permanent activity.

We had never imagined that they could be the mother-machines of our Universe.

Now we know: the stars are machine-beings which cosmogenesis made bloom by the billions. They are motors-machines for fire and on fire. Nuclear motors, they transform gravitational potential into thermal energy. Smith-machines, they produce, from the less organized (nuclei and light atoms), the more organized, namely heavy atoms, including carbon, oxygen, metals.

Wild machines, the stars are born without *deus ex machina*, from enormous turbulences, through gravitational interactions, electromagnetic, then nuclear. They become machines when gravitational retroaction triggers the ignition, which in turn triggers an antagonistic retroaction in a centrifugal sense.

They have existence and autonomy through the yoking of these two antagonistic actions whose effects, self-canceling, *de facto* effect a regulation.

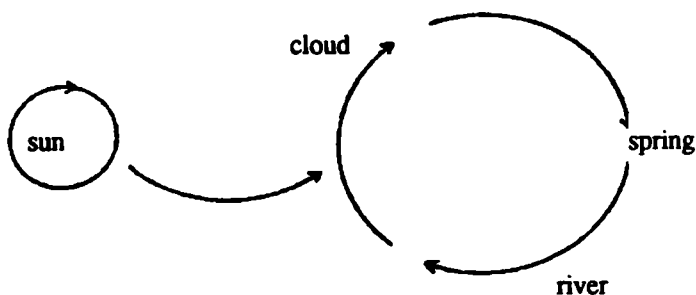
The suns are, therefore, fully physical beings which organize. They are endowed with properties ordering, producing, fabricating, creating. They are much more than the centers of a clockwork machine made of planets. They are simultaneously the most archaic of motors, the most archaic of regulatory

systems. They remain the greatest known distributors of energy, the most advanced of all known nuclear reactors, the greatest transmuting ovens known, the most grandiose of all known machines, always superior (in global organization) although—and because—still inferior (in detailed organization) to artificial machines. They offer the most admirable example of spontaneous organization: this fabulous machine, which made itself, in and by fire, and that not just once by incredible luck, but billions upon billion of times, turbines, fabricates, functions, regulates without conceiver, engineer or specialized parts, without program or thermostat.

Therefore, our Sun deserves much more, much better than the hymns to Ra and the homage to Zeus, devoted to energy power and sovereign order. We must above all devote our praises to its matrix truth, which Zeus had hidden by swallowing his wife, the great Metis.⁶

Protomachines and Wild Motors

Solar radiation and the rotation of the earth trigger eolian fluxes which, with differences in temperature and inequalities of terrain, take diverse directions, sometimes opposite, and as the solar loop was constituted in and by the encounter of two sequences of antagonistic actions, so the swirling forms of cyclones are constituted starting from encounters, shocks, confrontations, diversions. To eolian fluxes are added aquatic fluxes, evaporations, precipitations, and thus cycles of water are constituted which can be considered untamed mechanical processes of thermo-hydro-eolian character.



The cycle sea → cloud → rain → spring → river is made from

the looped association of distant processes, each one tied to a proper context, though constituting a moment of the cycle. It is a mechanical process simultaneously thermal (evaporation of sea water and formation of the cloud), eolian (transportation of the clouds), hydraulic (fall of water from the spring to the sea), of which the river, in hollowing out a bed, a valley, transporting and transforming materials, is the most productive moment. This cycle, not being differentiated and autonomous with respect to all the processes which constitute it, does not really have a physical being, its own existence, and that is why I say "cycles or mechanical processes" and not machine-being.

Aerial whirlwinds (cyclones, tornadoes, typhoons) have an intense but ephemeral existence. Aquatic swirls, like those which are formed with a certain duration on and around a rock sitting in the bed of a river, can in a lasting way come to existence.

A swirl can be considered, not only as a system, but also as an active organization and even as a wild motor. It is a system composed of a very large number of assembled and mixed elements (molecules of water), and it constitutes a global unity, complex and organized. Its spiraloid form is constant, although improbable with respect to the flux which flows out unidirectionally; the organization of the swirl replaces the haphazard interaction of the molecules within the undifferentiated flux with a heterogeneous spatial distribution and a differential speed, very rapid in the center, slower on the perimeter. It is, then, definitely a system, by its emergent global form, its organization creating a difference, its relative stability even though it is crossed by flux.

This open system (it is fed by the flux) is integrally active: not only are all its elements in movement, but also its stationary state is assured by the organizing activity of the swirling movement which unceasingly makes the molecules circulate from entry to exit; without the action of flux and action on flux, it would disintegrate immediately.

Certainly, form, organization, praxis are quasi-undifferentiated in the swirl. But we are definitely talking about a producing being, a wild motor. Not only is it "working" to deepen a little more the bed of the river of which it is a part (and which itself is a part of a mechanical process), it also produces the same movement which characterizes the principal race of motors, rotary movement. And the movement of this wild motor is not purely and simply devoted to dispersion; it is part of a global process of production which is the production of the swirl by this motor movement, and the production of the motor movement by the swirl. The swirl is, in this sense, not only produced by the encounter between a flux and an obstacle, but a *phenomenon of production-of-self* (I explain further on why I say production-of-self here and not

self-production). Aeolian whirlwinds, which are so ephemeral that one hesitates to label them systems, since one of the characters of a system is its relative permanence, fully have on the other hand, during their brief existence, the characters of a wild motor, whose wildness precisely unleashes the uprootings, upheavals, grindings, tumblings, crumbling which tornadoes, hurricanes, and other cyclones produce on their passage.

It is precisely these wild motors—whirlwinds and swirls—whose domestic race man has created in the mill, propeller, and turbine. The first anthropo-social motor machines were the mills: the windmill (which transforms an aerial flux into a whirlwind), then the watermill (which transforms an aquatic flux into a swirl); much later on, in the same energy line but having henceforth enormous technological powers, came the rightly named turbines, which transmit movement by means of a tree. And thus domesticated and harnessed, the whirlwind/swirl became fully a motor.

Let us come to the most archaic and troubling wild motor: fire. If, to constitute the sun-machine, gravitational, electromagnetic, and thermonuclear interactions became *Metis*, fire became the motor of this *Metis*. This fire is regulated by the very regulation of the star, which keeps the motor from exploding. The flames which on earth rise up into a blaze are temperamental and unstable; overnourished, they break out into generalized burning, explosion, and finally, of course, extinction; or else, deprived of nourishment, they die out immediately. But we can consider here as example the domesticated flame of the candle. If we focus on the flame and consider the wax as its energy reserve and the wick as a principle of order, then the flame strikes us as a system, as active organization; this system is differentiated into regions diversely hot and colored; as in the swirl, the energy flux is transformed, and this transformation becomes organizational; as in the swirl, the combustion activity not only dissipates energy into smoke, it assures both the stationary state and the original form of the flame. Now, this flame is, like the swirl, a naked, wild motor, which can be immediately used to grill, cook, boil. Even before the domestication of water and of wind, even before historical society, even before *homo sapiens*, the hominid knew how to tame and then domesticate fire, regulating it by the supply of combustibles, knew how to heat, to grill. Then, man the blacksmith appeared, where the couple man/fire constitutes a machine which transforms and produces. With sedentary society, *homo sapiens* really domesticated fire, fixing it in homes; but he also used its senseless violence to burn and destroy other homes. It is only in the 19th century that he finally succeeded in putting it in a straight jacket—the fire machine—and that he started, henceforth with awesome efficiency, to enslave and exploit its force for work.

Thus, we see turbulences and encounters, convections of air, water, fire emerge, still most often placental, unfinished, Ouranian, fantasmatic, most of them ephemeral and uncertain, all of them labile and fragile. They can be stabilized only around or starting from a solid acting as a nuclear "invariant." But once existing, even though they have very little being, they are incontestably not only systems but naked, wild motors. We are so used to considering casings and cylinders as motors, not what operates inside, that we forget that the motor is what "turbines" inside. And what is inside first existed in a wild state...

Living Polymachines

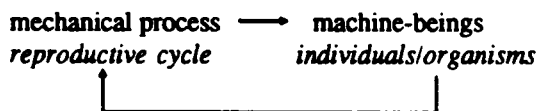
The idea of a living machine is not new. The theory of animal-machines was formulated by Descartes, and the materialism of a LaMettrie generalized it to man. But this idea of machine was mechanical and clockwork. Today we must conceive the machine, not as a mechanism, but as praxis, production, and *poiesis*. In this sense living beings are auto-poietic existents (Maturana, Varela, 1972), *formulation where life is not reduced to the idea of machine but includes the idea of machine, in its strongest and richest sense: organization simultaneously productive, reproductive, self-reproductive.*

Thus, we can conceive the living being, from the unicellular to animal and man, both as thermal motor and chemical machine, producing all the materials, all the complexes, all the organs, all the devices, all the performances, all the emergences of this multiple quality called life.

The idea of cybernetic machine slipped into the track of molecular biology and became in fact the armature of the new conception of life. Molecular biology took over the organizational model of the cybernetic machine to inscribe the chemical processes which it was bringing to light. Certainly it manipulated the cybernetic notions as tools in order to envisage molecules, and not molecules as materials to envisage organization. The idea of machine was in its eyes nothing but the lining of the new molecular dress of life. In fact, it had become the pattern of life. The integration of cybernetics in biology constituted an integration of biology in cybernetics. The living being thenceforth could be, and was, conceived as the most complete of cybernetic machines and even the most complete of automatons (von Neumann, 1966), outstripping in complexity, perfection and efficiency, already in the least bacteria, the most modern of automated factories. (de Rosnay, 1966)

Much more: we must conceive life as a polymechanical complex. This generally remains unperceived because we disjoint an organismic conception of life from a genético-reproductive conception. At one time, we put the organism in high focus, and it hides the cycle of reproductions, while the

organism fades and disappears. Now life is a complex combination of a cyclic mechanical process (the genetic cycle of reproduction), starting from which machine-beings are produced, individual organisms, themselves necessary to the continuation of the mechanical cycle without which there would be no individuals. *Life is, therefore, a polymechanical process which produces machine-beings, which maintain this process by self-reproduction,*



We see immediately that life accomplishes and expands fully the idea of machine (while at the same time going beyond it existentially and outstripping it biologically). The artifact thenceforth no longer appears as the model of a living machine, but as a degraded and insufficient variety of machine.

The Social Megamachine

Animal societies can be considered, not only as multi-machines (constituted of machine-individuals), but as wild macro-machines: spontaneous interactions between individuals are knotted in regulatory retroactions, and on this basis society constitutes a homeostatic whole which organizes its own higher life. Certain societies of insects (termites, ants, bees) attain a degree of unheard-of mechanical organization and appear to us as formidable *automatons*. (Chauvin, 1974)

But it is in primate evolution that two key mutations take place, with *homo sapiens*, in the mechanical development of societies. The first characterizes archaic societies. Culture appears. Generative memory, depository of the rules of social organization, culture is a reproductive source of facts [Fr. *savoirs*], of *savoir-faire*, of programs of behavior; and conceptual language allows a communication in principle unlimited between individual members of the same society.

Now language, and this has remained unnoticed because it is invisible and apparently immaterial, is a real machine which evidently functions only when there is a speaker. It is not by chance that I called on the conceptual couple competence/performance of Chomskyan linguistics in order to characterize a mechanical praxic organization. Effectively, the language machine produces words, statements, meaning, which themselves lock into the anthro-social praxis, possibly causing actions and performances therein. This language machine joins these two productive qualities: the quasi-unlimited creation (*poiesis*) of statements and the quasi-unlimited transmission/reproduction of

messages. It is a machine both repetitive and poietic. Therefore, we can say that *the great revolution of hominization is not only culture; it is the constitution of this language-machine*, with a very highly complex organization (the "double articulation" phonetics/semantics), and which, on the inside of the anthropo-social machine, totally and manifoldly engaged in all its processes of communication/organization, is necessary to its existence as well as to its development. Thus, an anthropo-social arkhe-machine is constituted which includes several hundred individuals; it swarms henceforth over the whole earth, which it will cover for tens of thousands of years, and it will die only when destroyed by historical societies.

The birth of these historical societies, of thousands, of hundreds of thousands, of millions of individuals constitutes an organizational metamorphosis as considerable in its order as was the constitution of polycellular organisms in respect to unicellular ones. We know that this transformation, tied to agriculture and war, is marked by the development of the language machine which from talking becomes also writing, by the appearance of the State apparatus, the city, the division of Labor, of hierarchized social classes with the elite of power (kings) and of knowledge (priests) at the top, and at the bottom the mass of slaves reduced to the state of animated tools, that is to say of enslaved machines. We needed the brilliant intuition of Lewis Mumford to perceive in the most accomplished of these historical societies a formidable *megamachine*. (Mumford, 1973) "Pharaonic social organization (is) the first large-scale motor-machine." (Mumford, I, p.261) Mumford even calculates that the total output of this machine, ranging from 25,000 to 100,000 "man-power" is equivalent to that of 2500 horse-power. "This unique act of royalty was to assemble the workforce and discipline the organization which allowed the realization of work on a scale never known before." (*Ibid.*) For Mumford, the invention of this machine constitutes not only the arkhe-type of all the social megamachines which have been constituted up to this day, but also "the most ancient model still functioning of all the complex machines which came afterwards, even though the accent passed slowly from workers to mechanical parts." (Mumford, I, 1973, p.251)

Under the rule of its apparatuses (State administration, religion, army) the megamachine manipulates enormous masses of humanity enslaved as workforce; it executes urban or hydraulic works, erects large walls and high fortresses. But everything is not utilitarian or defensive in its productive wave crashing ahead. Be they the unbridled dreams of the sovereign for power, glory, and immortality, or be it the *hubris* of Leviathan, the megamachine transforms its imaginings into giant columns and statues, materializes its deliria, generates fabulous monuments, overwhelming temples, grand pyramids!...

In the Western nineteenth century, an interesting metamorphosis occurs at the heart of social megamachines: they become industrial, creating and developing artificial machines of prosthesis, first in several sectors then in the entire social fabric. (Giedion, 1948) The artifact machine takes off. It is, then, a late production, an integrated and integrating part of the social megamachine; it can no longer be considered as the matrix machine, the ideal model of all machines.

Artificial Machines

We can now place the artificial machine in context: it is the last-born of earthly machines; it is born from the development of the anthropo-social machine, and it constitutes one of the aspects of this development.

Yet, it is indeed by and in organizational autonomy and energy generativity that artificial machines are properly machines, that is to say are distinguished from tools and instruments, which are purely appendages. The development of energy generativity is the development of motors. The development of organizational autonomy is the development of automation, and automatons have their motor.

In a first stage, historical societies exploited the capacity for work and the productive abilities of live motor-machines (yoking of animals for portage and haulage) and of humans (enslavement, then subjection of the workers). This is not the place to try to understand how and why strictly physical motors have been conceived, invented, utilized, developed in the history of the West, from the thirteenth century until today. (Needham, 1969) I only want to situate artificial machines in reference to other machines.

First of all, motors. The invention of the mill is capital: windmills and waterfalls produce swirls whose energy will be captured by wheel and transmitted by tree. Then, as we know, motors were plugged into every source of physical generativity by playing, no longer only with swirls, but with turbulences and explosions. A bond altogether new is created then between humanity and physical nature.

In fact, under the guise of capturing and utilizing energy, the anthropo-social machine was plugged into the genesic and poietic forces of *physis*, that is to say into its primordial motor forms. It captured, utilized, tamed, domesticated, enslaved, reproduced, produced them at will, and it tremendously developed the control and manipulation of power.

In one sense, the artificial motor serves as mediator between the social megamachine and the machining forces of *physis*. In another sense, it is a question of an extraordinary *civilization* of motor forces which, in their "wild" state, are inconsistent, whimsical, labile, ravaging. But the other face

of this civilization is barbarity and enslavement. Barbarity, because mad violence proper to human history (Morin, 1973), already manipulator of explosive power to massacre and terrorize, is henceforth able to unleash the mad violence of solar protuberances and stellar explosions.

Whereas motors play with fire, automated machines play with life. Starting with mechanisms and clockwork devices (13th century), there developed an automation of operations more and more precise, delicate, and diversified, constituting chains looping on themselves reiteratively; thus, we arrived at the automatons of the 18th century, which imitate in an amazing way the gestures of animal and human behavior. This clockwork automation developed into industrial mechanisms, until a new state of complexity appears in machine automation: the cybernetic stage. Henceforth, a command, until then external, becomes internal (program) and organizing (computer as "ordinator"), and the cybernetic automaton starts to resemble life, no longer in appearance, like the clockwork automaton, but by the organization of behavior.

Thus, as artificial machines developed their productive competences, they also developed their organizational competence, and necessarily their autonomy. Although they are the least autonomous of all the machine families, they possess a minimal phenomenal autonomy, necessary for the precision of operations and performances, and for doubly resisting external risks and determinisms on the one hand, internal degradations and wear on the other.

Nevertheless, however developed it is, the artificial machine seems, in respect to living machines, both a rough sketch and a rough copy. Although artifacts today surpass living machines in performance and in computation, although there exist as of now computers which effect superhuman intellectual operations, the most perfected and the most advanced of artificial machines is incapable of regenerating, repairing, reproducing, or organizing itself, elementary qualities which the least bacteria possess. Its parts are supplied from the outside, its construction was carried on from the outside, it was given its program from the outside, its control is controlled from the outside. Thus constructed, supplied, repaired, maintained, programmed, controlled by man, it does not itself possess the least *generativity*. It does not itself possess the least *poiesis*, the least creativity. This is why even today the term "machine," conceived in opposition to the term "life," signifies roughness and rigidity of organization and behavior. The artifact machine remains in effect a poor machine, insufficient in respect to living machines and social megamachines, on which it depends directly and closely.

Thus, considered in themselves, artificial machines could certainly develop energy generativity, informational competence, organizational autonomy. But they could not develop *organizational generativity*. They have been able really to develop only phenomenal organization, which produces products, *but not*

generative organization, which produces its means of production, and produces itself.

This certainly signifies that our intelligence, so capable in the organization of power, of manipulation, of enslavement, is incapable of creating what creates, of generating what generates, of conceiving what conceives. And here we have the whole problem of my second volume which springs up at the turn of this sentence. This also signifies, and it is the subject at hand, that our artificial machines must not be considered *real* machines, but as fragments of prosthesis in the social megamachine. Their generativity, for sure, is in the machinist society!

It was certainly legitimate to consider the artificial machine isolatedly as a physical being which organizes. As such the artificial machine is already a machine. But it lacks the generative infrastructure which all other machines possess. With regard to this generativity, the artificial machine is no longer a machine—that is to say active, productive, praxic organization—but instrument and appendix in the anthropo-social being. Therefore, cybernetics, in revealing the physical being of a machine, has totally hidden not only the social megamachine of which it is only one moment and one element, but also the key problem of organizational *generativity*, proper to all physical, biological, and social machines, except artificial machines.

Of course, the generative deficiencies of the artificial machine, considered isolatedly, no longer cause a problem if we think of its anthropo-social insertion. Thus, it cannot regenerate, generate, repair, reproduce itself, but it is regenerated, repaired, renewed, changed, reproduced in mills, factories, workshops... It can only increase its entropy as soon as it is born, and it increases it each time it functions, but anthropo-social negentropy repairs it, restores it, and re-establishes stationary entropy. In addition, by producing objects more complex and organized than the raw materials it receives, it contributes to the production of social negentropy, and, although it is only fabricative, when it produces objects from a new model, the poietic sap which irrigates society imbues its being and expresses itself in its productions.

Thus, we must conceive of the artificial machine as bastard and mongrel. It is in a sense the last-born, the poorest, the most organizationally infirm of machines. But, as a fragment of the megamachine which produces and reproduces it, makes it evolve and increases its competence, its productive and performing power, it develops the praxis of the anthropo-social megamachine. But let us not see only the rich and complex aspects of these developments; we must also see that, while reflecting, expressing, and prolonging social creativity, artificial machines, in their poverty and rigidity, reflect, express, and prolong the organizational poverty and rigidity of the societies which produce them: those that govern their industrial organization by division/specialization/

enslavement of work. It is the enslaving organization of the first historical megamachines which prolonged and developed on, in and by the organization of the physical being which is the artificial machine. Let us wait only two chapters: we will then begin to consider it head-on.

We can now consider, therefore, the artificial machine in a multidimensional way in its relation not only to the social megamachine considered en block, but also in respect to the great social apparatuses, to the motor forms and forces of *physis*, to the organizing forms and forces of life.

It is, then, by a disturbing aberration that this fundamentally dependent machine, enslaved and enslaving, totally deprived of its own generativity and *poiesis*, has been promoted by cybernetics as the Archetype of all machines.

But let us not forget: the artificial machine has allowed us to disengage the concept of machine. Conceived thenceforth as launching pad, and not as reductive model, it made us discover the immense and prodigious universe of sun-machines, wild motors, living machines, and even of the anthropo-social megamachine that generated it. In the course of this trip, the concept of machine was transformed, developed, complexified, enriched; and returning to its starting point, it retroacts on the artificial machine itself. In fact, physical, biological, anthropo-social machines have become necessary for us to conceive the artificial machine, both in its poverty and in its multidimensionality, not only rooted in society, but plugging social praxis into physical motricity and organization.

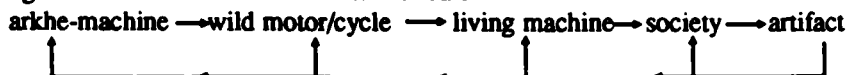
III. The Generic Concept of Machine

1. A Physical Concept and a Generic Model

There are physical machines, biological machines, social machines, but the concept of machine is fundamentally physical. The proof is that at both ends of the chain of machines, at the beginning (arkhe-machines, wild motors) and at the end (artificial machines), machines are purely physical. There is certainly an irreducible originality proper to biological and social machines, but this originality is the fruit of the biological and social developments of the physical principle of active organization, itself founded on the immanent organizational potentiality proper to *physis*. My insistence on registering physically the concept of machine does not at all tend, the reader must begin to know it, to reduce what is biological and anthropological to the physical; it tends, on the contrary, to *rehabilitate the degraded concept of physics*; it tends to understand how what is biological, human, social can and must be, at the same time, necessarily physical. *And that not only because everything biological, human, social is constituted of physical "matter."* But especially because all

that is biological, human, social, is active organization, namely a machine.

This concept of machine, one of the most physical which can be conceived, is at the same time a complex intellectual construction. It is not enough to say that, like every concept in general, like every organizational concept in particular, the machine is a concept with two entrances, physical and intellectual. We saw that to generate this generic concept starting from the more immediate and empirical idea of active organization, we had to proceed to conceptual elaborations, to analogical, homological, archaeological reasoning. We had to effect an intellectual circuit:



The generic concept of machine is thus an ideal type constructed by the general mobilization of troops from all fronts of knowledge [Fr. *savoir*]. The observer/conceiver must, in making this construction, face crucial problems. He must necessarily question his conception of society and his conception of science. He must, finally and especially, profoundly expose and question himself, if he wishes to generate a rich and complex concept which can be applied to dissimilar entities and existents without annulling these differences, which can respect the extraordinary diversity of the universe of machines; if he wishes no confusion between the sun, the automatic punching machine, the living organism; if he wishes to avoid, in short, physical reductionism, formalistic homogenization, mutilating extrapolation.

2. The Copernican Reversal

Henceforth, for us, the concept of machine is a generic concept which allows us to conceive the diverse types or classes of active organization whose extreme diversity we have seen, from purely physical machines (arkhe-machines, wild machines, artifact machines) to biological and social machines, from spontaneous machines to programmed machines, from poietic machines to copying machines, from existential machine-beings to purely functional machines.

Given this, the artifact machine appears to us as a poor concept, not only in respect to living machines but also in respect to arkhe-machines. It was needed for the gestation of the concept of machine, but it was insufficient for its generation. It is a version, not matrix but appendicital, of machine. It is even a sub-machine in the sense that it is a prosthesis in the social megamachine.

Whence the necessary Copernican revolution in the idea of machine. Today still, the cybernetic universe turns around the artifact machine. As

Ptolemy's geocentrism allowed us to conceive the rotation of the planets, but on the basis of a false perspective making the satellite Earth the royal planet, in the same way cyberneticism, which makes the artifact its solar notion, allows us to understand certain characteristics proper to machines, but in doing so it imposes a narrowing of the vision, an inversion of perspective, and a hiding of the richness of the universe considered. In fact, the application of the model of the artificial cybernetic machine to the living being causes more mutilation and impoverishment than heuristic strength. This strength can only be momentary. *Technocratic simplification and denaturing constitute the durable effect of such a reductionist extrapolation.*

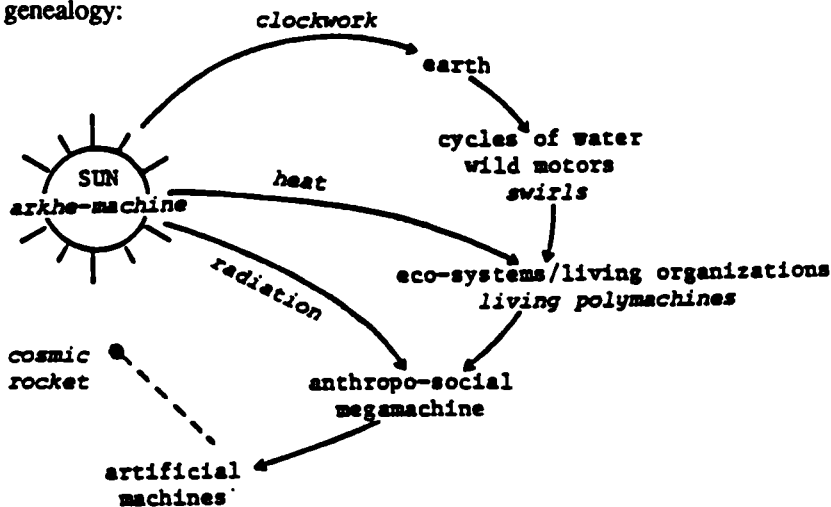
We must, therefore, effect a gravitational reversal of the concept of machine. We must put the arkhe-machine in its solar place: we must put the sun in its place as Sun. Then, we can no longer conceive of the living being in the robotic image of a cybernetic machine which obeys its "program." We must rethink the idea of *living machine*.

3. The genealogy of machines

We can attempt to work out the generic concept of machine. Generic signifies:

a) which allows us to establish a genealogy, that is to say an evolutionary logic in the universe of machines;

b) which allows us to define the common genus whose transformations, developments, derivations produce the diversity of types. Let us recapitulate the genealogy:



Thus, for the abstract and reductionist genealogy:

cybernetic artifact —→ living machine —→ society...

which furthermore tends to ignore the arkhe-machine, the wild motor, the machine cycle, I substitute the logical and evolutionary genealogy:

arkhe-machine → wild motor → living machine → human society → artifact

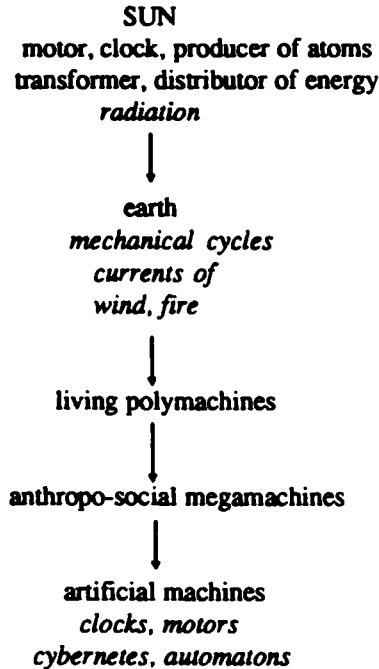
4. *The Great Machin Family*

Our solar system contains, around the arkhe-machine, a very diverse people of mechanical cycles, wild motors, and, on the satellite Earth, living polymachines, anthropo-social machines, artificial machines. Now this diverse and dispersed people constitutes in fact a large family, not only by the genealogical bond, but also by the interactions, interdependences, and articulations between all these machines around the *Pater familias*.

The Sun made us. It is in its furnace that hydrogen, carbon, nitrogen, oxygen were created, minerals of which we are fashioned and nourished. It has no finality, but it does not stop producing *for us* photonic rays, source of all life. This finality, created retroactively by the life it has created, becomes by that very fact a byproduct of its activity.

Our Earth, spit up, vomited in one of its hiccups, is a peripheral piece of the great clock whose center is the sun. There, the thermodynamic relation hot source-sun/cold source-earth opens up the possibility of work, transformations, productions. Thenceforth its radiation and the clockwork rotation it commands gave birth to and maintain mechanical cycles and wild motors. It is in these open mechanical cycles, themselves inscribed around the sun in the cycle of the "round machine,"⁷ that have been formed, coiled, encycled living beings, humid and lukewarm machines, which self-produce, reproduce, multiply, diversify to all points of the compass as vegetals and animals, beings whose interactions weave ecosystemic polymachines, themselves constituting together the megamachine of life or the biosphere. At the same time and in interrelation appear collective mechanical processes which are going to develop into numerous animal species in social machines. Finally, a few thousand years ago, formidable anthropo-social megamachines became dominant. From recent developments of these megamachines, and in their womb, artificial machines are born, each having a little something which takes after ancestors of the family: mills and turbines (following the model of wild motors), clocks (following the model of the astral clock), automats (following the model of

animal behaviors).



Behold then the maternity/paternity of Meis/Zeus. Our Hermaphroditic progenitor has generated and generates unceasingly all physical, chemical, thermodynamic, organizational conditions, all the materials, all the energies, all the processes necessary to the formation, perpetuation, replacement, development of zoological, anthropological, sociological life. It is, therefore, starting from him, under his sovereignty and under his manna, that are born all the active organizations of the planet Earth, including humans. We all belong to the Machin family, intermingled, intertwined, intercombined, dovetailed, intertransforming, symbiotic, parasitical, antagonistic, in a process which simultaneously self-produces, self-devours, self-recommences. We are children of the sun, and, to speak like Paule Salomon, we are, somewhat sometimes, infant suns!

Thus, the idea of family imposes itself, not only by its genealogical character, but also by the imbrications and intrications between members of the family under the dependence of the sun. And this dependence cascades, is a

chain dependence: artificial machines depend ontologically and functionally on the anthropo-social megamachine, which, weaved continuously by the interactions between human machines, depends on these latter, which depend on the animals and vegetals on which they feed, on oxygen produced by plants; plants and animals depend on the eco-machines of which they are constituent parts, and these eco-machines depend on geo-atmospheric cycles, on photonic radiation, that is to say, still, always, on the sun. We could almost consider that all these machines tied together constitute a fabulous polymachine whose center is the sun, whose pseudopods stretch to the earth, and through the mechanical processes of the atmosphere and the productive organization of the biosphere are prolonged in society and in the artifact itself, which is also, in its own way, bastard child of Metis.

5. *The Machine People*

Just as we must conceive the unity of the Machin family as well as the polymachine whole, so must we conceive the irreducible diversity of different machine types and the autonomy, certainly always relative but also always real, of each machine.

ON ONE SIDE	ON THE OTHER
spontaneity (in assemblage, regulation, organization).	preconception of the elements, the constitution, the organization of the machine
exists and functions with and in disorder	can neither exist nor function with disorder
the production of outside products is a by-product	the production of outside products is the primary finality
production-of-self (generativity)	no production-of-self
<i>poesis</i>	manufacturing
create	copy

The machine is relatively autonomous. Machines are also beings and existents. Therefore, let us not drown these beings in the great totality: let us integrate them, in a complex way, with their autonomy as well as their interdependence. There is, therefore, a people of machines. Just as there is a people of living things, issued from the same original trunk; just as there is a human people, issued from the same stump, *homo sapiens*. But even more, this people is diverse, and the unity of the concept of machine must absolutely respect this diversity; better still, it must be enriched by it.

This diversity is developed between two extreme polarities, both constituted by purely physical machines, but between there is life, man, society: the pole of *arkhe*-machines and wild motors on the one hand, the pole of artificial machines on the other.

6. *The Polycentric Concept*

We could fix the concept of machine on only one of the poles, that is to say either on manufacturing or on *poiesis*, on the artifact or on the *arkhe*-machine, and the consequences would be decisive for our conception, not only of the machine as machine, but of life and society.

If the artifact is the pole of reference or model, the machine will be defined by the maximum specialization of its components, regulation, functionality, strict finality, economy, rigid control, the external or internal program, the production of copies or the reproduction of objects or performances according to a preset model. These aspects return to what in biological or social organization is founded on the division and specialization of work, regulation, functionality, etc., excluding and hiding all that is "noise," disorder, "liberties," afunctional, excluding finally and especially every aspect of creativity.

If on the contrary the *arkhe*-machine, that is to say a people of billions upon billions of stars, becomes pole of reference and model, then we can conceive of machines without specializations, without programs, with spontaneous regulations born of antagonistic processes, having formidable risks in their existence, unheard-of disorder and expense in their production (we have seen this for the carbon atom), an apparently total absence of finality, and at the same time poietic and generative power. Thenceforth, this model returns to what there can be of order, chance, creativity in living and social machines.

The concept of machine does not oscillate only between these two extreme poles. The organization of the living machine and the organization of the anthropo-social machine constitute other necessary poles of reference. Which

means, of course, that the problem of living organization cannot be resolved, either by the solar model or by the model of the artificial machine, even though both can throw some light on it. Therefore, we must highlight the original character of living organization, where to create and to copy, the two antipodes of the conception of production, are intimately linked to biological reproduction, where disorder is intimately linked to organizational order, where there are simultaneously preconception and spontaneity. Finally, there is the original problem, non-reducible, of the anthropo-social machine, but which necessitates a preliminary theory of machine. This is for us today the critical, decisive problem. But to understand it, we cannot skimp and skip the grand tour of the world. And conversely, *the trip into the physical and biological universe of machines cannot skimp and skip the anthropo-social problematic.* It is thus that the *necessarily polycentric concept of machine* is woven, by shuttles, exchanges, development.

7. To Isolate and to Link. Machines and Machines of Machines (Polymachines). The Problem of the Conceiver.

The problem of the observer/conceiver—must we already say, of the subject?—appears to us here and now as capital, critical, decisive. He must know both how to isolate the machine-beings and how to link them to one or more sets (polymachines), to one or more totalities (like the totality of the solar system of which all the diverse machines active therein are like members of a family). We must isolate being and existence, singular, particular, individual, so as not to drown them in a soup machine. We must link, in order not to hide the retroactivity of the totalities and the extreme complexity of the polymachines. It is necessary to have autonomism, not atomism: complex totalism, not totalitarianism. This applies at all levels, even the lowest. Let us take the swirl: we must isolate it in its own existence and organization, but we must also situate it in the river, of which it is part, which is itself a part of a wild machine cycle. We can isolate the flame of a candle, a very beautiful small motor, wild in its nudity, civilized in its regularity: this wild motor exists only in terms of the civilized candle, and the set flame/candle constitutes a small polysystem; whereas individually the flame is an open system as energy and the candle a closed system, together they constitute something else, multiple and ambiguous, where the candle can appear as the energy reserve of the flame system, where the flame can be conceived as the process of disintegration of the candle system, where the candle can be conceived as a small machine to produce light which is part of the anthropo-social megamachine. In the same way, the artificial machine can and must be isolated

as an autonomous physical being, but also tied and integrated as moment and element of an anthropo-social organization. Now, in each of these examples, we see that *the description of the machine changes, and sometimes radically, depending on whether we change the point of view.*

Whence the problem of the observer/describer/conceiver: he must have a method which allows him to conceive the multiplicity of points of view, then pass from one point of view to the next; he must have theoretical concepts which, instead of closing and isolating entities (physical, biological, sociological), allow them to circulate productively. He must conceive at the same time the individuality of machine beings, Machines of machines which encompass them, and the complexes of interdependent machines or polymachines which associate them. In fact, the developments of praxic complexity are polymechanical. Thus the polymechanical relation which constitutes the notion of man: individual (machine-being); species (machine cycle); eco-system (macro-polymachine); society (megamachine). The idea of polymachine is therefore necessary; it respects the complexity of reality and develops the complexity of thought.

The observer must not only practice a method which allows him to pass from one point of view to the next and conceive the polymachine; he also needs a method to accede to the meta-point of view on the diverse points of view, including his own point of view as subject inscribed and rooted in a society. The conceiver is in a paradoxical situation: he is bound to a machinist society where the concept of machine which imprisons him is nonetheless necessary to the blooming of the complex concept of machine. But for such a blossoming, the observer/conceiver must be engaged in a problematic where his vision of the world of machines simultaneously questions his vision of the world, the vision he has of society, the vision which comes to him from society.

We already glimpse here that the richness, the complexity, and the pertinence of our conception of machine are in reciprocal interdependence with the richness, the complexity, the pertinence of our conception of life, of society, and that these interdependent conceptions depend also on conceptions which orientate our knowledge and dominate our society. Therefore, the observer/conceiver must reflect on himself and think that sooner or later he will have to envisage an epistemological circuit, from the sun to the society of which he is a part, and which will imbue and quarter him.

Meanwhile we can form a polycentric concept of machine, simultaneously physical, socialized, and open. It calls for no reduction to the artifact machine, no reduction of any kind, and it will perhaps be able, at its level, to make physics, biology, anthropo-sociology communicate. It is no longer the concept

born of 17th and 18th century mechanistic thought, nor is it that of Wienerian cybernetics. It is a regraded concept, no longer degrading the being or the existent to which it is applied. It revolutionizes the previous notion of machine. This new concept, instead of hiding the great problems and mysteries, poses them necessarily:

—How can machine-beings be born of the disorder of interactions and encounters?

—How can there exist machine-beings self-organizing by themselves, self-producing and self-reproducing by themselves?

—What is the being of a machine and the machine of a being?

8. *The Hidden Side of Machines: Production-of-self (Poiesis and Generativity)*

Artificial machines, conceived in isolation, conceal a key problem: that of *poiesis* (they are only fabricators), that of generativity (they are incapable of generating and regenerating themselves). However, as I have already said, they are deprived neither of *poiesis* nor of generativity, but these come from the outside, from the anthropo-social organization. Now, all the machines (physical, biological, social) which we have seen, with the exception of artificial machines, are endowed with internal generative and regenerative virtues: they are producers-of-self, organizers-of-self, reorganizers-of-self, their *poiesis* is identified in the first place with the permanent production of their own being. Even the swirl, this naked and wild motor, produces continuously, reorganizes continuously its own being. The star, at the same time as it produces atoms and radiation, produces and reorganizes continuously its own being by continuous retroaction of the whole on the contrary actions which constitute this whole. The living being, by decomposing molecules (organic matter on which it feeds) as well as by manufacturing molecules (by chemical combinations and syntheses) produces its movements, its performances, its components, their organization; and all these productions are conjugated in the continuous production of its own being, including the organization which produces these productions.

Therefore, what we must question now is this level of generativity and *poiesis* hidden in the artificial concept of machine. It is the whole problem of organizational infrastructure, of the immersed and obscure part in every theory of active organization, in every theory of machine. And we are led thereby to raise a notion unknown in the artificial machine: it has being, it does not have a self. The self is born in the continuous production and organization of its own being. Thus, we see a new conceptual constellation rise from the depths with the notion of *poiesis*, generativity, retroactive loop, production-of-self, self.

2. The Production-of-Self

(loop and opening)

The machine-being has an immersed activity, invisible because non-existent in the artificial machine. It is there that the production-of-self and the reorganization-of-self are effected.

To have access to the intelligibility of the profound praxis, proper to every active natural organization, the ideas of loop and of opening are fundamental and inseparable.

The idea of retroactive loop has emerged in and by Wienerian cybernetics (corrective feed-back loop). The notion is born in and for the organization of complex performances (coupling of a computer and of a radar to guide the course of an anti-aircraft device in function of the modifications of the path of the target). The idea took on broad scope with the development of automatic regulations, in which devices of negative retroaction cancel out deviances in relation to the norms assigned to machines. But the development of the idea of regulation and of the idea of correction of deviance have almost smothered the very idea of loop.

Since the artificial machine does not generate itself, the retroactive loop was not conceived, by cybernetic thought, as a fundamental, generative idea: it is, thus, an idea to regenerate, to generalize, to fundamentalize.

The idea of opening emerges at the organizational level with the Bertalanffyian notion of open system. It links the thermodynamic problematic to the organizationist problematic. But this theory, so necessary to conceive the ecology of every praxic phenomenon, has not been sufficiently opened nor sufficiently organizationist, and it has hidden the key problem of reclosing.

Finally, these two notions have not been linked, though they constitute two sides of the same phenomenon.

Therefore, it is necessary here to set forth, implant, develop these notions of (retroactive) loop and of (organizational) opening, and to couple them at the heart of active organization.

I. The Loop: From Genesic Form to Generative Form. Recursive Organization and Permanent Reorganization

In my end is my beginning
T.S. Eliot

A. The Loop: From Retroaction to Recursion

1. *From Vortex to Loop*

We have seen that rotative form is constitutive of wild motors (vortices, eddies).

This form is born of the encounter of two antagonistic fluxes which, interacting one on the other, are intercombined in a loop retroacting as whole on each moment and element of the process. This loop constitutes thus the *genesic* form of the eddy or vortex.¹

This genesic form is at the same time the typical and constant form, that is to say *generic* form, of vortices and eddies.

This generic form is organizational: it organizes the centripetal and centrifugal movement of the flux; it organizes its entry, its circulation, its transformation, its exit. Endlessly rotative movement traps the flux, sucks it in, detours it, wheels it in circles, differentiates it, heterogenizes it, gives it a spiral form, then expels it. This form, which generates the (genesic) eddy, gives it its (generic) genus, at every instant generates the organization which regenerates the vortex. This form is, therefore, thus not only *genesic*, *generic*, but also *generative*. And furthermore, since it is a matter of wild motors, it is *generator* of kinetic energies (which man will know how to domesticate and harness).

The vortex is a loop, not only because its form recloses on itself, but because this looping form is retroactive, that is to say constitutes the retroaction of the whole on the particular moments and elements whence it came. The circuit retroacts on the circuit, renews its force and form, by acting on the elements/events which otherwise would immediately become particular and divergent. The whole retroacts on the whole and on the parts, which in their turn retroact by reinforcing the whole. If the flux and external conditions of formation of the eddy do not vary beyond certain thresholds of tolerance, the eddy can last long thus, almost indefinitely.

The genesic form of galaxies and stars is reflected in the transformation of turbulences into vortices. The whirling form, which is constituted under the effect of gravitational interactions, is animated by a centripetal movement and is concentrated in a core more and more dense and hot, until ignition. At that

moment, the centripetal movement of the genesic vortex and the centrifugal movement sprung from the thermonuclear fusion cancel each other out and recombine in a retroactive loop which is identified with the spherical form of the star. Certainly something remains—in any case in our sun—of whirling forms, notably in the differential rotation of superficial layers which slide on each other in regard to the central core, and the periphery of the original vortex is prolonged, transformed, and arranged in the rotation of planets around the central heavenly body.

The retroactive loop of the star, like that of the eddy, is simultaneously genesic, generic, generative, that is to say it assures the birth, specificity, existence, autonomy of the star. As in the eddy, but in a much more remarkable way because the sun-star is an organized being of extraordinary complexity,² seat of innumerable interactions of all orders and of multiple productive and motor activities, the loop, born spontaneously of the union becoming complementary of two antagonistic movements, assures negative retroaction and regulation without any informational device. The loop is not born of a negative retroaction or regulation. It is the negative retroaction and regulation. At the beginning and at the base of the solar being there is the loop, that is to say the retroactive whole, producer and organizer-of-self.

The loop can be confused, under its wild or archaic species, with a whirling, circular, spherical form. But the *idea* of loop is not a morpous idea; it is an idea of circulation, circuit, rotation, *retroactive processes which assure the existence and the constancy of the form.*

2. The Key-loop: Retroaction and Recursion

The retroactive loop is not a form, but it remains linked to rotative forms, that is to say it always comprises circuits and/or cycles.

It is a key process of active organization, simultaneously genesic, generic, and generative (of existence, organization, autonomy, motor energy). Retroactive looping, in the aforementioned examples, is a physical process (eddies, vortices), a physico-chemical process (stars), but not an informational process. Among living beings, physico-chemical looping is effected by the circulation of information. Besides, it is under its communicational form, with the first cybernetic device, that the retroactive loop emerged in our consciousness. But this emergence, instead of extracting the idea of generative loop out of the shadows, immersed it on the contrary still more deeply.

In fact, the idea of loop finds itself thus brought back to the informational idea: it is a device for the elimination of deviance by correction of error; actually, in the cybernetic artifacts, the only loop is informational. Now, this

vision hides the primordial character of the loop and breaks whatever totalizing and integrative activity it has. It is, therefore, superficial and atomizing. Consequently, we must deepen and de-atomize the idea of loop; this necessitates, once again, an inversion of perspective: the loop does not proceed from an entity called "information;" the loop precedes information genealogically. We must introduce information into the loop, and not reduce the loop to information.

Let us recapitulate the organizational characters of the retroactive loop. To say that it is *genetic* is to say that it transforms turbulent, disorganized, dispersed, or antagonistic processes into active organization. *It effects the passage from the thermodynamics of disorder to the dynamics of organization.* Interactions become retroactive; divergent or antagonistic sequences give birth to a new, active being which will continue its experience in and by the looping. The retroactive loop makes irreversible processes circular, while not ceasing to be irreversible; they take on organizational form. Thereby, it transforms the disparate into the concentric. Thus, the loop becomes permanently generative, binding and associating into organization what otherwise would be divergent and dispersive.

At this level, the idea of retroactive loop is confused with the idea of active totality, since it articulates uninterruptedly into a *whole* elements/events which, left to themselves, would disintegrate this whole. Thus, active totality signifies the immanence and the superdetermination of the total process in and on each individual process. The looping is by that very fact the constitution, permanently renewed, of a systemic totality, whose double and reciprocal emergent quality is the production of the whole by the whole (generativity) and the reinforcement of the whole by the whole (regulation). In fact, the looping of the whole on the whole effects regulation by itself, by reabsorbing in the form of oscillations and fluctuations the deviances provoked by perturbations and accidents. Thus, every totality, in a praxic system other than the artificial machine (which is praxic only in the organization of its functioning, not in the generation of its functioning, not in the generation of its being), necessarily takes the form of retroactive loop.

Such a totality can comprise in its bosom other retroactive loops which it generates and regenerates as much as they generate and regenerate it. Thus, the true form of a living being is not so much the architectural one of an edifice of components; it is that of a retroactive looping on itself starting with multiple and diverse loops (circulation of blood, air, hormones, food, nervous impulses, etc.). Each of these loops generates and regenerates the other. The global loop is concomitantly the product and the producer of these special loops. The idea of recursion is obvious here.

3. Recursion

The idea of loop does not signify only retroactive reinforcement of the process on itself. It signifies that the end of the process feeds the beginning, by the return of the final state of the circuit on and in the initial state: the final becoming in a way the initial state, while remaining final; the initial state becoming final, while remaining initial. This is to say by the same token that the loop is a process wherein the products and the ultimate effects become primary elements and characters. This is what a recursive process is: *every process whose final states or effects produce initial states or causes*.

Therefore, I define here as recursive every process by which an active organization produces the elements and effects which are necessary to its own generation or existence, a looped process by which the product or ultimate effect becomes the first element and first cause. It appears, therefore, that the notion of loop is much more than retroactive: *it is recursive*.

The idea of recursion does not supplant the idea of retroaction. It gives it more than an organizational foundation. It brings a logical dimension quite fundamental to active organization. In fact, the idea of recursion, in terms of organizational praxis, logically signifies *production-of-self* and *re-generation*. It is the logical foundation of generativity. In other words, recursivity, generativity, production-of-self, re-generation and (consequently) reorganization are so many aspects of the same central phenomenon.

The idea of recursion reinforces and sheds light on the idea of active totality. It signifies that, isolatedly, nothing is generative (not even a "program"); it is the process in its totality which is generative provided it loops on itself. At the same time the total action depends on the action of each moment or of each particular element; this dissipates every obscure or mystical idea of totality.

The idea of recursive organization is going to take on quite a remarkable development in the geno-phenomenal organization proper to life, as we will see in Volume II. Here we must indicate only that the concept of retroaction will be derived and satellized. Which signifies that the Wienerian planet, which appears to be a sun, must be conceived in function of Foersterian lighting. We are indebted to Foerster for having put the recursive idea at the center of self-organizing (living) processes. I want to show that we can already find it at the level of organization-of-self, of permanent reorganization, of production-of-self. That is to say, not only at the level of biological organization, but at the level of the organization of non-artificial physical machine-beings.

Production-of-self: the term signifies that it is the retroactive/recursive

process which produces the system, and which produces it without discontinuity, in uninterrupted re-beginning which is melded with its existence.

Regeneration: this term signifies that the system, like every system at work, produces an increase of entropy, therefore tends to degenerate, therefore needs generativity in order to be regenerated. Permanent production-of-self is seen in this light as permanent regeneration.

Permanent reorganization: whereas the term regeneration takes on meaning in function of generativity, the term reorganization takes on meaning in respect to disorganization which is continuously at work in the system; given this, the phenomenal organization of the being itself necessitates permanent reorganization. It is at this level of permanent reorganization that I am now going to consider what constitutes the permanence and constancy of a being endowed with active organization.

B. Morphostasis and Permanent Reorganization

Where there is a recursive loop, there is nothing which is outside of flux, degradation, renewal. Organization itself is constituted of elements in transit; it is crossed by flux, degradation, renewal. The wonder, the paradox, the problem is that this permanent and generalized activity produces stationary states, that the uninterrupted turnover produces constant forms, that becoming continuously creates being. As we are going to see, recursive organizations are organizations which, in and by disequilibrium, in and by instability, in and by an increase in entropy, produce stationary states, homeostases, that is to say a certain form of equilibrium, a certain form of stability, a certain form of constancy, a true morphostasis.

1. The Stationary State

The constancy of the flame of a candle, the form of an eddy, the morphology of a star, the homeostasis of a cell or of a living organism are inseparable from thermodynamic imbalance, that is to say from a flux of energy which travels through them. Instead of destroying the system, flux feeds it, contributes necessarily to its existence and organization. Much more, stopping flux entails the degradation and ruin of the system.

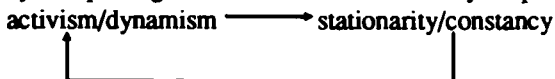
Therefore, it is a matter of considering these states, which are balanced in imbalance; which, composed of unstable elements, are globally stable; which, crossed by fluxes, are constant in their form. The term steady state, or stationary state of non-balance, defines them. Consequently, the organizational

problem is posed: how are these stationary forms and states tied to change and to movement?

It is already remarkable that there is a stationary state *although* there is disequilibrium, instability, movement, change; it is altogether admirable that there is a stationary state *because* there is disequilibrium, instability, movement, change.

The relative invariance of the forms of the system depends in fact on the turnover of its constitutive elements. Thus, we must conceive that the permanence of the movement maintains the organization of the permanence of the forms and that this organization maintains the movement. Consequently, a recursive relation appears between the organization and the renewal of the components, including components of the organization itself. Thence is born and maintained the primary state of every active organization: the stationary state.

An active system can only be stabilized by action. Change assures constancy. Constancy assures change. Every organization of constancy is devoted to assuring renewal which assures constancy. The two antinomous characters, activism/invariance on the one hand, stationarity/constancy on the other, not only compete against each other but mutually co-produce each other:



This idea is clearly visible in the eddy, where phenomenal form and generative loop blend: it is what is constant which is at the same time in movement. Recursive movement is what transforms the dynamic flow of flux into a circuit with constant form, and henceforth each of the two terms co-produces the other. Flux is the condition of work, which transforms flux into productive organization, not so much the production of some object, but the production-of-self, not so much the production of some distant activity, but the organization-of-self. Flux feeds the recursive circuit which is that of the whole as organizer-of-self.

The stationary state must be conceived as a key aspect of the production-of-self, and that in these two senses: the sense of production, the sense of self.

First of all, the stationary state is part of the recursive organization which produces it: it is not only permanently renewed, it is also necessary to the renewal of the recursive process itself; there must be constancy, permanence, in a word *being*, for the organization which feeds this being to exist. Being, in its own way, maintains the organization which maintains it.

And here the ontological aspect of the stationary state must be emphasized

all the more because it is commonly ignored. Like mayonnaise under the whirling blender, being and existence take a first consistency, under the effect of recursion, in and by the stationary state. In fact, starting with disorder, generative movement produces an internal order and determinism; starting with general statistical improbability, it produces a local and temporary probability of existence. From the same movement organization, being, existence reciprocally create, keep in position, and maintain each other. To be, in fact, is to remain constant in one's forms, organization, genericity, namely in one's identity. The stationary state constitutes, thus, the primary state of a being endowed with active organization. And, for the living being, homeostasis, a complex of stationary states through which the organism maintains its constancy, is identified with the being of this organism.

The stationary state, in an atomized physics without concept of organization nor concept of being, is a particular physical state. On the other hand, we see in a perspective of organization which is recursive, *ergo* generative, that it is a being, endowed with self-reserve [Fr. *quant-à-soi*], which is formed and affirmed in and by the stationary state.

2. Stationary Dynamics: Meta-disequilibrium, Meta-instability

In these conditions, we cannot oppose as simple alternatives equilibrium/disequilibrium, stability/instability: we must simultaneously encompass and exceed these terms which are becoming complementary without ceasing to be antagonistic.

In fact, neither the thermodynamic notion (absence of flux) nor the mechanical notion (state of rest resulting from the equality of antagonistic forces) of equilibrium, nor the notion of disequilibrium, each taken isolatedly, is pertinent for understanding steady state, and yet each can bring a part of truth to it on condition that we speak of *meta-disequilibrium*. In this notion equilibrium and disequilibrium are associated complementarily (since disequilibrium is necessary to the constantly renewed re-equilibration of the stationary state), but they remain antagonistic. The idea of meta-disequilibrium is an active idea; it is disequilibrium/re-equilibration, compensated or regained disequilibrium, the dynamics of re-equilibration.

To the complexification of the relation equilibrium/disequilibrium, we must join the complexification of the relation stability/instability. The idea of stability already includes, not only the maintaining of a definite state, but also the property to regain this state after small perturbations. In this sense, we can consider steady state as a state of stability which supports variations and

oscillations. But this is to forget that the return to a stable state is, in steady te, ot the return to rest, but the product of activity. This is to forget especially that steady state includes instability as original virtue. We have seen that disequilibrium and instability are genestic; active organization is marked indelibly with the sign of this origin; it is born of turbulences, collisions, ruptures, antagonisms. This genestic trait has become generic: suns, eddies, vortices contain in themselves the confrontation whence they were born.

In their origin, their existence, their permanence, stationary states of machine-beings include, as a fundamental factor of their order and of their organization, a fundamental factor of disorder and of disorganization.

Thus, steady state is born of an instability, is maintained through instabilities, reconstitutes continuously a global stability beyond instability. We could have spoken of meta-stability if the term had not already a circumscribed physical use. The idea of ultra-stability (Ashby, 1956), proposed to express the property of a system to keep its stability in conditions of stress which should normally suppress it, would be integrable here, but insufficient. We need a notion indicating that the new stability is no longer a true instability: whence the idea, which I suggest, of meta-instability, which is integrated in the idea of stationary dynamism.³

What is said here holds *a fortiori* for the living being in which going beyond equilibrium and disequilibrium, beyond stability and instability, in which unity of being and of movement is effected in this assured and fragile, constant and fluctuating state called life.

Thus, in order to conceive of any active organization, any natural machine, we must couple in a central way the ideas of equilibrium and disequilibrium, stability and instability, dynamism and constancy; but this coupling must be conceived as a *looping*, that is to say a recursive relation between these terms forming a circuit, where what is generated generates in its turn what generates it.

3. The Idea of Regulation

The idea of regulation appears in the universe of artificial machines with cybernetics; it is the introduction of informational devices effecting negative retroaction by the detection and cancellation of error. Regulation seems, therefore, to be one of the properties of organization properly informational. However, we had noticed that devices of negative retroaction existed on pre-cybernetic machines (like the ball device in the steam engine). Neverthe-

less, we will not conclude therefrom the theoretical consequence that regulation preceded information. Now, we must base regulation, not on information, but on the recursive loop; the latter is not a device perfecting the automation, effectiveness, reliability of machines; it is generative of the very existence of being. Therefore, we must stress:

—that natural machine-beings cannot exist without regulation and that regulation is one of the characteristics proper to the recursive retroaction of the whole on the whole;

—that arkhé-machines and wild machines do not have any specific device for correcting deviance and error.

The retroactive loop is not, therefore, fundamentally the result of the effect of the informational device for correcting error; it is the retroactive loop which is fundamental, and the corrective informational device is a development proper to the living phenomenon, which reappears, in a purely regulatory way, at the cybernetic stage of artificial machines.

As we have seen, the spontaneous regulation of the star, the result of two antagonistic processes, blends with the retroactive loop of a tremendously complex whole. This regulation includes, in what concerns our sun, enormous pulsations of very vast amplitudes, sudden jumps, crises. It includes terrifying turbulences in the photosphere. It includes enormous disorders. The remarkable thing is not so much the rough character of such a regulation, threatened by enormous disorders which can make the star explode en route, as we can see by the bits of the sun which here and there dot the astronomical map. The remarkable thing is that such a regulation, purely spontaneous, suffers and surmounts such disorders. Once more, what we have failed to admire in the world, not only biological and anthropolo-social but also physical, is the spontaneist force of the organization-of-self.

We are too used to looking for and finding regulation for correcting errors in a device and not in *poiesis* where the play of solidarities and antagonisms makes a loop. For, active totality is not, let us repeat, a transcendence investing the parts, but the set of inter-retroaction between parts and whole, whole and parts.

Thus, every active organization necessarily includes a regulation, in this sense that the retroaction of the loop (or global recursive circuit) tends to annul the deviances and perturbations which appear with respect to the total process and its organization; therefore, this retroaction of the whole can be called *negative*.

It is clear that there is a prodigious distance between the spontaneous

regulation of the great solar boiler, not distinct from the production and reorganization-of-self, where the heater, the heating and the heated are *the same*, and the thermostat regulation of the boiler for central heating, which concerns only the functioning machine.

Yet, even in this case where it is very circumscribed and apparently very simple, the regulation is much more than a correction of deviance proper to the creation of a loop, not only between the boiler's "exits" and "entries," but between the boiler and entities of its environment.

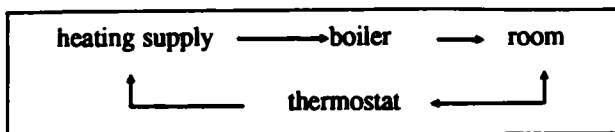
Let us consider first of all a boiler without a thermostat. The boiler corresponds to an apparently atomistic organization of the heating system where three distinct entities are involved:

heating supply —→ boiler —→ room to be heated

In fact, there is not only flux and transformation of energy between these three entities, but adjustments and regulations, the latter being effected by human beings.

The introduction of a thermostat, let us say in the area to be heated,⁴ constitutes the introduction of a regulatory device in the regulations between heating supply/boiler/room. The thermostat establishes a measure and fixes a norm. It measures by temperature the heat produced in the room, and when this temperature falls below the required degree, the information thus registered becomes a signal which sets off and increases combustion until the norm is restored.

Now, the introduction of this device of retroaction creates in fact a meta-system of a new type with respect to the former interrelations between the three entities: the flow of the heating supply, the combustion in the boiler, the room temperature have automatically become interdependent within a new retroactive totality endowed with its own qualities. The loop is not only between output, "information at exit," which in turn feeds back input, "information at entry." The loop is henceforth between the heating supply, the boiler, the room *via* the communication of information. There is no longer only the machine as boiler; there is the constitution of a vaster mechanical cycle encompassing heating supply and room. The loop constitutes in sum a recursive organization which is generated by itself, and which disappears as soon as it stops. From that moment on, the retroactive loop includes and brings the following organizational properties:



—the organization and maintenance of a stationary state;

—the durable organization of an improbable state, by modification of the probable play of causes and effects (the probability being shortterm the interperate combustion, and longterm the homogenization of the external and internal temperatures);

—the organization of work antagonistic to the homogenization of temperatures, creating and organizing thermal heterogeneity;

—the establishment of an internal determinism opposing accidents and perturbations of internal and external origin, notably the conjuration of the dangers (incendiary, explosive) of over-heating and the dangers (freezing, etc.) of under-heating;

—the subjection to a norm, a goal (cf. later on, Ch. 4 of this part).

Thus, negative retroaction is not so much an addition which brings finish to the correction, and regulation is not only a simple addition of regularity. It is not only the organization of efficacy and automatic precision in functioning. It is the constitution of a retroactive totality which is endowed with its own organizational properties. It is even a matter of generative loop! But this generative loop is only generative of this retroactive totality. It is generative, neither of the being of the boiler, nor of the constitution of the room, nor of the heating supply system, nor of the making of the thermostat. This loop, therefore, is phenomenal with respect to those objects which are generated by the anthropo-social megamachine.

Here the difference in the regulation proper to a living organism, or homeostasis, shows up clearly. As in the case of the sun, with this difference that there are henceforth functional organs and informational devices, the heating, the heater, the heated are the same. For the living being as for the solar being, to exist and to function are non-separable, and regulation concerns existence. The artificial machine can stop functioning without disintegrating immediately. Other machines, no. Regulation is, therefore, an aspect of the production-of-self. It is its negative side, that is to say annulling perturbations and deviances.

4. Homeostasis

Homeostasis had been accurately recognized by Cannon (Cannon, 1932)

as the set of organic processes which act to maintain the steady state of the organism, in its morphology and in its internal conditions, in spite of external perturbations. The cybernetic idea of negative retroaction by informational device seemed to supply in the Fifties the organizational infrastructure of homeostasis. In fact, it supplied only surface structure.

This is because we must conceive homeostasis in its fullness. Homeostasis is not limited or subordinated to the maintenance of a constant temperature (which only concerns homeothermal animals). It corresponds to the maintenance of all the internal constancies of an organism: pressure, pH, content in varied substances. Equally homeostatic are the immunological processes by which the organism rejects what it detects as foreign. We see, therefore, that homeostasis, and thereby the complex negative retroactions which maintain it, concerns not only the maintenance of the constancy of an interior milieu, but the integral existence of the living being. In his own way Claude Bernard had perceived that "the unity of the conditions of life in the interior milieu" blend with life itself, since it was for him the only goal "of vital mechanisms, no matter how varied they are." (Claude Bernard, 1865)

Here reappears the fault line which radically separates the artificial machine from the living machine. In fact, a non-regulated artificial machine can perhaps continue to exist, even if it can no longer function, whereas a living being without homeostasis, that is to say deprived of its complex of regulatory retroactions, disintegrates as machine and as being. The difference between living homeostasis and the regulation in an artificial machine reveals two levels of organizational difference. On the first level, the artificial machine resists degenerescence by the physical quality of the materials which constitute it; these elements are chosen and fashioned so as to possess a maximum of reliability, robustness, duration. On the other hand, "the organism constituted of hardly reliable materials," characterized by their extreme inconsistency and instability, "maintains its constancy in conditions which should reasonably disturb it deeply." (Cannon, 1932) Much more: we know that the organism hemorrhages uninterruptedly; unceasingly its molecules degrade, its cells degenerate and are remade, replaced. Whence a radical primary difference. The *fundamental* resistance of the artificial machine to corruption is effected by the quality of *non-changing* components; the resistance of the living machine is effected by an organizational turnover carrying out the changing and replacement of all the components. The regulation of an artificial machine concerns only the functioning of the machine. The homeostasis of the living machine is linked to its fundamental processes of existential reorganization.

Wiener said that homeostasis is the "conjunction of the processes by which we living beings resist the general flow of corruption and degenerescence." (N. Wiener, 1950, *in* Wiener, 1962, p.260) We must go further and say that this resistance is the other side of the production of our existence.

Here we see the second level of the difference between artificial machines and living machines. The products and performances of the artificial machine are external to it. The artificial machine does not produce its own components, it does not produce itself. Now, the living machine is devoted to making its own components and to its own reorganization. This self-productive and reorganizing action is permanent and total (it concerns the whole of the living being and almost all its components). Thus, we see that to live is simultaneously a process of corruption/disorganization and a process of making/reorganizing. Better still: these contrary processes are undissociable. Homeostasis is their active bond. It is constituted by the set of corrective, regulatory retroactions by which degradation triggers production, disorganization triggers reorganization.

Homeostasis thus becomes inseparable from permanent self-production, from permanent self-reorganization of the living being. As we will see amply in Volume II, the organization of life (or geno-phenomenal organization) is in fact a recursive coupling between a generative organization and a phenomenal organization, that of individual existence *hic et nunc*. Homeostasis is proper to phenomenal organization; as such it depends on generative organization/reorganization on the basis of which it constitutes and reconstitutes itself endlessly. But in its turn, homeostasis becomes necessary for the generative action which constitutes it. Here again we rediscover, in a complexified but always fundamental way, the circuit of recursion: *the organization of regulation must itself be regulated by the regulation which it creates*. Living regulation, therefore, includes a recursive regulation of the regulating by the regulated. In other words, homeostasis, loop in a loop, regenerates the loop which generates it. Thus, genes produce and bring to existence organisms which produce them and make them exist.⁵

5. From Regulation to Operational Regularity

Every recursive loop has a character of re-beginning, reiteration, repetition. Every regulation has a character of regularity. The trivial notion of "machine-like," which came to us from artificial machines, corresponds to these secondary traits: repetition and regularity. Artificial machines are founded on this machinality for their automatisms of repetition, comformable

to the very nature of industrial production. But they have lost *poesis*. It is in living machines that regular internal cycles and circuits have developed, which evoke incredible automated factories, but which do not alter the strategic, inventive, creative aptitudes of the whole as whole.

6. *Permanent Reorganization*

The paradigm of the artificial machine, overdetermined by the paradigm of simplification, dissociates the idea of regulation and the idea of existence, the idea of loop and the idea of generativity, the idea of retroaction and the idea of totality.

Actually, the artificial machine is a being totally dissociated between its functioning and its constitution. What is active in the artifact is the functioning, what is looped and regulated is the functioning. On the other hand, the being of the machine exists without loop, without regulation, without functioning. But this being, if functioning is no longer possible, ceases to be a machine and becomes a thing.

The extrapolation of the artificial cybernetic model onto the living machine has allowed us to conceive homeostasis as informational regulation by negative retroaction, but homeostasis was conceived superficially, as quality of finality. Now, we must conceive it in terms of generativity, where it appears as the basic character of an organization which produces, regenerates, and reorganizes itself.

Thus, for living beings as for suns, vortices, eddies, or flames, what is stationary, constant, regulated, homeostatic is undissociable from what is being, existence, production, regeneration, reorganization-of-self.

As soon as we want to define the specific character of the organization of any machine-being, except the artificial one, then it appears that this organization is not only integrally active, totally retroactive, and fundamentally recursive, but that it is also always *re-organization*. Reorganization is the properly organizational face of the recursive loop. It is astonishing that the idea of permanent reorganization had been singled out only so recently, and, to my knowledge, only by Atlan (Atlan, 1972b) starting with the discovery of the organizational role of "noise."

And yet, it is an idea that one arrives at by multiple avenues. The simplest itinerary is still this one: every active organization is at work, therefore it produces heat, therefore disorder which necessarily sooner or later alters the components of the machine, therefore necessarily by-produces wear, degradation, disorganization. Whence the necessity for a machine organizer-of-self to

reorganize. Now, this problem could only be hidden in the artificial machine, which is regenerated from the outside, by renovation, reparation, changing of parts. There is, thus, no regeneration-of-self. There is, therefore, no intrinsic reorganization.

Now, reorganization is a fundamental necessity of active organization, to such a point that this organization melds with the reorganization. This reorganization is permanent, because disorganization is itself permanent.

Thus, we glimpse the necessary and active link between the *meta* (meta-disequilibrium, meta-instability), the *retro* (retroactions which organize and the retroaction of the whole and the parts), the *re* (permanent recursion and permanent reorganization).

Permanent reorganization includes recursivity *ad infinitum*: organization itself, we have seen in the sample cases of the eddy, the sun, the living being, undergoes disorganization; thus, organization must be reorganized; since organization is already by itself reorganization, reorganization is also *reorganization of reorganization*.

Inseparable from permanent recursion, permanent reorganization is thereby inseparable from permanent production-of-self, that is to say the constantly re-begun production of the process by itself and, thus, of the machine-being by its own process.

Here, permanent reorganization emerges like a turntable idea between what is generative (recursive loop) and what is phenomenal (being and the singular individual existent).

Thus, therefore, *machine-beings produce their own existence in and by permanent reorganization*. Let us put it differently: in every active organization, in every praxic system, organizational activities are also reorganizational, and reorganizational activities are also activities of production-of-self, which are evidently activities of regeneration. Those terms are themselves in a recursive relation in reference to each other; they generate each other in a circuit interrupted only by destruction and death.

Thus, therefore, *the keystone or rather key-loop idea, which has a phenomenal face of retroaction and a generative one of recursion*, is of crucial importance. It links together morphogenesis and morphostasis; it links the birth, the existence, the autonomy of all machine-beings. Artificial machines do not have their own generative loop, but they are integrated and carried away in the permanent reorganization, the production-of-self, the recursive movement of the anthropo-social megamachines of the industrial era...

II. Opening

Only the insufficient is productive.

H. Keyserling.

A. From Thermodynamic Opening to Organizational Opening, from Organizational Opening to Existential Opening

1. *From Open System to Organizational Opening*

Thermodynamics opposes the open system, involving matter/energy exchanges with the outside, the isolated system (involving no matter/energy exchanges with the outside), and the closed system (where there can be an exchange of energy but not of matter with the outside, as in the case of the earth, which receives solar energy in the form of radiation). The distinction between isolated system and closed system is useless for my purpose (which is to consider thermodynamics as a theory of organization and not organization as a thermodynamic theory); I will limit myself to opposing the notion of opening (energy/matter) to that of closing (energy/matter).

The idea of system remained soft-wrapped before Bertalanffy; the idea of open system remained enclosed in thermodynamics before Cannon. By proposing the notion of homeostasis, Cannon defined "superior living beings" (useless limitation) as "open systems presenting numerous relations with the environment." (Cannon, 1932) But it took Bertalanffy to define the principle of living organisms as open systems, precisely because these organisms vitally need to draw matter/energy from their environment. Thus, thermodynamics and living organization found themselves more than linked, apparently reconciled: if living organization, instead of increasing its entropy, that is to say disintegrating, maintains itself, even develops itself, it is because it draws matter and energy without discontinuity from its environment.⁶ From Bertalanffy on, a vulgate in the track of systems theory was constituted in which the definition of living beings as open systems seems to resolve the problem posed by the second law and seems to link harmoniously thermodynamics and organism.

But as a result we had forgotten that the notion of open system posed previous problems.

2. *Opening and Active Organization*

We generally define open system in an external and behavioral way, as a system which includes input (entry/importation) and output (exit/exportation) of matter/energy. Such a definition puts in parentheses what happens between entry and exit: there is a black-out of the organizational activity of the system which moreover is openly looked upon as a black-box.

We must, therefore, consider the organizational character of opening. Entries and exits are linked to organizational activity, thus to active organization, that is to say organization which is by that very fact transforming and producing. Opening is, therefore, what permits the energy exchanges necessary for production and transformation. Moreover, every generative loop, every production of stationary states or homeostases, necessitates energy flow, therefore opening.

Thus, opening appears as a necessary trait among the interrelated and interdependent traits whose constellation allows us to define machine-beings. It appears that we could not define "open systems" only by opening. It would be mutilating even to reabsorb the multiple and diverse traits of the machine-being only in opening and in the abstract and vague notion of system. Nonetheless, opening is not a secondary character; it is fundamental and vital, since it is necessary not only to the functioning but also to the existence of all machine-beings, except artificial ones.

Thus, the decisive cleavage here is not open/closed. It is active/non-active. Actually, the integrity of a non-active system is linked to the absence of exchanges with the outside; organization protects its physical being and safeguards its energy capital in immobilism, which prevents hemorrhage but also prevents reprovisioning.

3. *Opening and Closing: a Complex Link*

The principal opposition is between fixed and active, not between open and closed, all the more so because the notions of opening and closing, if they are opposed, are not repulsive and must be always linked in a certain way.

There is no absolutely closed system, there is no absolutely open system. Systems, even thermodynamically closed, are "open" from the point of view of gravitational and electro-magnetic interactions; at the extreme, an absolutely closed system, that is to say without the least interaction with the outside, would be by that very fact a system on which it would be impossible to obtain the least information. (cf. pp.360f) Conversely, thermodynamically open systems have an original closing and re-closing. To conceive of opening,

therefore, is to conceive of a corresponding closing.

4. *The Virtue of Opening*

This being said, it is not a matter of forgetting or underestimating the reality and importance of the idea of opening. Although every closed system has something open and every open system has something closed, although a system cannot be defined only by opening, this opening, at first energy/matter then informational/communicational proper to active organizations, is something different and more than the relational/interactional opening which every system, no matter what it is, possesses. And because opening is linked to the idea of active organization, namely production, namely machine, namely production-of-self, it is a notion of capital importance. It brings an indispensable dimension to the idea of active organization and of machine, to the idea of recursive loop. We are going to see that the idea of opening is a very great and very profound idea, which transcends the idea of system.

Therefore, we are going to speak here, not of open system but of systemic, organizational, and also ontological, existential opening. We are going to start from energy/matter opening, then informational, but in order to associate it with organization, being, existence. The idea of opening, by not being isolated or hypostasized, will not be reduced thereby. We are going to see that it will take on a radicality and an amplitude unknown in theories of "open system."

5. *The Recognition of Opening*

The distinction between open system and closed system is not only too simple; it hides what in the reality of systems and above all of polysystems involves, here opening, there closing. And although the idea of open system links this system *ipso facto* to its environment, it risks isolating the open system in a closed universe.

We must clear ambiguities away in order to get to complexities. We are going to see that systems can appear to us to be partially closed and open. That, according to the angle and the framing of our vision, according to the reference system of the observer, the same system can appear to us either closed or open.

Thus, if we define opening only in a behavioral way, in terms of matter/energy entries and exits, artificial machines are much more "open" than natural machine-beings: they could have triple input (energy for work, materials to be transformed, program to be executed) and double or triple output (by-products and waste of transformation, finished products, messages

or signals concerning their functioning). On the other hand, a living being, like bacteria, does not export finished products, does not receive any outside program, and as a result would be much less "open." Now, such a vision masks the character, integrally open, of the bacteria, which need their food in order not to decompose, whereas the artificial machine, by the fixity of its assemblings, can be considered a closed system. It can perdure from day to day, without the least food, by the resistance of its components and the stability of its fixed articulations. This is to say that the opening of the artificial machine is only functional. If we consider it only at rest, apart from all activity, the artificial machine loses not only its virtue of opening but also its quality of machine and becomes a thing. Thus, we see a capital distinction appear between what is ontologically and existentially open, and what is only functionally open. The living being feeds on matter/energy, not only to "work," but to exist. It works at existing, that is to say at regenerating its molecules, its cells, *ergo* its being and organization which degrade unceasingly. The living being can never stop being open, can nowhere escape flux.

The artificial machine appears to us thenceforth either as a system partially closed (in its constitution) and partially open (in its functioning), or (at rest) as a closed being potentially openable and (in activity) as an open being potentially closable.

Everything changes again if we enlarge the perspective and consider the artificial machine within the social megamachine which built it, uses it, repairs it. In that case the artifact appears to us as *integrally but passively open* within the anthropo-social organization.

Therefore, once again let us avoid the simple alternative between closed and open. Here rigid opposition is not only insufficient; it brings confusion (between living machine and natural machine). Likewise, reducing the concept of opening to import/export hides the radical difference between a system producer-of-self and a system generated from the outside.

On the other hand we must:

- always define opening by its organizational character (and not exclusively by import/export);
- distinguish the types of opening: functional, ontological, existential;
- situate the problem in a set and a context where opening and closing appear as aspects and moments of a reality simultaneously open and not open.

We will see that the open rests on the closed, is combined with the closed. A non-lighted candle is a closed system constituted by an agglomerate of wax and a wick. After lighting, it becomes the reservoir feeding the open system flame, the wick becoming a relative invariant necessary to the constancy of the

flame. Eddies acquire a certain duration and permanence when they are arranged around a fixed and stable element, that is to say materially closed, like a stone or an arch. Thus, we have a relative, non-active "invariant," but which informs the action; non-praxic, but which allows praxis; non-productive, but around which the eddy effects its production-of-self; it does not reorganize itself but allows reorganization, it does not transform itself but allows transformation. It is like the pivot around which the generative loop turns. It is *hermetic* to the agitation which surrounds it.

When we consider the set that the solar system constitutes, encompassing in it, of course, the satellite earth and living phenomena, we see that opening and closing combine and envelop each other therein. The solar system is thermodynamically a closed system, but not isolated with respect to the galaxy and the cosmos from which it receives radiation, indistinct "noises," perhaps signals. Life is inscribed in a closed cycle, the rotation of the earth around the sun, but also in open cycles depending on this closed cycle: the cycle of water, from the sea to the spring and from the spring to the sea; as biosphere or totality of living beings forming a system, it creates and develops *open* cycles of chemical transformation (cycle of oxygen and of carbon gas), open nutrient cycles (where, from the vegetal, by devouring and preying, by parasitism, evacuation, decomposition, life feeds on life); every species is an *open* periodic cycle of reproduction of individuals; every individual includes open organizational cycles (notably, in the most evolved organisms, of blood, respiration, nervous impulses).

Therefore, we must insert opening in the polymorphous complexes of interrelated machines and fluxes. Moreover, we must recognize opening, that is to say isolate the notion relatively. Now, the eddy and the flame, which have allowed us to isolate almost experimentally the idea of loop and the idea of permanent reorganization, will allow us equally to isolate the notion of opening.

6. *The Opening of Entrance and Ecological Dependence*

From a thermodynamic point of view, the star, the eddy, the living being are equally open systems. From an ecological point of view, they are very unequally open.

The star is a machine-being, totally active, simultaneously open ontologically, existentially, and functionally. Yet, it has this characteristic which differentiates it both from wild motors on earth and from living beings: it does not feed on its environment; its matter/energy entry is inside. Or rather it has first of all "self-levied" itself on its environment; its sustenance is the

substance of its being. *Its input is anterior and interior*: it is the enormous reserve of matter/energy accumulated during gravitational concentrations. Thus, the flux which crosses it and which then flows out starts from inside. The star, therefore, eats its ontological capital until exhaustion. We must not underestimate the opening of the star because it is ecologically closed at entry: but we must not underestimate this closing because the star is in other ways ontologically/functionally open. The star, from the fact that it feeds itself, possesses thereby a formidable autonomy: it does not depend for each moment of its existence on a chance environment. Once looped, it no longer depends, except in very rare instances, on external perturbations.

On the other hand, earthly machines, from vortex to living being, from living being to social being, from social being to artificial machine, are all functionally and ecologically dependent, all (except artifacts) existentially eco-dependent.

Vortices are only loop and opening; the fluxes which are transformed into loops remain fluxes and continuously threaten the loop born of their agitations and contrarieties. These vortices are not protected from their environment by the least membrane, they are open on all sides; but this opening on all sides is simultaneously their re-closing on all sides; it is the loop which is simultaneously permanent and omnipresent opening and closing. Apparently there is nothing more debile than vortices. They are absolutely dependent on fluxes, they are incapable of the least chemical transformation, of the least production of object. And yet, they are capable of production-of-self and of permanent reorganization. In their extreme nudity they hold generativity in its pure state. Thus, existence is woven in an extreme ecological dependence, in generalized opening, provided this opening coincides exactly, in its looping form and movement, with re-closing.

Living beings have, in respect to eddies and vortices, an extraordinary autonomy of organization and behavior, which allows them to adapt to the environment, even to adapt the environment to themselves and to harness it. But they are in the same total ecological dependence as eddies, since their provisioning, needed every moment, comes only from that environment.

I am going to focus, therefore, now on this ecological opening, common to all earthly existents, to eddies and vortices, and to ourselves. It is our being, our organization, our existence which are integrally eco-dependent.

Which allows us to glimpse the double and rich character that living organization will take, especially with the development of animal behaviors: the organization of internal interactions and the organization of external interactions are going to constitute the two faces of auto-eco-organization.

B. The Ecological Relation

1. *Dependent Autonomy*

Opening-entry defines at the same time originality, condition of existence, viability. It guarantees a relation simultaneously energetic, material, organizational, and existential with the environment.

Eco-dependent beings have a double identity: an identity which sets them apart, an identity of ecological belonging which attaches them to their environment. The vortex is part of the movement of the winds, yet it has its own identity; the eddy is part of the river, in which it is nothing but a moment, and yet it has its own identity, with respect to which the river becomes an environment; but having become environment, the river is also part of the eddy. Always, somehow, an open system is part of its environment, which itself is part of the said system since it penetrates it, imbues it, co-produces it.

Whereas we tend to consider frontiers essentially as lines of exclusion, the word frontier, here, reveals the unity of the double identity, which is both distinction and belonging. The frontier is both opening and closing. It is at the frontier that the distinction and the linking with the environment is effected. Every frontier, including the membrane of living beings, including the frontier of nations, is a place of communication and exchange, while being a frontier. It is the place of dissociation and association, of separation and articulation. It is the filter which both represses and allows passage. It is that by which osmotic currents are established and that which prevents homogenization.

The environment is not only co-present, it is also co-organizing. Let us consider the eddy: is it the flow of the river which organizes the eddy around the arch or the stone? Is it the stone or arch which organizes the eddy become swirling? Is it the eddy system, constituted by the encounter of flow and stone, which organizes itself around itself? All of these together: flow, arch, swirling process are co-producers and co-organizers of a generativity which, looping on itself, becomes the eddy.

The environment, far from reducing its character as co-organizer, increases it in the living being. As we will see, the environment, having become eco-system, that is to say a machine spontaneously born of the interactions between living beings of the same "niche," is much more than a reserve of food, still more than a source of negentropy wherein being draws organization, complexity, information; it is one of the dimensions of life, as fundamental as individuality, society, the reproduction cycles.

Thus, the key idea is evident: the environment is permanently constitutive

of all the beings which feed in it; it permanently cooperates in their organization. These beings and organizations are, therefore, permanently eco-dependent.

But, in a paradox which is proper to the ecological relation, it is in this dependence that the autonomy of these beings is woven and constituted.

Such beings can build and maintain their existence, their autonomy, their individuality, their originality only in ecological relation, that is to say in and by dependence on their environment; whence the alpha idea of all ecological thought: the independence of a living being necessitates its dependence with respect to its environment.

2. Transformation of the Environment

Every open being acts and/or reacts on its environment. Every productive activity has multiple, diverse, complex effects on the environment. Praxis transforms: exports are not the restitution of import, the fashioned is not the given. The outside is transformed under the effect of actions, reactions, products, and by-products.

The most prodigious of all the conceivable transformations of the environment is evidently the one effected by the suns which, each starting with a gaseous cloud, create and continue to create a universe unimaginably rich, varied, complex.

Transformation is twofold. A machine-being can create the more organized, the organizing, that is to say can bring complexity and organization to the environment. But in doing so, and necessarily, it rejects degraded energy, by-products, waste; and the most richly organized praxis tends, in a certain way that can be simultaneously complementary, concurrent, and antagonistic, to reorganize and to disorganize its environment.

Thus, living beings transform their environment; in self-producing they feed and co-produce their eco-system, while at the same time degrading it by their pollution, excrement,⁷ predations (animal), degradations (human).

Therefore, we see: ecological opening is not a window on the environment, organization thus opened is not enmeshed in the environment like the simple part of a whole. Active organization and the environment, while at the same time being distinct from each other, are *in each other*, each in its own way, and their undissociable interactions and mutual relations are complementary, concurrent, and antagonistic. The environment both feeds and threatens, brings to existence and destroys. The organization itself transforms, pollutes, enriches. A phenomenal retroactive loop is going to unite the living

being to its eco-system, the one producing the other, and conversely, as we will see (v. II, ch. 1). Which leads to a fundamental problem concerning the identity and the intelligibility of everything which has ecological opening.

C. The Opening of Opening

1. *Re-opening*

We can henceforth recognize opening as an essential trait of every praxic organization, every machine-being, a trait which takes on amplitude and radicality among beings and existents immersed in a rich and haphazard environment, on which they depend for the continuation and total renewal of their components. Thenceforth the phenomenal loop which is constituted between the individual and its environment is undissociable from the generative loop, which feeds on the phenomenal existence which it produces. Opening, for praxic earthly beings, is the double opening of entry and exit on the haphazard, placental, fostering, enemy, threatening environment; it is the permanent and multiple exchange with that environment; it is the organization, internal/external, generative and phenomenal, tied to this exchange; it is the ecological dependence and it is the autonomy of the individual being; it is existence. Each in its own way, the eddy and the living being, bring the existential mark of opening to its highest pitch.

2. *The Quick of the Object: Upsurge of Existence*

Opening is existence. Existence is both immersion in an environment and relative detachment with respect to that environment. Whitehead said strongly: "There is no possibility at all of detachment and autonomous existence," and in fact everything that exists is dependent. The existent is the being which is under the continuous control of what surrounds and/or feeds it. But at the same time it must have a certain detachment and a certain autonomy, namely a minimum of individuality, in order to exist. Living beings are going to develop their autonomy and their independence with respect to their eco-system in a necessarily complementary way (although concurrent and antagonistic); the more complex they will be, the more fragile they will be (because they multiply their ecological dependences), the more they will develop the ability to struggle against this fragility by the strategy of behavior, which will become intelligence...

To exist is to be fragile: from birth the open being or existent is near ruin;

it can avoid or defer this ruin only by the uninterrupted dynamism of permanent reorganization and the help of outside provisions. It is a transitive, uncertain *be-ing* [Fr. *étant*] which always needs to re-exist and which disappears as soon as it ceases to be fed, maintained, reorganized, reorganizing... Its existence can only oscillate between equilibrium and disequilibrium, both of which disintegrate it.

Thus, an open system like the eddy or the flame carries in itself the fount of life—phenomenal existence assured by transforming and reorganizing exchange with the environment—and the fount of death—the natural disintegration and dispersion of components. As among the living, death comes from the outside (perturbation, accident, depletion of matter/energy resources supplied by the environment) and from the inside (disorder in the reorganizational process).

Let us go further: where there is opening, disorder is the antagonistic complement of reorganization. Everything that is open lives *under* the threat of death and *from* the threat of death. In other words, *all existence feeds on what eats it away*. This will lead us to the capital Heraclitean idea, “to live from death, to die from life.”

“To live from death, to die from life” is not only the privilege of living beings. Stars also live from their death and from their life, since each moment of existence contributes to exhausting the reserve of being which feeds them. They live off agony. They are celestial pelicans which eat their innards instead of drawing from their environment. But thereby the existential fragility of the star is different from that of the living being; it comes principally from the inside, from the flaming disorders and haphazards of fire, from the fury of photonic hurricanes unleashed inside them; on the outside, the star has a rather broad security and a certain independence with respect to its environment. The existential dependence of the living being is principally external: its vital and mortal risks come from the environment.

Ecological/existential opening is simultaneously the *mouth* by which life feeds its own existence and the hemorrhaging *breach* of its dependence and incompleteness. The mouth is a breach, and the breach is a mouth. All wealth, consequently, is founded on insufficiency, all satisfaction on deficiency, all presence on absence, all present on the imperfect, I mean the non-perfect. Consummation, as Bataille had admirably seen (Bataille, 1949), expresses both the fullness of life and the activation of death. The truths of the existent are always incomplete, mutilated, uncertain, since they depend on what is beyond its frontiers. The more the existent becomes autonomous, the more it discovers its insufficiency, the more it looks towards the horizons, the more it looks for

the yonder. That is what is at the origin of need, uneasiness, search, desire (which is not a reality first risen from who knows where, but a consequence of opening), love: that is what is going to blossom, worsen, ferment, become exasperated in human subjectivity, and the mystery of existence will emerge fully in one of the ultimate tendencies of philosophy, under the accurate name of existentialism.

The notion of open system, therefore, concerns the *quick of the object* (and leads to the quick of the subject). It always concerns a being-there (*dasein*), a phenomenal "be-ing" [Fr. *étant*], an existent whose existence supposes (and opposes) its own beyond, supposes (and opposes) its own mortality.

Thus, the concept of opening is not only thermodynamic/organizational; it is also phenomenal/existential. Far from dissolving existence, it reveals it; far from enclosing existence, it opens onto it.

3. Conclusion: the Opening of Opening

It is remarkable that we, open beings opening ourselves onto the world by our science, have in this very science developed a knowledge which dissociates, isolates, separates, and finally encloses objects in themselves. That is because what comes out of the scientific opening through which we strive to know the world is at the same time the iron arm of experimentation, which surgically tears the object from its environment and its adherences and, in so doing, manipulates and enslaves. It is because the disciplines have closed down upon mutilated objects. Thus, closed knowledge has everywhere destroyed or hidden the solidarities, the articulations, the ecology of beings and of acts, existence! Thus, we have become blind to openings, so true is it that the most difficult to perceive is the evidence which a dominant paradigm hides.

Here, we have already opened up the universal notion of system. We have seen likewise that even in systems trivially (namely substantially and not organizationally) conceived as "closed," there still exist interactions and interrelations with other systems and with the environment: every closed system is in a certain way open.

Thermodynamic opening is much more radical. It is even more profound than the discoverers of the "open" system had thought. They had only attained the outside characters of the phenomenal (input/output, stationary state). Sure, they had unveiled the capital importance of the ecological relation, but without drawing all the consequences from it. They had not seen that we could not dissociate opening from active organization, and that not only at the level of

work, transformation, production, but also at the generative level of the recursive loop, the production-of-self, integral and permanent reorganization. Especially they had not conceived that the full intelligibility of opening requires a paradigm of complexity.

Opening, we have seen, is a notion simultaneously organizational, ecological, ontological, existential. This notion of multidimensional import requires an intellectual chain reorganization.

Opening is a notion of empirical import: it allows us to characterize the phenomenal traits proper to the ecological relation; it allows us to disengage a fundamental character inherent to every active organization or machine; it allows us to recognize the particular statute of eco-dependent existents.

It is a notion of methodological import: it allows us to search as much for relation with the environment as for distinction from it, plus the complex association between dependence and autonomy; as much for opening and closing as for the alternative between these terms; more for reorganization than for organization, more for praxis than for structure; furthermore, every conception of open system leads us to conceive its eco-system of inscription and to elaborate a meta-system of reference.

It is a notion of theoretical import: on the one hand, it allows us to link organization theory to the thermodynamic theory of irreversible phenomena and to the nascent theory of forms; on the other hand, it gives a physical and organizational foundation to realities that are going to go beyond physics and organization: the autonomy and individual existence of the living being.

It is a notion of logical import: it introduces into the principle of the intelligibility of beings the necessity to link the constant and the changing, the moving and the stationary, the autonomous and the dependent; and especially, whereas classical entities were defined by opposition, separation, and exclusion, it introduces, at the heart of the identity principle of the existent, the excluded third part: the environment. The principle of ecological relation opens definitively the closed concept of identity which isolates objects in self-sufficiency, excluding from its principle alterity as well as environment. The eco-dependent being always has a double identity because it includes its environment in the most intimate part of its identity principle. I will develop the capital consequences of this proposition (v. II, ch. 1) which is allied in a complex way (complementary, antagonistic) with the reclosing of identity on itself.

It is a notion of paradigmatic import: it deepens the break with the paradigm of separation and isolation which has dominated Western physics and metaphysics. The classical principle of intelligibility is battered. Henceforth

every explanation, every elucidation concerning being, organization, behavior, the evolution of eco-dependent open beings (and that concerns not only living beings but also human societies and even our ideas) cannot isolate or exclude one by the other, either the internal logic of the system or the external logic of the situation (that is to say the environmental conditions); the explanation must be dialogical and dialectical, linking the inside and the outside processes in a complementary, concurrent, and antagonistic way.

Thus, opening is much more than a window: it is a revolution in the concept of systems, which is already a revolution in the concept of object. It brings not only dynamism but dynamite.

The notion of opening concerns all living beings and, not less but even more as we will see, everything which is human. Us, you, me, we are radically open. Certainly, opening is not the character to which we could reduce or subordinate all the others: we must inscribe it in a complex conceptual constellation, but in turn it must inscribe its wide-openness in each term of the constellation. Therefore, as we will see in the second volume of this work we must effect the fundamental openings necessary for the science of man, and that not only by opening up the concepts of individual, society, species to each other, but by considering ourselves, human beings, as an open race marked by the existential wide-openness in our beings, feelings, loves, phantasms, ideas. We will see more and more: an open theory, a *scienza nuova* do not have to reject existence as subjective waste.

We will see that the transformation which opening effects must have a chain reverberation on the entire organization of thinking and thought. We will see in Volume III that the closed conception of the object corresponds, as Maruyama clearly showed (Maruyama, 1974) to a classificationist, analytical, reductionist, unidimensional, manipulative vision of the world, and that opening calls for a complex vision of the world. It is a matter of opening up all our concepts, including concepts bearing on concepts; it is a matter of opening up all systems of ideas, including the system of ideas bearing on the systems of ideas. Thermodynamic opening effected a non-closable breach. This breach will be deepened and amplified here to its fullest consequences, to the ultimate and irreparable breach which Gödel's theorem opens up in the logic of knowledge.

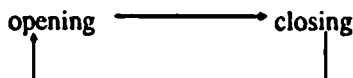
But we will never isolate the idea of opening. The opening which the idea of opening brings must also open us up to the problem of *the reclosing of open beings on self*. That is why, breaking with a vicious alternative, we are going henceforth to envisage opening in relation to *its* closing.

III. The Self: Autonomous Being and Existence

*Everything in nature dreams of itself,
and only of itself.* Diderot.

A. The Loop Links Opening to Closing

The recursive loop is what ties opening to closing. Opening feeds the loop, which effects closing. In the example, so pure, of eddy, where the loop is nothing but the swirling form itself, the circular movement effects the introduction and expulsion of the flow, namely the opening of the system; the same movement which forms the system closes it, by drawing the ultimate circle-boundary: the latter, in fact, recloses its territory, which becomes relatively autonomous. What forms closes. What closes forms. The spiral circuit of the eddy is, in fact, the circuit that recloses itself by opening itself, and thereby forms and re-forms itself. The loop is, therefore, both opening and closing. This is to say that opening and closing must be stated not only in undissociable terms, but also in recursive terms: opening produces the organization of closing which produces the organization of opening:



More generally, every loop (circuit, regulation, recursion) necessitates opening and constitutes reclosing.

A circuit exclusively closed would be a vicious circle; it is the ideal circle, unreal, of perpetual motion, radically driven out of our *physis* by the second law. The circle merely open would be impossible; it would be sequence, not a loop. It is because it is open that the closed circle is not a vicious circle, and it is because it is closed that it is a circle. It is because it is open—fed—that it produces; it is because it recloses that it exists as producer. Now, if we consider the closed/open loop in its profound, generative nature, then we see that its first and fundamental production is to produce itself, that is to say to produce by that very fact its being and its existence.

I want to indicate by that that the loop productive-of-self produces being and existence and that the *Self is the original and constitutional closing of open beings*.

B. The Existential Being

Since the beginning I have spoken of machine-beings. These beings, when they are artificial, are generated by the anthropo-social megamachine. But the other machine-beings, physical or biological, are generated from themselves, according to a process *sui generis*. The natural machine produces itself, the artifact machine produces.

The idea of being is not a substantial notion. It is an organizational idea. There is no being where there is dispersion; there is emergence of being where there is organization. But the idea of being takes on its phenomenal density only where there is active organization, namely autonomy and praxis. That is why machines, even artificial ones, are beings.

Being takes on consistency with the growth of organizing autonomy and productive praxis. Production produces not only products, but being which produces.

Nevertheless, artificial machines have neither fullness of being nor fullness of existence. They lack, for fullness of existence, the fullness of ecological opening; they lack, for fullness of being, the ability to generate themselves.

Thus, opening produces existence; the generative loop produces being. Given that every loop supposes opening, we must not dissociate production of being and production of existence. Existence is the quality of a being which produces itself non-stop and which undoes itself the moment there is a lapse in this production-of-self or regeneration. We have seen that the quality of existence is very intense where there is eco-dependence, that is to say where there is dependent autonomy.

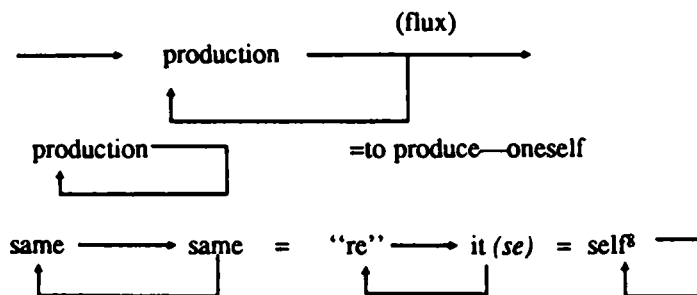
But at this point we must not forget the notion, so evident and nuclear that it passes unperceived, which the principle of the object of classical science totally hides: the notion of self, of the Self.

The Production of the Self

Generativity can and must be conceived as the circuit in which production produces a producer which produces production:



that is to say, the recursive circuit of the production-of-self:

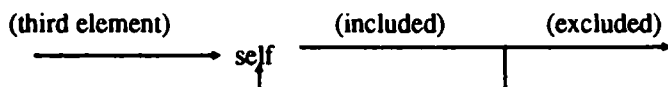


Recursion which produces the same on the same (*re*), producing and reproducing itself by itself, causes a reality of an altogether new order to emerge which the reflexive pronoun *it (se)* expresses, and which the concept of *self* substantizes.

To say that the self is a reality of a new order is to say that the production of one's own being is more than the production of one's own being: it is the production of a being which has some *self*, and which, because it has some *self* can produce its own being. The self produces that which causes it to be born and to exist. The self is what is born of itself, what returns on self, as in the reflexive pronoun *self*, what returns to self, what re-begins self (in regeneration, reorganization).

The principle of identity is not: Self=Self. *Identity arises, not as a static equivalence between two substantial terms, but as an active principle stemming from a recursive logic: Self.*

Unlike the in-itself [Fr. *l'en-soi*] of philosophical substantialisms, this identity needs a third element (energy flow, ecological relation, paternity of another self) which it includes and excludes:⁹ it is



But this is already almost the immanent finality of the for-itself [Fr. *le pour-soi*] since permanent reorganization, which is the work of the self on the self, is already at the same time almost the work of the self for the self. There is in the pro of production-of-self, the germ of a for-self [Fr. *un pour-soi*].

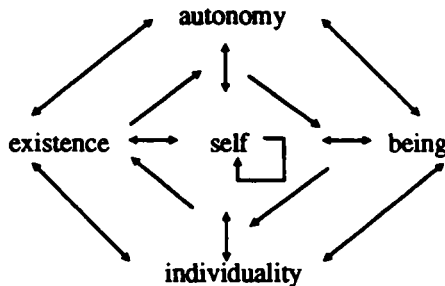
Important idea: the self is never immobile; it is always animated, always animating; whence perhaps the fact that it has been called *animus* and *anima*.

The idea of Self is capital. It constitutes the original and fundamental closing of the open system. It is the nuclear idea of the autonomy of machine-beings (non-artificial). With the self we are at the source of what will become the *autos* proper to the living being (auto-organization), a notion which we will place at the heart of all existential individuality. And, from loop to loop, we will arrive at the recursive loop which is both the most closed and the most open possible: man's consciousness.

Which once more confirms for us that opening and closing should not be stated in exclusion. The extraordinary perspicacity of Foerster, Maturana, Varela (Foerster, 1976; Maturana and Varela, 1972; Varela, 1975, 1976) in defining the idea of auto-reference, of "auto-*poiesis*," of closed logic in what concerns living beings, is not for all that legitimized in rejecting the notion of opening, which, while being antagonistic to it, is necessarily complementary to it. What I say here for the concept of *autos* is valid *ipso facto* for the concept of self.

The Constellation

Let us repeat: the self is not an in-self [Fr. *un en-soi*], sufficing-unto-itself. Not only is there not a self without opening, but the idea of self deeply tied to a productive (recursive) process, and that is an idea which must be set in a constellation with the ideas of autonomy, being, existence, individuality.



This constellation is inseparable from the generative constellation (recursive loop, opening/closing, *poiesis*). There we discover the infra-nature, immersed, hidden, but indispensable to the theory of productive being and jointly to the production of beings.

Artificial machines have being (praxic autonomy), a weak existence; cybernetic artifacts acquire a bit of phenomenal self (regulatory loops), but do not (yet?) have any deep self. Machine-like processes, like the water cycle

from the spring to the sea, from the sea to the spring, do not yet have being nor self. Vortices have some existence, still very little being, but already there emerges, in the reiterative duration of the eddy, a fragile self. Suns, though, have fullness of being, of existence, of self. With life, the self becomes reproducer-of self (reproduction cycles) and in individual beings the self gives way to the *autos*: auto-organization, auto-production, auto-reference, from which will be born the Me.

The Generative Principle and the Ontological Principle

Systems theory and cybernetics, in applying the same concepts to the phenomena of matter of extremely varied form and organization, had the merit to desubstantialize their objects. Unfortunately, in desubstantializing, they voided being, existence, and individuality. Whence the conclusion that some have drawn: cybernetics has no object. Let us understand: its object is purely ideative, that is to say formal.

We see here that organizationism, while being radically desubstantializing and "de-reifying," can and must rediscover being, existence, and self, on condition that it plunge into the problematic of the *physis*. This is because it leads us to discover organizational generativity.

At the heart of all active organizations, with the exception of artificial machines, we again find genesis become generativity. The classical aporia, wherein it is equally inconceivable that being be created *ex nihilo* and that it exist from all eternity, is not overcome but is enlightened continuously, as well by the birth of an eddy as by the birth of a child. An eddy is born by the meeting and looping of contrary currents; a child is formed from atoms and molecules absorbed, integrated, transformed in and by a generative process. Generativity creates *ex nihilo*, in this sense that it creates being where there was no being, existence where there was no existence, self where there was no self, individuality where there was no individuality. But it does not create *ex nihilo* in this sense that it creates with matter, energy, and organization. Creation here is transformation. The aporia, therefore, is repressed to a more primordial level, that of the conditions preliminary to the emergence of being: their sudden appearance *ex nihilo* is as inconceivable as their pre-existence from all eternity.

The mystery of being and of existence is not resolved, that is to say disguised: the mystery of *physis* remains, and our knowledge would be vicious, our method deceitful, if they were to foist the inconceivable on us. But we can conceive that in the same movement being be generated by praxis, existence by

opening, autonomy by organization, the self by recursion. Being, existence and self are emergences of a totality retroacting recursively on itself as totality; at the same time they are products producing production-of-self.

Thus, the ontological sphinx of the concept of machine comes out of the depths. Thus, we are able to forge and to found a theory of being starting at *the base*, at generativity. Systemic and cybernetic theories were discarding being, existence, and self as subjective by-products, waste. Now, the being integrally machine—which the artificial machine is not—recursively produces its existential being which produces it; it produces density of being and fragility of existence. Whence two capital consequences:

The first is that the re peopling of a cosmos and of a *physis* devastated by an atomizing and thingifying physics is not only a re peopling through organization and system: it is a re peopling by existential beings endowed with self-reserve [Fr. *quant-à-soi*].

The second is that notions of being, existence, self, that we believed to be reserved only for biological beings, are physical notions.

But, of course, on our earthly scale, it is life which will develop, and especially in and by the development of the individual, existentiality, and being; the *self* will become *autos*, and ultimately, the me-I.

IV. Time Opened Then Closed Again

Every system, every organization, is subject to time. But a fixed system, non-active, eludes time for a while, as long as it remains in its forms. It is born in time, time gnaws away at it and in the end will disintegrate it, but in its repose and respite, it finds itself waiting, outside of time, since time does not contribute to its existence nor to its organization.

On the other hand, time is part of the internal definition of all active organization. Activity is clearly a phenomenon in time. But time, from the moment it introduces itself into active organization, becomes bifid, dissociates itself at entry into two times without ceasing to remain the same time and finds itself again at exit. It is sequential time, which in fact imbues and pervades the system, and it is the time of the loop which recloses on itself. This is to say that time is doubly part of the definition of active organization since it is both irreversible and circular time. (de Rosnay, 1975, p.212)

Let us reconsider eddies and vortices where time is identified both as irreversible flow and whirling form. In the same movement as the flux rushes ahead, swirls, and flows out in the eddy, time does not stop imbuing it, winding itself in it, escaping from it. This time works for the generation and regeneration (of the eddy), but it also works for disorder: it is going to carry

the waters along in a great ocean-like confusion, it is going to disperse winds and vapors. Once again, the two antagonistic faces of time are one: irreversible time and circular time envelop each other, interwine and interbreak, live off each other; *they are the same*. Time, irreversible and disintegrating, while remaining irreversible and disintegrating, is transformed in and by the loop into time of re-beginning, regeneration, reorganization, reintegration.

And yet, they are distinct: one is sequential, the other repetitive. They are antagonistic: one works for dissipation, the other for organization. There is a loop precisely because there is a *double yet selfsame time*, otherwise there would be either the vicious circle of perpetual motion in an absolute vacuum or dispersion. Let us repeat: recursion is not annulation, but production.

This double yet selfsame time is that of change and that of constancy, that of flow and that of stationarity, that of homeostasis and that of homeorhesis (for there is no homeostasis without homeorhesis, as there is no homeorhesis without homeostasis). It is time where rebeginning is also repetition, where every moment has a double identity:

*the thirteenth returns, it is once again the first
and it is always the same...*

rightly said Nerval, but who forgot that the thirteenth hour, while always the same, *is never the same* as the first.

The unity of this double yet single time, associated yet dissociated, is like spiral movement, simultaneously irreversible and circular, returning on itself, biting its tail, closing itself up continuously in its re-opening, re-beginning itself continuously in its flow.

This spiral time is fragile because it is tied to physical improbability and because it is at the mercy of ecological dependence. It is not the time of clockwork rigor, like that of the rotation of the earth around the sun, which effects a gravitational ellipse and not an organizational looping. Sure, the rotative time of the earth undergoes countless small variations, it can be perturbed by collisions of comets, one day it will be shattered by solar explosion; but it doesn't need to be continuously regenerated, and it has little to fear from its environment. The time of the regenerative loop knows accidents, perturbations, lapses, which continuously threaten being and existence. This is to say that spiral time hauls in itself event-full [Fr. *événementiel*] time. It is chopped up by a thousand small, worrisome events whose effects it corrects by producing counter-effects. It integrates, therefore, the chance happening, which, beyond a certain threshold of aggression, disintegrates it.

Already the archaic form of the eddy carries in germ the ramified and diverse, multiple and single richness of the different complementary, concurrent, and antagonistic times which together constitute the Time of life. The time of life is, in fact, simultaneously the time of births, the time of developments, the time of declines and deaths, and the time of cycles (from the ecological cycle of day and night which commands the cycles of oxygen, to the cycle of the seasons which commands the cycles of reproductions, passing through the uninterrupted cycle of metabolism and the homeostatic loop of the organism). And, without a stop, by chance events, accidents hack at the threads of cyclic time, break the beginning of the time of development: some, irretrievable, entail mortal disintegration, others on the contrary stimulate evolution; which opens up for us a dimension of time which we will examine in its time (v. II).

V. Active Disorder: Permanent Disorganization

Disorders and Antagonisms in Action

Disorder is inhibited and virtualized in non-active systems; it is actualized only to corrupt and destroy them. On the other hand, disorder is present, virulent in active organizations: it is potentially destructive, but at the same time it is tolerated up to a certain point, necessary up to a certain point...

Everything is active in active organizations, including disorder. This disorder has different faces: instability, disequilibrium, chance, rupture, antagonisms, increase of entropy, disorganization. Now, we have seen that these traits are both original and constitutional. From being genesic they have become generic; Bénard's convection patterns are born of instability, they cannot be stabilized except in this instability, and they produce their form by dissipation of energy. Eolian vortices are born of the encounter of two contrary fluxes, and they cannot subsist unless the antagonism of these fluxes is maintained. Suns are born as two antagonistic actions, whose combination produces their generative and regulatory loop. The eddy is born of a disruptive element in a flow, and this element becomes the core around which the swirl is polarized and organized. We can suppose that life was born, as Thom suggests, from a "struggle of sub-systems with contrary effects which neutralize themselves in an optimal zone of homeostasis" (Thom, 1974, p.147); it maintains itself, we will see, through disorders, conflicts, antagonisms.

All these beings, all these existents perdure in and by disequilibrium and instability, which feed meta-disequilibrium and meta-instability, namely

stationarities and homeostases.

Better still: each term, each action, each process, taken isolatedly, is disorder or leads to disorder. Together they support the life of organization, namely the loop whose virtue is to combine and transmute disorders into generativity. The loop is built with disorder, overcomes it, fights it, represses it, tolerates it. Antagonism remains a genesic, generic, generative principle for all retroactive and recursive loops. Regulations were born of the antagonistic play in stars and swirls, and antagonism remains their motor and keystone. Antagonism is not thereby eliminated from informational regulations. Negative retroactions constitute actions antagonistic to the antagonisms which threaten them. Antagonism is in a sense undissociable from the regulation which corrects and represses it. Yves Barel noted very accurately that it is not enough to say that regulation supposes antagonistic processes; we must also say that antagonistic processes suppose their regulation (Barel, 1976): if regulation disappears the machine jumps, and the forces, antagonistic inside the system, become dispersive outside the system. Thus, active antagonism is inscribed necessarily in every active organization.

The presence of disorder and antagonism in active organization is complex, that is to say complementary, concurrent, antagonistic, and haphazard with respect to that organization.

It is concurrent in the sense that organization tolerates a certain degree of chance and disorder. It is complementary in the sense that organization by-produces disorder and feeds on disorder; it is antagonistic in the sense that all development of this disorder ruins and disintegrates organization. Thus:

1. Organization tolerates chance and disorder. Continuously, from the outside and/or from the inside there arise haphazard perturbations, sometimes of enormous amplitude like hurricanes or solar eruptions, which are absorbed through fluctuations, oscillations, variations.

2. Organization necessarily by-produces disorders; all work, all transformation, that is to say all activity in an organization where everything is active, by-produces wear, degradation which alter the components, the interrelations between components, the economy of the system; and thereby organizational activity chain by-produces chain disorganization.

3. Disorder lurks under regulation. Regulation continuously represses deviance which continuously reappears: this is to say that, under the deviance which always reappears, there lurks disorder; a blockage, an accident, a temporary stasis in negative retroaction would be enough to reverse the process, by an overflow of antagonisms, an unleashing of disequilibrium and instability, up to disintegration.

4. Reorganization feeds on disorganization. Continuous reorganization,

while struggling against continuous disorganization, necessarily supposes this disorganization as condition of existence and exercise. Continuous disorganization must, therefore, be conceived as the antagonistic complement of active organization, the continuous reappearing of disorder as an element of the forever reappearing construction of this organizational order. The central idea of continuous reorganization, therefore, gives ineluctably a central place to continuous disorganization, namely to the activity of disorder.

Thus, in its origin, its existence, its permanence the praxic being carries in itself, in a complex way (that is to say becoming cooperative while remaining antagonistic), active forms of anti-organization, that is to say integrates, as fundamental factor of organization, what is also fundamental factor of disorganization.

*The Integration of Disintegration:
the Twofold Play of Negative and Positive Retroactions*

Positive retroaction is accentuation, amplification, acceleration of a process by itself on itself. Positive retroaction, at the heart of a system regulated by negative retroaction, does not signify only rupture of this retroaction, accentuation of deviance; it signifies that the forces of disorganization which start up are going to accelerate, accentuate, amplify by themselves. It signifies that disorganization deploys and unchains disorganization. Thus, feeding deviance with deviance, positive retroaction first of all transforms deviance into tendency, whose increase becomes invasional, breaks all measure and rule (*hubris*), runs amok, and finally disintegrates and disperses. Example: the rupture in the spontaneous regulation of the star triggers a positive retroaction which ends up in a *nova* or *supernova* explosion; the chain reaction in a hydrogen bomb; the decomposition at first slow then accelerating into disintegration of the corpse after death; panic in a crowd, etc.

We see, then, that positive retroaction signifies not only disorganization but the unleashing of disorganization. We see, then, that all organization not only imprisons the furious and devastating forces which it feeds, but also feeds the furious and devastating forces which it imprisons.

Conforming to the paradigm of classical science which refuses any role to disorder and deviance in the becoming and organization of the world, cybernetics sent to hell positive retroaction which not only develops but unleashes deviance in devastating fashion.

Nevertheless, we have seen that great cosmic geneses were effected under the sign of positive retroactions. Gravitational concentrations are deviances, then tendencies in the overriding process of dispersion. These concentrations

are energetic, and, as Pierre de Latil had very well seen and said, positive feedbacks "are the great creators of differences in potential, they are the energy of the world." (de Latil, 1953, p.187)

Furthermore, positive retroactions are morphogenetic, since a positive gravitational retroaction effects the genesis of a star, and two positive antagonistic retroactions give the star life. However, it is clear that two positive inverse retroactions are needed to annul the destructive effect of each, and this annulment takes the form of negative retroaction. It is clear that every loop is an annulment of positive retroaction. Therefore, in this marvelous and fundamental example, we can see on the one hand all the creative potentialities of positive retroaction, actualized and deployed, from energy and morphological heterogenization to the morphogenesis of an organized being, then to the morphostasis of an organizing being; but we can see at the same time that the machine-being can survive only by annulling positive retroactions.

We could believe, then, that once morphogenesis is completed positive retroactions can no longer be anything but destructive. Which seems evident for suns, eddies, artificial machines.

Nevertheless, in what concerns artifacts, positive retroactions are produced voluntarily in the motor processes which must attain a very great power the most rapidly possible; thus, the thrust of jets is triggered with hubristic roar; but the piloting can at any instant suppress the positive retroaction it has triggered. Positive retroaction, then, is part of an organization which harnesses it. Finally and especially, it involves only energy power and not a phenomenon of organization.

The exception here proves the rule. Every organizational constancy can be maintained only by negative retroaction or regulation. Every positive retroaction which would rise up spontaneously in its bosom could only be disintegrative. This is true of the star; is it also true of the living being? We are going to see that, in the biological sphere, and especially in the anthropo-social sphere, positive retroaction, while remaining disorganizing but also because it is disorganizing, can play a genesic role, namely create diversity, newness, complexity. It is Maruyama who rehabilitated this damned part of cybernetic thought. (Maruyama, 1963)

Homeostasis and Unleashing

If we identify with the organism, then life is under the sign of negative retroaction, regulation, homeostasis.

But if we consider that life is reproduction, then living organization is a multiplication process multiplying infinitely, namely veritable positive feed-

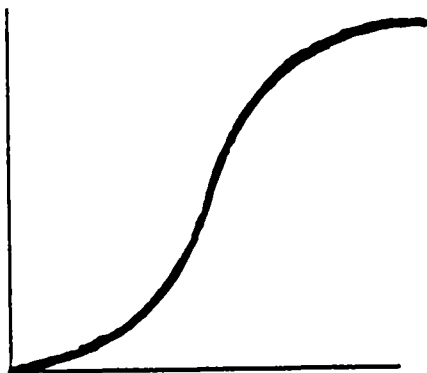
back. With the first cell life took off for infinity. It has proliferated over the entire surface of the earth, has plumbed the depths of the seas, has flown off into the skies...

It is not sufficient to unveil this fundamental character of a living phenomenon. We must unite in the same concept self-regulations and unleashings, we must tie in and overlap the play of the two retroactions. The unbridled self-expansion of life is effected starting from organisms which are prodigiously self-regulated, and this self-regulation is effected on the basis of disordered proliferation. Whence the problem which we came upon continually: does positive retroaction (multiplicative reproduction) act in the service of negative retroaction (individual organisms) or inversely? In fact, we must consider the problem, not in alternative but in ambiguity: negative retroaction acts in the service of positive retroaction which acts in the service of negative retroaction.



Homeostasis multiplies growth which multiplies homeostasis.

For sure, growth is not unlimited. It knows and undergoes quasi-regulations. All biological growth unfailingly takes the form of an S curve.



But the reproductive unleashing finds its corrections, not in itself but in external constraints,¹⁰ that is to say essentially in the limitations of the resources available for subsistence, and in the antagonisms of all against all. Thus, the "corrections," the "regulations" come also from the antagonistic relations between eaters and eaten, predators and prey, competitions between

species and individuals for the same food, in short on processes each of which is uncontrolled, but all of which taken together become controllers. (We will examine this problem in the first chapter of Volume II: "The ecological principle and the concept of eco-system.") In other words, a global regulation reappears at the level of eco-systems, but this regulation is effected not only starting from complementarities, but also starting from competitions, antagonisms and scarcities... We are very far from the rationalization and artificial schemas of engeneeral cybernetics, we are very close to the genestic tetralogue disorder/interactions/order/organization.

Thus, from the very first look, we could not conceive life other than as a stunning combination, on all levels, of negative and positive retroactions.

Towards Retroactive Anthro-po-social Complexities

Let us glimpse only, let us not yet enter here into the problematic of anthro-po-social regulations and retroactions. These cause the problems of the prodigious central machine of *homo sapiens-demens* (Morin, 1973), cultural regulations, constraints and antagonisms proper to human societies, to interfere. They present us with the problem of violence and the problem of liberty, or rather they allow us to shed a complex organizational light on these problems which political and sociological vulgates solve with their customary offhandedness. It is evidently in the becoming of historical societies, these megamachines both homeostatic and ubric (cities, nations, empires) commanded by Apparatuses which enslave in every sense of the term, producing enormous works, imbued with unbridledness and violence, vowed to inter-destruction, that regulations (themselves installed by antagonistic thrusts each tending to runaway) and destructive and/or creative unleashings mix, interfere, interdialectize. Our sociaugurs had believed that we had finally arrived, in the middle of the twentieth century, at the grand regulation of industrial Society. In fact, we were, we are in the era of exponential and surexponential demographic, technical, economic megagrowths. Worse: what appeared to us to be the grand regulator, industrial growth (and which was, partially and for a time), ruined and continues to ruin civilizations and culture, triggering profound crises in the cultural tuff of our society and our existence, sacrificing and subordinating all other developments to the sole techno-economical, degrading living eco-systems and threatening them with death, and, by retroaction, humanity itself... Nevertheless, here as elsewhere, we could not intelligently oppose as alternatives the idea of homeostasis (stationary state) to the idea of growth, the idea of "wise" regulation to the idea of "uncontrolled" becoming. Even the naive and terrifying folly of

believing that industrial growth is in essence regulatory and ordering carried in itself, mutilated and falsified, a great idea which remains to be developed, that of a becoming simultaneously open, creative, and self-regulating. We would have to dream today no longer of a homeostatic but of a homeorrhetic vision of modern societies; we must think today that the terms folly/wisdom mutually exclude each other only on certain levels, and not on all, not on the most fundamental; we must conceive finally in complex terms those urgent problems which bear down on us. But it is too soon to treat them here, and I hope it will not be too late later. I have to check my impatience, because I was able to undertake my long work only after having finally understood that one can, in fundamental matters, make haste only slowly.

Here we are, farther and farther away from engeneeral oilings and functionalities. We have just seen that regulation carried in itself, originally and necessarily, either larval or deployed, a play of antagonisms; we have seen that, tied to this play, the play of positive and negative retroactions is complementary, concurrent, antagonistic, and uncertain.

The Twofold Play of Positive and Negative

Let us recapitulate the traits opposing the two types of retroaction, the positive and the negative:

NEGATIVE RETROACTION	POSITIVE RETROACTION
cancellation of deviance constancy loop stationary entropy preservation of forms (morphostasis) <i>dike</i> repetition, re-beginning repression of perturbations	amplification of deviance tendency sequence increase or decrease of entropy destruction or creation of forms (morphogenesis) <i>hubris</i> becoming, dispersion crisis, scramble, accidents

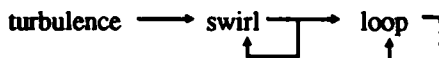
According to classic understanding, these two retroactions can only mutually exclude each other; they can be conceived only disjunctively. Now, as we have begun to see, they are associated in a complex way, that is to say simultaneously complementary, concurrent, and antagonistic, in the universe of

life and in the anthropo-social universe.

Positive Retroaction: Pulsion of Death, Genesic Pulsion

My too rapid incursion into the biosphere and the anthroposphere, surely premature and schematic, already poses the great paradox: how is it that the destructive process which goes from deviance *via* hubris to runaway is also the process necessary to development?

This is because positive retroaction awakens the genesic forces asleep in the humdrum of regulation. We have seen that the process whence organization is born is:



Positive retroaction inverts the process, namely unloops the loop, revives swirling fluidities, avalanches into turbulences. In its regressive movement towards disorder, positive retroaction is at the same time regression towards genesic potentialities. This is why it is not always, not necessarily, not only destructive. This is why great metamorphoses are always tied to destructurations brought about by positive retroaction. Thus, positive retroaction awakens whirling motricity, and formidable energies come into action; it awakens disequilibriums and instabilities which, we recall, are genesic, and which therefore bring the possibility of new organizing forms beyond disequilibrium and instability. It creates tendencies from deviances, that is to say from potential diversity and complexity. There is created, thus, a process of deviance/tendency/creation of newness/diversity, that is to say schismo/morphogenesis. But all of that really becomes morphogenetic only if a new loop is created, a metasystem, a new generativity. Whence will be born a new homeostasis, a new regulation, a new organizational order, and once again, as always, *Dike* will be the daughter of *Hubris*.

Negative retroaction alone is organization without evolution. Positive retroaction alone is drift and dispersion. Where there is evolution, that is to say becoming, there is a complementary, antagonistic, and divergent dialogic between negative retroaction and positive retroaction, *but whose real heroes are not the negative or positive retroactions in themselves, but the genesic, generative, metamorphic virtues*. Notwithstanding: in all becoming, positive retroaction is in action. It is altogether remarkable that cosmogenesis, biological evolution, the history of human societies are effected through the unruly deployment of deviances positively retroactive, with all they can hold of dispersion, destruction, and, sometimes simultaneously, of creation and innovation.

The evolution of living organisms, anthropo-social history are the new wedding, destructive and creative, of disorder and organization. The most terrifying form of disorder at the heart of an organization, positive retroaction, becomes yeast necessary for evolutions and shock wave of revolutions.

VI. Genesic and Generative Form

Genesis and Generativity

In the first chapter of this work we had set forth the genesic process:

disorders → interactions → order → organization

This process has now taken the form of:



or:



Now, the loop productive-of-self is at the same time productive of organization, being, existence. Which means that being, existence, organization are born of non-being, non-existence, non-organization, but not *ex nihilo*: they are born from what we must again call chaos, namely: turbulences, activities in disorder, agitations, oppositions, contrary movements, bumps, shocks...

Thus, in and by the loop (whirling, retroactive, recursive), chaos is transformed simultaneously into being, existence, organization.

But chaos does not totally vanish.

The presence of chaos in the loop, we have clearly seen, is the active, permanent, necessary, threatening presence of Disorder and Antagonism. This is really the face Heraclitus revealed under the apparent order and harmony of the spheres, by designating the omni-paternity and omnipresence of *Polemos* and after Heraclitus, everybody in his own way, Nicholas of Cusa, Hegel; and today Lupasco, Thom recognize, under the unity of beings and forms, contrariety and conflict. This chaos is already transmitted by genesis, which is the transformation of turbulence into vortex, the transformation of contrary actions into retroactive loop, the transformation of the dispersive into the concentric, the transformation of agitation into motricity. And, after genesis,

chaos is integrated, controlled, inhibited in the loop. Chaos and the loop are, with respect to each other, in a relation reciprocally overdetermining and dominated. Thenceforth, Polemos is no longer alone, he is no longer isolable from the other face, matricial in genesis, matriarchal in the loop, which is the gathering of what appeared to be promised to dispersion, ovulation, integration, and which records the struggle of contraries into and for *union*.

In a certain way, therefore, chaos remains present, transformed and transforming in the loop. In another way, genesis also remains present. *Generativity is, in fact, genesis indefinitely rebegun, organized, and regulated.* Continuously the generative loop transforms interactions into retroactions, turbulences into rotations; continuously it produces, in the same movement, being, existence, productive organization.

And the processes of genesis are pursued, but transformed into *poiesis* and production in and by these machine-organizations. Genesis falls asleep, loses all *poiesis* when the generative becomes purely repetitive, when regulations are only control and elimination of deviances, when production is only fabricative. But we have seen that genesis can wake up, in genetic mutation as well as in social transformation, by deregulation of the regulation, breaking of the loop, disorganization; and this regression towards turbulence and chaos revives along the way the poietic virtues, which, if they are not submerged, call forth a new genesis, which becomes the source of a new generative loop. Creation is always an irruption of genesis in generativity, occasioned by a rupture wherein the volcanic and vulcanic face of chaos suddenly flares up... Take the suns. They are profoundly poietic because they carry in themselves, scarcely tamed, the rumblings of chaos and the spontaneities of genesis. Thus, in existing they do not only grow old: they are transformed, they evolve...

The Great Wheel

We now understand why the whirling form has signaled to us everywhere, in the galactic skies, the circulating air and water, the flaming fire. It is the form in and by which turbulence is transformed into loop. It carries in itself the quasi-indistinct presence of chaos and genesis, all the while remaining the first Form of being, existence, productive organization. It swirls in the agitation of contrary fluxes, all the while already being the return *on self* and the motor-of-self.

We have seen that the swirling form is the arkhe-form by which a thermodynamic flux is transformed into an organizing being, from proto-galactic megaswirls to Bénard's micro-swirls which constitute genesic form in its pure state. If there is a form which can suggest the modern conception of

the atom, it is not an ordered solar system but a swirling. The swirl is the very form of stellar geneses. This genesic form remains that of a large number of galaxies, called spiral. It reappears each time a fluid, under the effect of contrarieties, takes form. The swirl reappears continually in air and water, and all these cyclones or eddies are sketches, fleeting or furious, of genesis...

Even when the swirling form properly called is reabsorbed to give way to its essential rotative/recursive form, it leaves behind its remanence, its souvenir, as in the spiral movements around the solar core after the lighting of the sun. We can suppose that life was born in the turbulences and swirls of a "prebiotic soup." It is striking, as has often been pointed out, how the first developments of an embryo evoke the form of a swirl. Furthermore, the analogies of form, not phenomenal but organizational, between the swirl and the living phenomenon have already been dreamed about, even reflected on, in biology: "Sherrington compares organisms to eddies in a current. We can elaborate on the analogy and say that eddies are phenotypes, produced by genotypes of stones or sandbanks which control the form of eddies... For this analogy to be more complete, we need something like a duplicatable stone, etc." (Cauns Smith, 1969, p.58)

The swirling form reveals its essential nature: recursive rotation. And whatever beings producers-of-self are, what remains through all the forms, what is developed through all the developments, is this recursive rotation here called loop, comprising opening/closing, renewal/repetition, irreversibility/return, motricity/stationarity, generativity/machinality. What will always be found in all recursive processes is circuits, cycles, reiterations, re-beginnings, that is to say the wheel. To sum up, everything which is existence, everything which is active organization, loops the loop. Suns loop the loop, planets loop the loop, cyclones loop the loop, life in its multiple overlapping cycles loops the loop: homeostatic loops, reproduction cycles, ecological cycles of day, night, seasons, oxygen, carbon... Man thinks he invented the wheel, whereas he was born of all these wheels. But his wheeler-dealing has indeed invented the solid wheel, which does not have to be permanently regenerated, and which has allowed him to enslave living machines (draft animals) and make motors (mills, turbines).

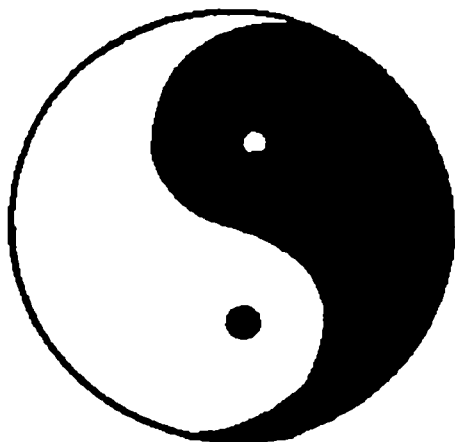
Matrices

Our science had eliminated all questioning of privileged matrix forms. Today we need to reflect on forms, in the sense asked for by Spencer Brown (Spencer Brown, 1972), as well as in the sense asked for by Thom (Thom, 1972). Today we would like to reflect on swirl, circle, wheel, recursive loop...

Meanwhile, we can only find matter to dream about in the great cosmogonies of yore, like the Chinese, the Semitic, the Greek...

The archaic idea of God-Creator *Elohim* is not at all expressed in the idea of *Adonai*, Lord-God, nor in that of *JHVH*, God-Legislator. The singular plural of *Elohim* expresses the *unitas multiplex* of genies whose whirling group constitutes a *Generator*. We can conceive these genies, in materialistic terms, under the form of motor energies—that is to say having a whirling form,—or in terms both magical and spiritualist, as *spirits* whose grouping constitutes the Spirit Creator, the Breath, therefore still the swirl. Thus, the idea of *Elohim* unites and translates in its expression, albeit indistinctly, the idea of geniesic swirl, the idea of creative power, the idea of an organizing process. As the proto-solar whirl is transformed, once genesis is accomplished, into organizational order whence emanate the apparently universal Laws of Nature, so *Elohim*—thermodynamic Swirl—(without ceasing to be subterranely *Elohim*) gives way to the God-Ordainer of the Law, *JHVH*. *JHVH* is not a solar god, he is a cybernetic god. *JHVH* writes down the Law, that is to say institutes an informational apparatus to command-control the anthropo-social machine. He becomes God-Program.

The *I Ching* or *Book of Transformations* in archaic Chinese magic furnishes the most exemplary image of the identity of the Genesisic and the Generic. The circular loop is a cosmogonic circle symbolically swirling by the interior *S* which both separates and unites the *yin* and the *yang*.



The figure is formed not starting from the center but from the periphery, and it is born of the encounter of movements in opposite directions. The *yin* and the *yang* are intimately wedded one in the other, but distinct; they are simultaneously complementary, concurrent, and antagonistic. The primordial figure of the *I Ching* is, then, a figure of order, of harmony, but carrying in itself the idea of swirl and the principle of antagonism. It is a figure of complexity.



We can dream also of the serpent-which-bites-its-tail, symbol of cosmic creation. But where the symbol degenerates is when the swirling idea and the idea of antagonism are lost and the circle becomes the image of the perfection of the One as one and of the Whole as whole. The circle, pure and closed, becomes the dried up residue of the turning wheel, the fleshless specter of the loop. Recursion finds itself disfigured into a vicious circle, that of the impossible perpetual motion. We see how the loss of a dimension in a symbol (here the loss of opening, of disorder), how the simplification of a complex form entail denaturation. The way in which we conceive the rotative circle translates either the genesic and the generic complexity of *physis*, or extra-physical platitude.¹¹

The laicized cosmogonies of the pre-Socratics, through the thematics of fire, air, water, conceived swirling turbulence as genesis and *poiesis*. We must first of all understand that fire, air, water were not, for the philosopher-magi of the Greek isles, simple elements or elementary principles, as we believe according to the reducing optic retrospectively cast on the arkhe-machines: *they were the first dynamic modalities of existence and of organization in the universe*.

Now, modern chemistry has wanted to see in fire, water, air only their composition and their state, not their modality of organization. Air has become a gaseous fluid, and the mysteries of the liquid state are returned to the mechanics of fluids. Fire, grandiose principle of Heraclitean cosmology, source of volcanic transformations and alchemic metamorphoses, has been stunted: "Chemistry books, through the ages, have seen the chapters on fire become shorter and shorter." (Bachelard, 1938b) A flame is no longer anything but the combustion of a gaseous composite which contains solid particles in suspension.

Nevertheless, concurrently with this chemical decadence, fire and flux knew their first physical rehabilitation; thermodynamics vivified and unified

under its banner the flaming of fire, liquid flux, Eolian breath. But it concerned itself only with the forces of energy, not with forms which organize.

We must go further, since the genesic link between thermodynamics and organization has finally been unveiled, since the generativity of permanent regeneration and reorganization mesh with genesic processes, since the organizing dynamic of liquid cycles and of combustions is in our being. *Therefore, we must conceive Heraclitean fire revived by Carnot, Elohistic whirl re-envisioned by Prigogine, the prebiotic swirl à la Oparine sauce, as genesic modalities of existence and organization.*

We live under and in the organizational thermodynamics of fire and swirl. The living being is a thermo-hydraulic machine in slow combustion functioning between 0° and 60°C, 80% constituted of water circulating and imbibing, self-consuming and self-consummating continuously. Certainly, it is a well-tempered machine, polyregulated, having formidable informational equipment. Nevertheless, this hyperregulated machine is suffused by *Hubris*. Life, and most particularly human life, anthropo-social life, oscillates between turbulence and order. We forget too often that our regulated and regulating society has been swamped in the first-half of this century by the monstrous tidal waves of two world wars, and is plunged, in this second half-century, in a profound historical chaos. We forget that the impeccable order of our artificial machines, wholly rationalized, functionalized, finalized, works for *Hubris* and *Thanatos*.

Degraded Machinality, Producer of Energy.

We can now better understand the nature of our artificial machines.

These machines are evidently degraded and degenerated in respect to natural machines. They have lost *poiesis*, generativity. They retain the machine-like, but not the machining. They produce, but they do not self-produce. They would not know how to exist nor to function with internal disorder. What they have lost in creation they have gained in order, repetition, precision in fabrication—that is to say the multiplication of standard objects.

This signifies that, for these machines, order takes precedence pitilessly over organizational complexity.

Nevertheless, in what concerns motors, humanity has learned to harness and reinvent the swirl. The creative genius of *Homo faber* has been directed towards exploitation, either of the generativity of life (by enslaving living beings) or of the motor generativity of *physis*. Modern humanity is capable of resurrecting the creative chaos of genesic forces, but in order to have them become generators of productive or destructive energies. Carnot's fire-machine

opens the era of a formidable harnessing of chaos, of turbulence, of the disintegration of energy.

It is certain that, in one sense, the development of artifact machines and motors contributes to the development of anthropo-social complexity. But it is no less certain that it also goes in the sense of the development of pitiless order and barbaric power. For, the harnessing of chaos is achieved by forces worked by chaos. The harnessing of turbulence is effected by turbulent forces. The harnessing of harnessing is the work of harnessed forces. The controllers of harnessing are uncontrolled...

And henceforth the apparently contradictory forces of merciless order and hubristic deluge are knotted and, in the same knot, the forces of emancipation and of development are mixed in. And all of that now forms a vortex... And we are in the eye of the cyclone... We are in hesitation, confusion, mortal combat, between a great disintegrative turbulence and a new genesis of the anthropo-social being.

It is extraordinary, but it is no doubt enlightening, to find once again, in their very fundamentality and extreme virulence, these key problems of chaos, genesis, generativity, knotted in the Gordian knot today gripping our times, our society, our humanity, our lives.

VII. The Parenthetical

The reader no doubt will have noticed that I have said nothing in these last two chapters about the atom, active organization if ever there was one, matrix form whose genesis, beginning before that of the stars (formation of light cores), contributes to that of the stars and is pursued in the heart of the stars.

The atom is an integrally active organization; it exists only by interactions and only by the retroaction of the whole on the parts. The permanent activity of its components produces and maintains its stationary state. Everything takes place as if the atom produced itself without discontinuity, therefore as if it was endowed with its own generativity. In fact, the atom seems to be still genesic. Its form does not evoke an ordered solar system, but an agitation quasi-whirling, having for the observer an important part of indetermination, that is to say of disorder. Actually, it seems at every moment to issue from particle chaos, where all our notions of identity, form, matter, break down, and actually, it is in its permanent production-of-self, producer of the first consistency of being to take micro-physical form. The being of *physis* is first of all the atom.

The big problem which the atom poses for us in reference to the theoretical sketch of the machine-being which I have attempted is the problem

of opening. The atom is not eco-dependent and accordingly we could assimilate it to the sun, whose input is internal. But the sun consumes and degrades its energy in its own machine-like process, whereas the atom seems to be energy-autonomous. Of course, it is open in this sense that it is in multiple interactions with the environment, and it is even very open to external exchanges: it reacts to radiation by emission; its electronic belt is very transactional, and molecules are atoms associated to electrons conjointly owned.

The more the core and its electronic belt are diversified, the more the atom is open to exchanges, transactions, combinations. But these external exchanges modify the atom. To exist, the atom does not need such exchanges. On the other hand, it effects intensive and multiple internal exchanges: bonds between nucleons (protons and neutrons) seem to rest on exchanges; between neighboring nucleons, of one or several ephemeral particles—pions—and of particles still more ephemeral, called meson resonances. Everything happens as if, in certain cases, the particles interact with themselves. Thenceforth, the atom appears to us as an endo-machine, an introactive machine permanently practicing internal exchanges, on occasion external exchanges. Is it a matter, then, of a loop merely closed? Here the incongruity of all our concepts concerning the micro-physical level of reality asks us not to close down our logic on this paradox of pure closing. Maybe atoms, if they are not "open" on an environment, are open "by underneath," on the inconceived and the unknown of *physis*.

In any case, it is remarkable that a large set of atoms forming a retroactive whole on the basis of their mutual interactions can constitute a machine open on the environment: a living organism. The latter can be considered a polyatomic machine with electronic circuits whose stationary state, metabolic transformations, exchanges are founded on and use the properties of stationarity, of transformations and exchanges of the individual atom. We must add: living organization harnesses the atom, and, machining it for its service, opens it up systematically to outside exchange. The living organism appears, therefore, as a macro-machine which mechanizes the atom by regulating and productivizing its transformations. But the living organism is an open electronic macro-machine only because the atom was already an openable electronic micro-machine.

Thus, the atom, while confirming the crucial genesic and ontological importance of active organization in the universe, while having the essential traits of a machine-being and of generativity, poses a problem of opening for us presently enigmatic and unsolvable. It shows us, in any case, that primordial micro-beings are machines of a type admirably endowed with autonomy,

endo-machines... And the endo-machine, if it appeared first in our cosmos is perhaps the proto-machine?

VIII. Conclusion: The Machine of a Being and the Being of a Machine

We started out with the idea of active organization. We saw that, in nature, activity is a total organizational phenomenon. Everything is active in an active system, and all the more so since it must support and maintain stationary states. Activism is generalized: flux, disequilibrium, instability, turnover, reorganization, regeneration, disorder, antagonisms, disorganizations, looping, variations, fluctuations. Everything is interactions, transactions, retroactions, organization.

Now, this activity goes far beyond the idea of activity. It comprises a diversity of aspects and consequences, the list of which we can now draw up.

ACTIVE ORGANIZATION	
stationary state meta-disequilibrium	permanent reorganization matter/energy exchanges with the outside
meta-instability	existential opening/ reclosing
turnover of the components	interactions with the environment
uninterrupted transformations	existential being
production	self (-reserve)[Fr. <i>quant-à-soi</i>]
praxis	links with other systems
loop (retroaction, recursion, regulation)	birth, evolution, ending in;
cycles and fluctuations	an irreversible, cyclic, circular,
stationary entropy, negentropy	event-full [Fr. <i>événementiel</i>] time

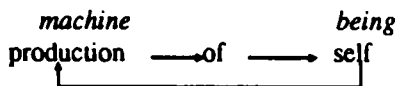
All these traits which together define active organization must be constellated, ordered, organized according to a twice double description, which evidently always concerns the same reality.

The first double description is effected by distinguishing and uniting phenomenal description and generative description. Phenomenal description brings to light the rich concept of machine constituted by the interdependent constellation of the ideas of praxis/work/transformation/production. I say rich concept, because the notion of production is not straightjacketed in the idea of

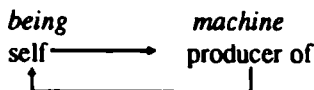
fabrication, but can also signify *poiesis* and creation. Generative description also needs the ideas of work, praxis, transformation, production, but at this level it is a matter of work *on oneself*, production *of oneself*, reorganization *of oneself*. Here the central spot is occupied, no longer by the notion of machine properly speaking, but by that of the recursive loop, comprising opening/closing. At this level appear the key ideas of production not only of being and of existence, but of *its* being and *its* existence.

The second double description distinguishes and links absolutely the terms of machine on the one hand and of being, existence, self on the other.

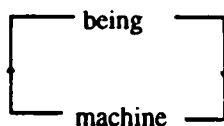
The link is in the idea of production(machine-concept)-of-self (ontological/existential concept). The term production-of-self constitutes the central recursion wherein each term generates the other.



This is the same as:



The relation machine-being is a relation of mutual dependence, without there being one term first with respect to the other:



Or rather, we must say:



Being and existence are "emergences" of the production-of-self, but these emergences constitute by that very fact the fundamental global characters, and they re-become first recursively.

Said in still another way: *the idea of machine is the organizational aspect concerning existential beings animated by self-reserve* [Fr. *quant-à-soi*].

There are not on the one hand existential beings, on the other machines;

there are existential beings because they are machines, and there are machines because they are existential beings.

Now, this obvious remark is diametrically opposed to Western metaphysics and physics. Our dominant metaphysics¹² recognized existential quality only in man, and wondered about being in essences, substances, the idea of God. Physics, not only classical but also modern, and not only physics but also systems theory and cybernetics, reject existential being as waste product and residue of the filtering they do on reality. And this filtering, which is evidently *clarification*, namely decomposition of complexity, preserves only the rationalizable, the idealizable part of the real; being and existence are emptied out. As for the *self*, it is totally unknown and misknown.

Here, we see that it is a matter of a radical conceptual reform to link together at the base the idea of self, being, existence, machine. And we have the proof of it *a contrario* in the artificial machine: the latter is not fully a machine (actually, it is a fragment of a megamachine which generates it); partially completed, non-generative, it has very little existence, little being, almost no self... By the same token, we understand finally the basic methodological vice of cybernetics, which, by bringing the concept of machine back to artifact, has missed the generativity and the complexity of the machine-being, and therefore could only conceal existence and self.

3. From Cybernetics to Communicational Organization (Sybernetics)

I. Command and Communication

Cybernetics appears in the middle of this century both to designate a new type of artificial machine and to formulate a theory which corresponds to organization, communicational by nature, proper to those machines.

Communication

The first originality of cybernetics was to conceive communication in organizational terms. I will consider further on what such an innovation brings to communications theory properly Shannonian. Here, I want to note the innovation brought about on the plane of organization. Communication constitutes an organizational link effected by the transmission and the exchange of signals. Thus, processes which regulate, produce, perform, can be triggered, controlled, verified by emissions/receptions, exchanges of signals or information.

Communication is economical in energy and generous in competences; in assuring interrelations, interactions, retroactions by the transmission of signals and signs, it uses very little energy; in developing the variety and precision of signals, in multiplying their *ad hoc* intervention, it allows the constitution of an extremely supple, adaptable, performing, opportunist intervention. Communication, therefore, not only extends the field of existences and competences of organization, it also allows multiple developments.

The second originality of cybernetics is to link informational communication and command. The word cybernetics, whose origin goes back to the idea of steering, rudder, government, is in its principle the theory of the command (piloting and control) of the systems whose organization includes communication. In this perspective, communicated information becomes *program*: it constitutes "instructions" or "orders" which trigger, inhibit, coordinate the operations. From the outset (coupling a computer and a radar to command the course of an anti-aircraft engine) the problem of command is posed in intra-machine terms. An *automatic* command is set by the computers, specific machines processing the information. This new type of machine stores or "memorizes" information, performs calculations and logical operations, and

without fear of "franglicizing," since the word is derived from the Latin, I will designate by the term *computation* those operations that go beyond calculations *per se*. The computer developed by becoming capable of elaborating strategies adapted to variable circumstances, by controlling the application of programs, by making decisions in function of problematic situations, by pattern recognition, and by learning. Whereas motors developed by developing amperage, computers developed by developing organizational competence. Computers have, henceforth, a very great aptitude for organizing precise, subtle, and complicated operations and performances in changing conditions and circumstances, for controlling and commanding not only material productions, but also behavior.

Given that, computers command machines based on their informational competences, and the integration of a computer in a machine with a motor constitutes a robot, a machine-being self-run and apparently self-commanded, piloted, controlled.

We can now grasp the revolution which separates this cybernetic automaton from the Vaucansonian automaton. The old automaton was animated by a clock mechanism, the new one is animated by an informational mechanism; the first was set once for all, the second is regulated by its operations in function of changing circumstances.

It is this model of the perfected cybernetic machine or *automaton* which has been applied to the human being with the success we know. The human being was considered a machine commanded, controlled, governed by a "program" inscribed in its DNA. The mechanism of the genes in the nucleus of the cells, the neuro-cerebral apparatus of evolved organisms could be considered as computers processing information. Thenceforth, cybernetic artifacts and human beings could be homologized in the same superior class of machines. Molecular biology had found in cybernetics the framework in which to integrate its bio-chemical operations; cybernetics had found in molecular biology the living proof of its organizational validity. The euphoria of this marriage of cybernetics and molecular biology blotted out some fundamental problems which existed: a) at the level of the cybernetic concept itself, b) at the level of its application to the living phenomenon.

The Gordian Knot

The first problem is located at the heart of the cybernetic concept. Cybernetics knotted together the idea of an organization founded on command. This tie seems evident if we consider all our artificial machines, but it was far from being evident in its principle, and long after its formulation it caused the

retrospective astonishment of its founder: "I have put communication and command together. *Why?*"

Actually, Wiener has not only put command and communication together, which is a must in all theory of communicational organization: he has subordinated communication to command, whence the term cybernetics defining the new science. In fact, *cybernetics became not only the science of communicational organization, but the science of command by communication.*

The legitimate amazement of Wiener on the tie command/communication posed the problem of organization in and by communication. His absence of surprise on the dominance of command shows that he clearly recognized an organization normatively and imperatively commanded by a superior entity. Thus, the principle of Mind commanding Matter, of Man commanding Nature, of Law commanding Citizen, of the State commanding Society became the principle of Information ruling over Organization.

And, as in the mythology of social power it is always God who speaks by the mouth of the Monarch, the general Interest which inspires the Sovereign, historical Truth which guides the Party, so also Information became the sovereign, universal, truthful entity, whose authenticity is guaranteed by the computer, its faithful servant.

Cybernetic theory hides the problem of power concealed behind command:

a) at the level of the machine-being *per se*: the power of the apparatus constituted by the computer and its means of action, an apparatus which not only processes information but transforms information into coercion (program);

b) at the level of the anthropo-social matrix of the cybernetic artifact: the power that designs the machine, directs the computer, programs the program, commands the command.

Let us now consider the first level, that of the computer and its means. Here the French term for computer, *ordinateur*—which expresses the giving of orders as much as the putting in order—completes the Anglo-saxon term "computer," which expresses the processing of information. We are dealing with an *apparatus of command*.

II. The Notion of Apparatus. Enslavement and Emancipation

The artificial automaton gives rise indirectly, and surely in a distorted and insufficient manner but conceivable in terms of being and organization, to the problem that I am going to call the Apparatus. I define the term apparatus as

the original arrangement which, in communicational organization, ties the processing of information to actions and operations. As such, *the apparatus has the power to transform information into a program, that is to say into organizational constraint.*

The apparatus then is computing (processing information) and ordering (giving orders, organizing order). The apparatus *capitalizes* (and the irruption here of this term is, I was going to say capital, I mean of primary importance, for capitalizing is to capitalize signs), *monopolizes* (if it is alone) and *programmizes* information. Concentrating in itself major organizational competences, it assures the key role of organizer of praxis. The more it is developed, the more it will be capable of assuring functions which until then seemed the privilege of the brain: pattern recognition, learning, problem solving; the more it will multiply competences, controls, commands, etc., the more it will develop a *praxis* not only internal but also external, in the environment.

As we can guess, since I have just evoked the neuro-cerebral apparatus, the truly rich and ambiguous problematic of the apparatus unfolds not only on the level of living beings, and especially of anthropo-social beings. But the artifact allows us already to distinguish two ideas in a complex way (complementary, concurrent, antagonistic) to the notion of apparatus as organizer: the idea of emancipation and the idea of enslavement.

The idea of machine, in the sense that I have indicated, signifies immediately the emancipation of the being in its entirety with respect to external risks and constraints: henceforth, the machine can "think" out the situation; it can find solutions; it can elaborate strategies adapted to the circumstances; it can conceive possibilities of choices and make decisions in function of alternatives; finally, it can trigger action and reaction. The machine, therefore, opens the door to liberty which is: to choose (the second being: to choose its choices).

A. Artificial Enslavement

But what brings emancipation also brings enslavement. To grasp the idea of enslavement one must start with the idea of servomechanism. A servomechanism is an apparatus which corrects the corrections and re-regulates the regulation in function of the perturbations which constrain it to modify its action (namely modification of the situation, variations affecting the intended goal, etc.). Thus, at the same time as it allows the machine to adjust its action efficiently, at the same time as it frees it from constraints, the servomechanism binds it entirely to the execution of the action, which means to the command of

the apparatus. There cannot be the slightest autonomy of the constitutive elements. Hence the idea vigorously exposed by Albert Ducrocq: "Bringing a system under control is commanding it without suffering its reaction." (Ducrocq, 1963, p.110) A formula which one must understand properly: it is not canceling reaction, it is on the contrary using and integrating it for correcting. But the reaction must not modify the execution of the order given, nor doubt the competence of the controller and the organization of the system. Communications function between the controlled and the controller, but the controller imposes his goals in and by this communication.

Enslavement at the level of the artificial machine seems to be effected simply on two levels:

1. The apparatus (the computer and its means of action) enslaves the system which produces or the machine which it commands; in return it receives all information from the parts without undergoing the slightest antagonistic reaction. It manipulates but is not manipulated.

2. The behavior of a controlled machine controls its sphere of action; this machine imposes its domination (arranging and/or destroying) on what, in its environment, was either amorphous, or haphazard, or obeying some other organizational order. We already see here that there is a bond between the two controls: the total mastery by the apparatus of the machine-like organization it possesses allows it to control the environment. (In this sense, the controlled organization is the one which controls. This is clearly seen at the level of human history.)

Let us not forget now two other degrees of control:

3. The apparatus of the artifact is itself completely subject to and controlled by the anthropo-social beings who have conceived it, who have furnished it with programs and goals, who control and command it.

4. The control which the artifact effects on its environment (social milieu and natural eco-system) retroacts on the human producers of this artifact: such a retroaction is at first sight emancipating: the enormous energies cybernetically controlled applied to productive activities free the human worker from the most painful and tedious part of his work, whence "social progress," "human dignity," and by a series of well-known consequences, "raising of the standard of living." But this point of view must not hide the enslaving constraints which the "machine civilization" imposes on everyday life and the degradations in the quality of life denounced nowadays. Whence the theme, by no means illusory, of "man enslaved by the machine," provided we situate it in the potential complexity and ambiguity of emancipation/enslavement and in a dialectic that can conjugate energy emancipation with informational enslavement.

We see that the problem of the machine begins to emerge in its complexity. The machine is both what is at the service of an organized whole, that is to say at the service of its functioning, its praxis, its protection, its existence, and what commands the organized whole. The machine is the brain mechanism [Fr. *cerveau-mécanisme*] (solving problems) whence comes the emancipation, and at the same time it imposes a servomechanism, whence comes enslavement.

If we consider the machine artifact isolatedly, the apparatus is nothing but a computer processing information and endowed with a means of action, and enslavement seems to have only a technical meaning. But when we consider the machine artifact in the anthropo-social group of which it is a part, the apparatus becomes an instrument of command, a term which translates its character, dependent (with respect to man) and imperative (with respect to the machine), whence the necessity to question the command also in its anthropo-social dimension.

Finally, if it is true that all communicational organization supposes an apparatus in the meaning defined here, then the problem of the relation between computation and action, between emancipation and enslavement, is posed in the fundamental terms of organization and existence for human beings and dramatically for human societies.

B. The Life of Apparatuses

*1. Servomechanisms and Brain Mechanisms [Fr. *cerveau-mécanismes*]*

In order to clearly expose the physical and organizational notion of machine, I am once again obliged to make an incursion, inevitably schematic and deceiving (as much for me as for the reader), into the realms that will be treated as such in the second volume of this work: living organization and social organization. And once again, what is for me the opening of a necessary conceptual communication will appear confusionism. (But why irritate myself beforehand by the irritations that I am going to create? Let's continue!)

We can consider that the fundamental form of all life, the cell, possesses in its nucleus a sort of proto-apparatus which gathers the principal memory, constitutes a center of computations and communications, and in a sense, emits instructions (the schema DNA-RNA-Proteins is a schema of control). Nevertheless, unlike the apparatuses/computers of artificial machines, there is an intimate relation, totally symbiotic and totally recursive, between the nuclear and the metabolic, between the genes and the other components of the cell whose activity is necessary not only to the reproduction but also to the

existence of the genes. Therefore, the relation between the nuclear proto-apparatus and the cell, of which it is part, is a complex enslaving/enslaved relation in a profound unity constituted by the mutual belonging to the recursive loop which produces the being of which each constitutes one of the aspects.

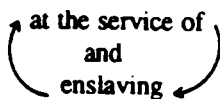
It is especially in the brain-organism relation that the cybernetic computer/machine relation seems naturally to impose itself. The computer having been assimilated to a brain, the brain has been able to be assimilated to a computer, and we could think that all multicellular organisms necessarily possess a central apparatus or brain. Now, plants do not have a brain, neither do a large number of animal species. Everything happens as if the computation of a vegetal being resulted from intercommunication between cells, namely between nuclear proto-apparatuses; in other words, plants possess a polycentric network and not a central apparatus. In a more general manner, we must realize that living organization has in multiple and diverse ways explored the acentric and polycentric track, which does not have a central nervous apparatus. Thus, the echinoderms, sea urchins, and starfish have nervous systems, insects have a polycentric ganglionated system. It is the fish, and then the reptiles, birds, and mammals that develop a central nervous apparatus and the apparatus of apparatuses, the brain. But there again, the more the brain develops in mammals, primates, and hominians, the more it becomes polycentric; the more the relations between parts are simultaneously complementary and antagonistic, the more it functions with some "noise," that is to say disorder, unlike all artificial computers. (Morin, 1973)

Let us add that it is pure illusion to consider the neuro-cerebral apparatus as the only informational apparatus of the vertebrates. On the one hand, these vertebrates possess a sexual reproductive apparatus. On the other, the cells which constitute the organism possess a broad autonomy, and a large part of the life of this organism is constituted by the interactions between their proto-apparatuses. The neuro-cerebral apparatus is an epi-apparatus, compared to the reproductive apparatus; both are in a relation of relative autonomy and of mutual dependence, and they take their place in a global recursive relation. Similarly, between the neuro-cerebral apparatus and the relational network of the proto-apparatuses, there is relative autonomy (which means, consequently, that the command of the "brain" over the cells is partial and relatively imperative) and mutual dependence, and both take their place in the global recursive relation of the whole. Therefore, the conception of an organism commanded by a sovereign central apparatus, in the manner of a computer commanding an artificial machine, must be transcended for a conception much more rich and complex, simultaneously *bipolarized* (neuro-cerebral apparatus/

reproduction apparatus), *geared down* (in the connections between billions of cellular proto-apparatuses), *recursive*, and finally *integrated in an active totality* which is the individual.

In fact, the brain depends on the organism as much as the organism depends on the brain, and it is in an enslaving/enslaved relation with respect to the organism which irrigates and feeds it. The cerebral apparatus belongs to the whole, and *at the level of the whole the brain is indistinct, not from the organism itself, but from the individual who is the "whole" of the relation brain/organism.*

Therefore, the recursive relation cerebral apparatus/organism is not only enslaved/enslaving; it is:



and the loop forms a whole emerging as an individual being transcending and integrating these characters in its unity as whole. Thus, the brain-mechanism [Fr. *cerveau-mécanisme*] is not only the most complex of all the servomechanisms, as Victorri says: it is inscribed in the complex unity of an individual existence.

2. Ambiguity. *The Machine, the Part, the Whole.*

The machine is a master concept. Absent from our theories of cybernetics, biology, and, tragically today, of society and politics, its absence renders these theories blind or servile. I am convinced that all theory of communicational organization (embodying, therefore, organization of life and anthropo-social organization) must be reconstructed by developing therein a theory of Machines. Such a theory must from the beginning conceive the radical difference which separates the artifact apparatus which organizes from the genetic and neuro-cerebral apparatuses of living beings. Not only because the latter are, by far, more complex in their organization and in their relation with the machine-being, but also because they are part of a complete *whole*, whereas the apparatus of the artificial automaton is the instrument of command for the society which manipulates the machines. Now, we are going to glimpse here a third type of problematic, in which the relation part/whole is broken, deranged, by the hypertrophy of the machine: the problematic posed in our historical societies. To conceive this type of problematic, we must have recourse to the systemic relation part/whole; or rather, we must consider the

complex problematic of the relation part/whole such as it is transformed and aggravated by the fundamental problems which the existence of a machine poses for all communicational organizations.

I have already indicated (p.125) that the relation whole/part is ambiguous and can take very diverse forms, since normally there is conjointly in the whole a tendency to exploit the parts and a tendency to serve, protect, and even develop them. The machine adds a new ambiguity. It is always a part of the whole, but which develops its complexity, its competences, its powers—and by the same token its liberties—which will be so much greater with respect to the other parts that the latter will find themselves in complementary fashion constrained to be specialized and subordinate, that is to say to restrain their competence and their autonomy. The apparatus is, therefore, a part that can appear, simultaneously or alternately:

- as the servant of the whole in reference to the dangers which threaten it;
- as the executor of the whole with respect to the parts;
- as the part which controls the whole, and thereby tends to live off, exploit, enslave both the parts and the whole.

Human history develops these potentialities in complementary, concurrent, or antagonistic ways, in and by the action of the anthropo-social apparatus with two aspects: the one of the superhuman State (although it is constituted by interactions between humans, that is to say neuro-cerebral apparatuses) and the other of the Prince, himself having multiple aspects (absolute sovereign, deified, sacralized, laicized president, clan, dominant caste...). The Prince-State complex, potentially or actually, alternately or simultaneously, is the pilot maker of decisions, the organizer of the strategies and praxis of the social Whole, defender of the Whole against external and internal dangers, enslaver of the parts by the Whole, enslaver of the Whole for its particular goals, exploiter of the other parts and of the Whole.

Such ambiguity must be considered also from an evolutive point of view. The constitution of a part into a central apparatus is, at the same time, the emancipation of the part which can develop superior creative and organizational potentialities, notably in the elaboration of strategies, and correlatively the aptitude to use disorder and chance. This development allows the apparatus to bring the benefit of its competences to the whole, which, as whole, becomes endowed with the qualities of the apparatus. These benefits can retroact on the parts, which can then let emergent qualities develop. But inversely, when the development of the general competences of the apparatus is effected at the price of irremediable specialization and a strict subordination of the parts, then there is not only aggravation of the enslavement, but duality and profound

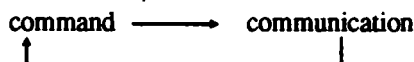
scission in the unity of the whole. These problems, abstract and formal in themselves, become existential and virulent for us, for they are our key anthropo-social problems (which I will take up in Volume II).

C. The Harnessing of Nature and the "Production of Man by Man"

1. *Eco-enslavements*

Let us now consider the problem of the enslavement of the environment. Every living being tends to enslave the zone where it feeds; in the vegetal kingdom, plants control their nutritive space by secreting a substance which inhibits the growth of other plants in their proximity. It is most evidently in the animal kingdom that enslavement spreads and precisely in those species which have developed correlatively a central nervous apparatus, a rich strategy of skillful, precise, rapid, and intelligent behavior. There are enslavements in eco-systems, but eco-systems are not enslavers by themselves: they have no central nervous apparatus, they are organized through the inter-retroactions of the living beings which constitute them; among these living beings, there are, simultaneously, chain parasitisms, interdependences, mutual enslavements, and all this together with cooperations, struggles, competitions, and submissions.

Thus, the relation command/communication



is always complex, presenting characters which are complementary, concurrent, antagonistic, uncertain, rotative, accidental...

2. *The Harnessing of Physical Motricity*

The history of humanity inaugurates a new type of enslavement in and on nature.

Everything starts by a taming, a domestication, and a first enslavement: the hominian learns how to maintain, that is to say regulate fire, then to make it. Fire serves to protect, light, grill, cook, then smelt: it is enslaved. But the great enslavement will occur only later, when fire will be imprisoned, corseted, exploited as the motor of the industrial age.

Between the first tamings of fire and its generalized enslavements in the hulls of the Western nineteenth century anthropo-social machines there is the production and the harnessing of eddies and vortices (watermills and windmills) for anthropo-social finalities. These wild motors are henceforth

encaged, channeled, triggered, inhibited by man. Then it is the fire-motor, as I have just said. Then the anthropo-social machine creates motors from energies more and more turbulent, harnesses the explosion, releases the energy of the atom in a flash akin to the beginning and the end of the world, then starts to harness it in the nuclear motor. Thus, at the end of a reverse genesis, man smashes the core of the atom, that is to say of the first physically organized reality, of the first physical being, and resurrects thermonuclear fusion which gives birth to and maintains the suns. Thus, the history of the production of man by man is inseparable from a re-creation and rediscovery of the genestic potentialities of *physis* for and by their enslavement.

3. *Controlling the Vegetal and Subjugating the Animal*

The transformation of natural fluxes and turbulences into harnessed motricity is only one aspect of the harnessing of nature. Beyond parasiting (partial and localized harnessing) and symbiosis (mutual enslavement becoming cooperation and co-organization) begins a multidimensional enslavement of the living universe which goes from exploitation pure and simple of corporal energies up to *subjugation*. The enslaving of life is effected principally by enslaving not only the reproduction process but also reproduction apparatuses (manipulation and selection of seeds, selection and castration in the breeding of animals). In other words, in all domestic species, the foundation of all life, reproduction, is concomitantly controlled, transformed, manipulated from the outside, totally enslaved to human goals.

Subjugation is the enslavement of the animal-being by control/command of its *autos*, that is to say its cerebral autonomy. That done, the human neuro-cerebral apparatus enslaves other neuro-cerebral apparatuses, which retain their competence and organizational autonomy, but whose every activity is henceforth enslaved for the purposes of their enslaver. Here the philosophically fuzzy term of alienation takes on concrete meaning: the *autos* of the subjugated finds itself alienated in the *autos* of the master. This relation master/subjugated is much more fundamental, complex, and dramatic than Hegel's relation of master/slave. The *autos* remains endowed with subjectivity, but this subjectivity becomes the satellite of another subjugating subject: the intelligence and the aptitudes of the subjugated can and must find full employment, but directed to the finalities of the master. Obedience can be imposed by constraint (enslaving), but it can also be engrammed and take on the force of law, program, "natural" order in the subjugated, thereby totally alienated in the service of the law, the program, the master order.

Thereby also the formula for social enslavement is ready. It will be a juxtaposition and/or combination of subjugation and enslavement, alienation and exploitation. Slavery is itself a combination of absolute subjugation (the slave becoming the property of the master) and of energy enslavement (forced exploitation of work power).¹

Besides, the massive enslavement of plants (agriculture) and animals (breeding), the enslavement of enormous masses of humanity, and the upsurge of the social megamachine with its central apparatus, the State, are concomitant and correlative.

This is because the harnessing of nature has from the beginning retroacted in a complex way on the beginning of humanity. The domestication of fire has domesticated man; by creating a hearth for him, it has barbarized him by inviting him to destroy by fire. The harnessing of turbulences and explosions has allowed him to civilize enormous wild motor forces, it has augmented the explosive turbulences of human history and created the conditions for generalized self-destruction. The culture of plants has culturized man by creating rural urban life; it has made him lose the rich archaic culture of the nomadic hunter-gatherers. The domestication of the animal world has created models for the domestication of man by man.

D. The State-apparatus and the Social Megamachine: The Play of Enslavements and Emancipations

The anthropo-social megamachine has been formed and developed in and by the generalized enslavements of human beings. The enslavement of humankind arose at that crucial moment. The entry of humanity in history is the entry of the State as enslaver at the heart of societies, at the same time as it is the entry of turbulence and disorder in the course of societies. War and conquest produce enslavement and Empire: conquered enemies furnish enormous contingents in ancient slavery: subjugated ethnic groups become enslaved peoples.

The formidable enslavements of living beings and human beings is inseparable from the formation of a State apparatus, circulating, regulating, decisional which enslaves society and organizes it into a megamachine.

The State is the Machine of machines, which concentrates in itself the administrative machine, the military machine, the religious machine, and then the police machine. The administrative machine imposes machine-like organization on all of society in the sense that this term signifies uniformized rule, inflexible "mechanics;" religion and army each impose their own machinality, composed in both cases of ritual (preponderant in religion) and of

discipline (preponderant in the army).

The appearance of the State machine constitutes a formidable organizational metamorphosis with respect to all other archaic societies, animal, hominian, and human. Social megamachines already exist among termites, ants, bees, but these were societies without State and government: their organizational praxis is effected starting from the interactions between the nervous apparatuses of individuals, and it is this neuro-active set which constitutes a sort of gigantic brain endowed with mobility and mandibles. On the other hand, in the human species the social megamachine has been able to constitute itself only with the State.

The State machine both emancipates and enslaves. It is not only the emancipation of man but also the enslavement of man which is effected in and by the "mastery of nature." It is the enslavement of a society which allows the enslavement of its environment (neighboring societies, the natural milieu) but which in and by this predatory barbarity develops centers of civilization among the elite dominators. In ancient societies and "Oriental despotisms," there is a hierarchical pyramid of enslavement from the summit to the base. At the summit the Sovereign, Subject in the egocentric sense of the term, reigns over subjects, in the submissive sense of the term. At the upper levels of the pyramid, the subjects enjoy a certain subjective recognition, and have some subjugated persons at their service; the enslaved have servants. At the base generalized subjugation and enslavement prevail. In a few micro-societies called cities enslavers of a new type appear: free men. Their subjugation is itself of a new type: it is the filial relation to the laws and gods of the city. The liberty of the citizen is guaranteed by the City-Machine in a reciprocal alienation in which the City depends on the citizen elector/actor who depends on his City. It is this model of liberty which is going to inspire the movement of the enslaved for their emancipation.

Finally, the great historical societies, from Antiquity to our times, always function between two poles of organization, one pole of rigid order which emanates from the State machine and more broadly from all that is power, the other pole one of infrastructural anarchy, that is to say of spontaneous and spontaneously organizing interactions. Even (and especially) where there reigns the most total and most ramified machine despotism, there is underground anarchy, quasi-clandestine when society is smothered by the machine, but an anarchy which makes society function and thereby feeds the machine which enslaves it, while escaping from it. Even where more advanced liberalisms reign, there reigns a sphere of rigid and coercive order. Each polarity carries its ambivalence (order can be more or less oppressor or/and protector, it can guarantee liberties or/and forbid them, it can impose inequality or equality;

disorder can be liberty or/and delinquency, community or/and merciless competition, spontaneity or/and brutality).

Thus, in terms of megamachines and apparatuses, we glimpse even though schematically and confusedly the complex, ambiguous, uncertain, and dramatic conditions of the dialectic of enslavement/emancipation, subjugation/liberation which characterizes human history. It is not a matter of reducing our most urgent and virulent problems to terms of organization, machine, and apparatuses. On the contrary, it is a matter of clarifying these problems by introducing precisely what was missing: the apparatus. I mean that these problems, in order to be confronted, need, certainly not only but necessarily, a theory of communicational organization which conceives the problem of the apparatus. Henceforth, such an implanting of theory, far from leading away from our concrete history, leads to it.

If the apparatus is invisible to those subjected to it, it is also because a theory of communicational organization has not yet emerged in the sciences, neither in physics, nor in biology, nor in anthropo-sociology. It is because cybernetics, which could announce this theory, has conjured it away. It is because the theory of apparatus requires a total reform of understanding based on organizationist complexity.

Let the reader understand me: the idea of apparatus takes its departure here; it is not a matter of brandishing it like a club, of manipulating it like a pass-key. The notion of apparatus asks us to begin to reflect *a little differently*, as I myself am beginning to reflect, to better understand the dialectic enslavement/emancipation, rather than submit to it in resignation, to arrogantly ignore it, to stupidly deny it, or, once again, to think we are serving emancipation by serving what enslaves.

III. Apology for and Condemnation of Cybernetics

In the course of my treatise, I have supported and opposed cybernetic theory. My point of view on cybernetics is necessarily twofold. I mean that cybernetics, in its very principle of intelligibility, embodies a serious obfuscation. It is for the better and for the worse that Wiener isolated the physical being of the machine. It is for the better and for the worse that he proposed his concept of physical autonomy, even though the artificial being is totally dependent on the society which creates it. Consequently, I am going to attempt a critique of cybernetics, which preserves and allows the development of its pristine virtues, but on condition, not only of detecting and critiquing its deficiencies, but causing a reversal in its machine concept and a cracking in its paradigm of command/communication.

The cybernetic virtues are not only to have brought a sheaf of enriching concepts, like retroaction in reference to interaction, loop in reference to process, regulation in reference to stabilization, finality in reference to causality (cf. further, p.262), ideas henceforth all indispensable to conceive physical, biological, anthropo-social phenomena; it is not only to have bound this sheaf in and by the ideas of command and communication; *it is to have linked all these terms in an organizational way and to have thus given birth to the first general (that is to say, physical) science having organization as object.* Cybernetics is the first science, since the rise of Western science in the seventeenth century, to have founded its method, effected its operational success, and made itself recognized by the other sciences by envisioning a physical system, the machine, not in function of its constitutive elements, but in function of its organizational characters.

Conceiving the machine as an organized physical being was a founding thought which greatly transcended the machine; it was to introduce the idea of organization, ever repressed, hidden, and particularized in the sciences at the heart of *physis*. It was, in this founding movement, to implant all machine-organization (that of the living being, of the human being, and of the social being) in *physis*, while at the same time liberating this *physis* from the paradigm of atomization/decomposition into simple elements. This revolution, profound though not explicated, remained quasi-invisible, except to the perspicacious few, first of all to Gottard Gunther (Gunther, 1962). Finally, in the same movement, the very notion of machine became the framework concept where one could inscribe, as I have tried to do here, the description of active organization.

To be sure, Wiener, in devoting himself to cybernetic machines, omitted to formulate a theory of machine; but, although he deformed the theory from the beginning, he made the extraordinary discovery of communicational organization, without which one could not henceforth conceive what is living, human, and social.

Finally, Wienerian cybernetics brought with it a potential complexity whose flowering would (will) sooner or later open up and explode the cybernetic framework; thus, retroaction already had two aspects, negative and positive; given that, a "second cybernetics" (Maruyama, 1963) could be formulated, rehabilitating positive retroaction and opening up the dialectic retroactions. The idea of finality and the idea of loop, by introducing a first complexification of causality, opened the way to "mutual interrelational causality" (Maruyama, 1974) and especially to *recursive causality* (Foerster, 1974a).

Thus, there is a fundamental and founding cybernetics, rich and heuristic,

witnessed to by the thought of Wiener, Ashby, the tinkering research unjustly forgotten today of Grey Walter, Ducrocq (before devoting himself, it seems, exclusively to popularization), the reflections of Sauvan which woke me up, the developments of Stafford Beer, Boulding, Bateson, Moles, the breakthroughs and advances, already meta-cybernetic, of Pask, Gunther, Foerster.

Such cybernetics by itself has shattered disciplinary barriers. Its formalism does not destroy "realism" since it is applied to physical beings, viz. machines. It rehabilitates and allows the development of the analogical imagination, which grasps the relations between the heavenly bodies, clouds, whirlwinds, living beings, humans. It can integrate diversity in its unity without destroying it.

This being said, cybernetics, like all theory, developed along two opposite sides each leading to a valley unknown to the other, though they both bear the same name. The first side is that of a new look, a new dimension, which bring new complexities to everything; the second is that of the replacement of the simplification by another, under the rule of a master formula which resolves all problems. Already by the double virtue of its Wienerian principle (the concept of the physical machine-being and the relation communication/command) cybernetics had its double vice of method which gave it a "bad inclination." In these conditions the paradigmatic, technocratic, sociological weights carried most of cybernetics along the side of simplification, reduction, and manipulation.

Cybernetics was thus shaped in the framework of the dominant patterns of thought and action. After having gone, in the concept of machine, beyond reductionism which decomposed the whole into its elements, it developed reductionism which brings all living or natural machine-beings back to the model of the artificial machine. Instead of inscribing the artificial machine in its genealogy (the Gadget [Fr. *machin*] family) and its generativity (the industrial matrix of the anthropo-social megamachine), it has made the artificial robot the universal model. After having usefully put society between parentheses in order to conceive of the autonomy of the machine, it has erased, not the parentheses but society, forming a theory in appearance purely physical, in fact purely ideological.

Cybernetics lacks a foundation. It lacks a principle of complexity. It lacks a substratum of organization. It even lacks the generic concept of machine. Wiener shows us the necessity for a theory of machine, but he forgot to work his theory out, so taken up was he with commanded machines. There is a place in cybernetics for the concept of machine, but it is empty. Consequently, cybernetics, failing to break away from the engeneral orbit of the artificial machine, has not been able to develop the complexity of the ideas of

retroaction, causality, finality, information, communication which had the merit of gathering into an articulated group: it has on the contrary expelled the ambiguities, repressing positive retroaction, ignoring the dialectic of retroactions, complex causality, the uncertainties of finality; the information therein means purely and simply program; communication therein means transmission.

Cybernetics fundamentally lacks a principle of complexity which would allow it to include the idea of disorder. This is why it is incapable of conceiving permanent reorganization, antagonisms, conflict, and because of this, incapable of conceiving the originality of natural machine-beings.

Cybernetic formalism has the merit of unifying under the same categories organizational traits proper to the separate spheres of physical machines, living machines, social machines, but this formalism, which very precisely desubstantializes what it touches, is incapable of conceiving being and existence. It lacks the existential, ecological, and organizational sense of the idea of opening, the ontological sense of closing (the self). There is neither essence (which is an advantage) nor existence (which is a deficiency) in the cybernetic grasp of the living being, which becomes very serious as soon as cyberneticism claims to interpret and treat life, man, society. Thus, cybernetics gives a skeleton of organization to living beings but takes away their life. Incapable of introducing life into an artificial machine, such a cybernetics is too capable of introducing its absence of life into our individual lives and our social life, whence consequences both debilitating on the theoretical and possibly terrifying on the practical plane.

In fact, and here we rejoin the other paradigmatic deficiency, the subordination of communication to command not only prevents cybernetics from conceiving the relation communication/command in its generic complexity, but forces it to conceive biological organization and social organization only as enslavement.

And it is on the problem of society which converge, in one great blinding, the deficiencies of cybernetics. The too abstract model of the artificial machine is the fruit of a too concrete practice: engineering. But cybernetics does not have the vision which would allow it to consider its engeneero-social grounding. By that very fact it becomes the theoretical pseudopod of an enslaving organization of work and of a technocentric, technomorphous, and technocratic practice.

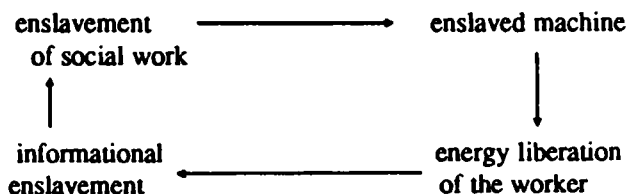
Already the richest cybernetics is becoming cryingly insufficient as soon as it becomes sufficient, that is to say claims to explain all that is machine-organization. Now, cybernetics, which claims universality, is not transdisciplinary but autocratically superdisciplinary. It believes it holds the monopoly on knowledge [*Fr. savoir*] of organization and organization of

knowledge [Fr. *savoir*]. It is a cybernetics which goes from the limited practice of the engineer to imperialism without limits (only the limited have an arrogance without limits...). Thenceforth, once again in the history of the West, the Mutilating believes it is Optimizing, Abstraction calls itself Rationalization, and Manipulation calls itself Information.

Worse still, a cybernetoid Vulgate has been born from cybernetics, in which the terms retroaction and information, having become master words, instead of expressing their deep complexity, banalize the mysteries of nature and the problems of culture. This Vulgate associates in itself engeneeral reductionism and pan-cybernetic imperialism. It conceives life according to the informational functionalities of the artificial machine. Therefore, the assaults of this Vulgate on living beings and social beings have been able to be perceived precisely as one of the aspects of the formidable expansionism of technocratic thought to all points of the compass, like a new industrialized form of reductionism which always leads the complex back to the simple (here the reduction of living organization to the organizational principles of the artificial machine), like a new offensive of Cartesian mechanistic theory, which this time, not content to limit itself to laying siege anew to the animal, endeavors to annex man and society.

Therefore, though the official defense of anthropo-social complexity often coincides with the unconscious resistance of isolationist simplism, of a "humanism" which does not conceive anthropo-socio-bio-physical complexity, it is quite justly that a Georges Friedmann (Friedmann, 1970), a Henri Lefebvre (Lefebvre, 1967) have denounced cybernetization and "cybernanthrope."

We have already seen even here: the model of the cybernetic artifact, projected on society, is the model of integral enslavement, because it is integrated. This model, emancipator with respect to energy, becomes enslaver with respect to information:



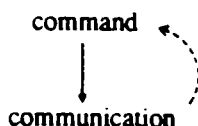
In fact, such cybernetics, stretching the vision of an engineer on machines onto all the vast anthropo-social sphere, tends and pretends naturally to reduce everything to its model of self-styled rationality: the automated, functionalized

machine, purged of all disorders (self-styled optimized), end-purposed for industrial production. It can consider society only as a vast machine to be functionalized. Since it is blind to the command of the command and to the reality of apparatuses, it can only serve the dominant social apparatuses, which always pretend to be the Faithful Bearers of Information/Truth, Servants of the Public Good and General Interest. Thus, by these reunited traits, it can soon become the instrument and the justification of absolute enslavement.

We must, therefore, effect a double extraction, a double change of orbit, physical and sociological, for the development of a science of communicational organization. We must revolutionize cybernetics, that is to say go beyond it to a sy-cybernetics, so that the latter might express its revolutionary message: the discovery of communicational organization.

IV. For a Science of Communicational Organization: Sy-cybernetics or Sybernetics

The cybernetic paradigm is the master union of the concepts of communication and control. It is a matter of a paradigm, that is to say of the association for all ulterior reasoning of these two concepts until then irrelevant and indifferent to each other. Now, this union did not reveal but rather hid the reality proper to the apparatus, therefore the problematic of command. The Wienerian paradigm was overdetermined both by the paradigm of simplicity proper to classical science and by the techno-industrial form of the enslaving organization of work proper to historical societies. Whence the subordination of communication to command, which signifies that communicational organization has established itself necessarily by enslavement (slavery or subjugation):



The idea of communication becoming organizer and becoming creator of information, that is to say of an organization where communication commands, is inconceivable according to this schema.

In a word, command has hidden the richness of communicational organization, and information has hidden the problematic of apparatuses. Power is concealed, and communication is servile.

“Going beyond” (simultaneously critique, integration, rejection of)

cybernetics necessitates some preliminaries:

1) the basis of physical complexity (the principle and full use of the idea of disorder, not only as disorganizing phenomenon, but also as organizational phenomenon);

2) the development of the idea of "retroactive loop" into the idea of recursive organization;

3) the Hubblean reversal of the generic concept of machine which becomes polycentric;

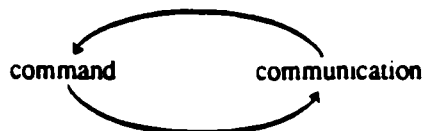
4) complexification as principle in the relation command/communication, that is to say by the same token intellection of the complex of relations:

command/communication

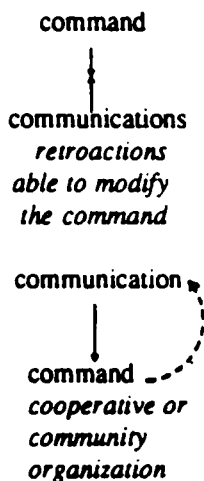
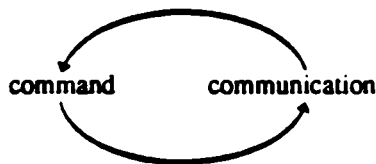
enslavement/emancipation

apparatus/organization/environment.

That done, we can consider the relation command/communication in its correlatively recursive and complex character proper to biological organization:



The diversity of sociological experiences can suggest to us, alternately or oscillatorily, the schemas:



We will produce along the way some elements of reflection to ask

ourselves if it is delirious or wise (or beyond wisdom and delirium) to envisage, for a human society, the communicationist model given above. But in any case, we will have to integrate in all communicational organization the problem of the apparatus, which will be stated according to the modalities either acentric/polycentric, centric, or centric/acentric/polycentric:



We can understand that in any case going beyond cybernetics necessitates not only the development in and by complexity of the new concepts which it has brought, but a reversal of the sovereignty of command in favor of communication.

The idea of cybernetics—art/science of steerage—can be integrated and transformed into sy-cybernetics, art/science of piloting together, where communication is no longer a tool of command, but a complex symbiotic form of organization.

The idea of communication must be examined and questioned in all its organizational and existential dimensions. Communication is the new dimension which life brings. It is a capital idea, as well for the organism as for the eco-system. It throws rich light on the problem of biological improbability, since communication is the reunion into an organized set of what would otherwise be dispersed. Do other living communications exist outside of our planet? Are there communications other than living ones even including on our planet? Are there unknowable communications?

In the meantime, we should recognize our own communications. Once again we are at the heart of our anthropo-social problems. For it is at this level that communication takes on its fullness and its intensity, existential, individual, social, political, ethical! It is at the heart of the problematic of communication that the shadow of incommunicability is inscribed. Finally, it is on the plan of social organization that the fundamental problem arises: can we imagine, hope for an organization wherein communication commands, a community of communication? Let us already know here that all hope is silly if it ignores that, behind social communication, there is command by apparatuses, that is to say the link, hazy and unrecognized, between communication and enslavement.

Let us also already know that it is in the development more and more existential and subjective of communication that this anthropo-social emer-

gence becomes evident: love. Our modern experience reveals it to us, sweetheart, lover, friend: love brings about communication and unites what otherwise would never be encountered... The ultimate developments of communication form the river Love...

Therefore, we will have to intensely question communication and, consequently, consider this term, which it necessarily implies and which I have left in the shadow of this chapter in order to bring it up in the following part: *information*.

4. The Emergence of Complex Causality

I. From Endo-causality to Generative Causality

While the principle of causal determinism which governed classical science continued to ease into probabilistic causality of a statistical character, the very idea of causality stayed rigid, linear, stable, closed, imperative: everywhere, always, in the same conditions, the same causes produce the same effects. There could be no question of an effect disobeying the cause, there could be no question of an effect affecting the cause by retroacting on it, and, without ceasing to be effect, become causal on its cause which becomes its effect while still remaining cause.

Now, just the idea of retroaction affects, and much more profoundly than it seems at first sight, the simple, external, anterior, imperial, classical idea of causality.

Retroaction returns to the loop, that is to say to the organizational autonomy of the machine-being. Organizational autonomy determines a causal autonomy, namely *creates an endo-causality*, not reducible to the “normal” play of causes/effects. In these conditions, we must consider:

- the existence of a causality which is generated in and by a process producer-of-self, which we can call generative causality;
- the character simultaneously disjointed and associated, complementary and antagonistic, of exo-causality and endo-causality in a complex of mutual, interrelated causality;
- the introduction in causality of an internal uncertainty.

The Disjunction between External Cause and Effect

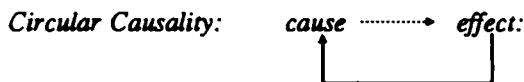
Every system, in producing its internal determinism, imposes on its territory and, as the case may be, on its surroundings constraints which prevent certain external causes from having their normal effects. Whereas statically organized systems passively resist the hazards and determinisms of the environment, dynamic organization resists actively: the retroactive loop, which assures and maintains its internal determinism, absorbs or corrects the random perturbations which threaten the existence or/and the functioning of the system; it reacts by “response” which neutralizes the effect of the external cause. And,

wherever retroactive causality comes into play, from wild motors to living beings, the effects of external causes are neutralized, stopped, diverted, deformed, transformed. External causality cannot function directly and mechanically, except when its aggression exceeds the tolerance threshold of the organization which it then destroys.

The annulment of deviance (negative retroaction) is the very process of annulment of effects sprung from external causalities. Whence the idea, formulated by Bateson (Bateson, 1967), of a negative causality which flows logically from the idea of negative retroaction and which develops wherever there is regulation. Thus, a drop in the outside temperature should bring about a drop in the temperature inside the house of the living organism. Now, this internal temperature remains constant, despite external fluctuations. The cause does not entail its effect, and the important thing, from the point of view of external causality, becomes *what has not taken place*. Retroaction has not annulled the cause, it has annulled its normal effect.

The idea of negative causality has not only the meaning of annulment (of normal effect), it also has the meaning of inversed or antagonistic causality. In fact, maintaining the temperature in a room or an organism corresponds, not to an isolation insensitive to the external variation, but to a heat-producing activity: the cooling of the surroundings triggers an increase of combustion in the boiler, stimulates in the homeothermal animal the thermogenic centers of the thalamus, which triggers the production of heat. This is to say that the external cooling provokes, in fact, internal reheating. We have, therefore, a causality which provokes an effect contrary to the one which it should have provoked.

Thus, negative retroaction is capable of annulling, diverting, transforming, opposing, even reversing the effects of an external causality.



Self-generated/Generative Causality

It is evidently because a looped causal cycle is created that there is relative disjunction between external cause and appeared effect. There is no annulment of the external cause; rather, in a complex (complementary, antagonistic, concurrent) relation with external causality, there is production of an internal causality or endo-causality. Therefore, Bateson could have insisted on the idea of positive causality, at the same time as on the idea of negative causality

(from the external point of view), that is to say on the active and productive character of endo-causality.

Endo- and exo-causality are different in nature. Endo-causality is local, and exo-causality is general. Exo-causality comes from a diverse play of forces, not necessarily or principally organized; endo-causality is tied to a singular active organization. Exo-causality is statistically probable. Endo-causality is marginal, improbable with respect to determinisms and external physical risks, and it probably resists this probability by its own recursivity. *Circular causality, that is to say retroactive and recursive causality, constitutes the permanent transformation of states generally improbable into states locally and temporarily probable.*

External causality (which, we must repeat, is the same as classical causality) can explain only states of equilibrium or disequilibrium. It is only with circular causality that stationary states, homeostases, are constituted, which repel external causality from the looped zone.

Finally, the retroactive loop can produce reactions, counteractions, which in annulling exo-causality, protect and maintain endo-causality. Endo-causality is thus able to produce original effects.

We see here that the fundamental deficiency of behaviorism, in conceiving reaction as the mechanical extension of stimulus, was to be unaware of the original causal source of behavior.

Endo-causality implies production-of-self. In the same movement in which the self is born from the loop, there is born an internal causality which generates itself by itself, that is to say a causality-of-self producing original effects. The self is, therefore, the central figure in this internal causality which generates and regenerates itself by itself.

Now, this central idea of causality-of-self, generating its own effects, has been doubly stifled, sandwiched between classical external causality and the idea, revived thanks to Wiener, of finality. As we are going to see, it is not only more ample and more profound than the idea of finality; it is its foundation.

II. Finality and Generativity

The Turnabout of Finality

(from the Teleology of the Clock-maker to the Teleonomy of the Clock)

Western science had been founded and developed by extirpating from its womb every principle of finality.

Finality was driven easily enough from physics. It was expelled from

biology with difficulty and only incompletely. This is understandable: the ideas of goals and purposes were clearly evident in ontogenesis, physiology, behavior. Driesch's experiment in 1908, in proving that each half of a sea urchin embryo cut in two managed to reconstitute a complete adult organism, clearly showed the domination of purpose (the constitution of an adult organism) over external causalities. But how to understand this finality in a non-Providentialist way? The idea of finality, even rinsed out and disinfected, still gave off a mystico-religious odor. Therefore, the problem was suppressed, like every bothersome unresolved problem. We persuaded ourselves that action/reaction, stimulus/response, which gave primacy to external physical causality, were sufficient for the "objective" study of the organism.

When finality seemed consigned definitively to the dungeons, included in biology, it returned in grand theoretical pomp (Rosenblueth and Wiener, 1950) in an integrally physical science, that of cybernetic machines.

It was not at all for these founders a matter of drawing our attention to the fact that each part of the artificial machine and the machine itself were conceived, constructed, and used in precise, definable and verifiable goals. These finalities are of an anthropo-social character and do not directly concern *physis*. The discovery of Wiener/Rosenblueth was that *the theory of machine needed the concept of finality to explain physical processes which could not be described according to classical causality*. It was necessary to call upon finalist ideas of norms and goals to explain the regulated states of a machine, unexplainable according to ordinary causality. Everything which is conceived in the machine, beginning with the notions of program, communication, control, is inconceivable according to classical determinisms, which are unaware of the notions of retroaction and information; on the other hand, the organic link which Wiener established between information and retroaction entails recourse to the ideas of norm, goal, finality.

It is by the intermediary of cybernetics that finality has been reintroduced at the heart of the fundamental theory of life. In fact, cybernetics offered molecular biology, which needed an organizational armature, its concepts of code, program, communication, translation, control, direction, inhibition, and of course, retroaction. The cell appeared from then on as a fabulous automated factory where each operation, each function had its own precise, verifiable goal, the complete set of these goals being conjugated in the grand finality: to produce, to organize in order to live. This living machine appeared, therefore, naturally as a *goal-seeking machine* endowed with *purpose behavior*.

Finality, therefore, was rehabilitated. But it was not the one which had been deprived of all scientific rights. "Vitalist" finality was welcomed with open arms: it came from technology, under the label of computer programs,

with total machine-made guarantee. It was no longer the teleological idea, coming from the general designs of Providence; it was a teleonomical idea, localized in machines, including the living machine. It did not emanate from a superior mind guiding the world. It sprang from the cellular machinery.

Purpose Causality

From then on finality becomes not only explicable, it becomes explicative, that is to say causal. Finality is an internal causality which stands out more and more precisely, actively, determinantly, wherever there is an information/program to command the performances and productions. The notion of performance takes on prominence precisely in function of the idea of goal: performance consists in reaching a very definite goal despite the perturbations and hazards which arise in the course of action.

Thus, the productions, performances, regulations in the artificial machine as well as in the living organism are evidently goal-purposed.

Purpose causality is an aspect of endo-causality. Its particular character with regard to classical determinism is not to take shape until the goal (the effect) is achieved. It can, therefore, remain virtual and invisible as long as the being or organism is in repose or latency, like a grain of wheat hidden in the great pyramid and, though dormant for a few thousand years, germinates as soon as we put it back into favorable conditions.

Purpose causality, unlike classical determinism which is merely constraint, expresses actively and praxically the virtue of endo-causality: to produce autonomy and, beyond, possibilities of freedom. It is precisely what allows us to understand the development of strategies and decisions which have meaning only with respect to a/some finalities. From then on, the living being subjects its environment to the effects of its own finalities; enslavement can be conceived in this sense as an overflow of generativity and finality into the territories of exo-causality. In sum, purpose causality, which is opposed to external causality, can, in given conditions, enslave this causality. Thus it is with man who enslaves the "Laws of Nature" themselves, by imposing on external determinisms the overdetermination of his own finalities.

The return of finality in the chariot of cybernetics has been triumphal. Inscribed in the pragmatic constellation of the notions of program/information/retroaction, circumscribed and made trustworthy in teleonomy, it filled the gaping holes left by classical causality. From then on, cybernetic finality became the new cream-pie of facile explanations with which we believe we have finally resolved the enigmas of life; too facile because they drive back into the shadows the original problem which the new idea of

finality should, on the contrary, bring to light: unlike the artificial machine, conceived by a superior being which constitutes its providence and gives it beforehand its program and goals, the living machine came from a lower state of physical organization, without *deus pro machina* or "information" or program: where does the "program" come from? where does the "information" come from? *where does the finality come from?*

The finality of artificial machines doubtlessly clarifies many functional aspects of living super-machine, but it hides its fundamental problem: that of a finality without finalist origin and intelligible destination. We are going to see: the idea of finality is incontestably necessary, but it is far too insufficient.

Uncertainty from Below: Finality as Emergence

Artificial machines are goal-purposed before existing. But arche-machines and wild motors exist without original finality and without functional finality. They are non-purposed interactions which have looped into retroactions in geneses: the star functions without preconceived design, without computer regulation, without program, in and by the antagonism become complementary of centrifugal and centripetal processes. There are no goals in the stellar machine. There is only a generative/regenerative loop in and by retroaction of the Whole on the whole. Yet, everything happens as if this recursive looping has self-maintenance as its goal. Let us say even: an immanent finality emerges in all loops, in all re-beginnings, in all regulations; each moment/element of the process seems to be both the end of the preceding one and the means of the following; and all these moments seem moved by the immanent finality which would be like the perpetual re-beginning of the loop.

We are, then, in the prehistory of finality. All generativity generates a potentiality or an embryo of finality; every Self already becomes almost a "for-Self" [Fr. *pour-Soi.*] But there is no finality yet. Finality emerges really only at the level of a communicational organization which has apparatuses of computation/control/command. Thus, the living machine is truly constituted of purposed processes and elements. Molecules in cells, cells in organs, organs in organisms are quasi-specialized according to quasi-programmed tasks which aim at achieving goals, and all these goals meet again in the global goal: to live. We can even say that this living being which self-purposes is the purposed product of the reproductive act from which it sprang. We can thus trace procreation by duplication back up to the origin of life. But there, not only do we find once again the same absence of given finality as for natural physical machines, but especially this specific problem: how does finality

spring from non-finality? How does a random process of encounters and interactions between macro-molecules lead to purposed "cybernetic" organization? How could RNA and DNA molecules, previously not "coded," have been able to possess information able to reproduce and control the proteins *with which they were not yet associated*? The idea of information, *ergo* that of program, *ergo* that of finality, cannot be anterior to the constitution of a first proto-cellular looping. We must, therefore, eliminate all idea of purposed process before the appearance of life.

A living being, like the sun, like every wild machine, is born from interactions which, haphazard and determinist, are all devoid of finality. We must, therefore, necessarily imagine, between the first nucleo/proteined looping and first cell carrier of an informational "message," an entire evolution across which organizational developments generate finalities. In such an evolution, the organizational traits which maintain the survival of the proto-living machine become more and more combined, adapted to each other in function of this survival, and becoming thus functional, they become quasi-purposed. Therefore, it is the development of a praxis productive-of-self which is finally going to produce the finality. The double and coinciding production (of molecules and of its own being) is going to retroact more and more to end-purpose the productive system and end-purpose the operations, arrangements, elements, mechanisms, actions which concur to this production. This process is inseparable from the constitution of a proto-apparatus which apparently "programs" the operations in function of the metabolic and reproduction goals.

Thus, every organization producer-of-self carries the seed to produce finality, which can emerge only with organizational developments having the constitution of a proto-apparatus controlling and linking the generative loops and phenomenal activities. Finality is a product of self-productive production.

Thus, biological and, of course, anthropo-social finality is immersed in a recursive process of generation-of-self of which it is a part. It is the immersed and informational face of this generation-of-self. Given that, finality is an immergence born of the complexity of living organization in its communicational/informational characters. It is not a character previous to this organization. It is clearly "teleonomical" and not "teleological." Whereas teleology starts from a clearly planned intention, teleonomy bathes in an obscure zone of immanent finality, and the recursive loop is itself immersed in a zone of physico-chemical interactions without finalities, wherein plays the dialectic disorder/order/organization.

Uncertainty at the Top: the Uncertain Goals of Living

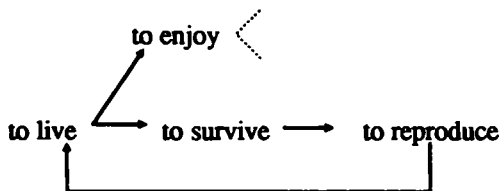
Artificial machines and living machines have in common some practical and utilitarian finalities, easily definable. Yet, the non-finality of the origins of life are echoed and reflected in the global goals of living machines, and even of artificial machines.

Thus, a wing has flight for a goal, that is clear; flight has displacement for goal, that is no less clear; displacement serves very numerous and varied goals (search for food, flight, migration, play, etc.) and all these goals have one common goal: to live. But if the practical goals of life are verifiable, the goal of the goals is uncertain. What is the finality of living? We can still discern two great finalities closely dovetailing: the finality of metabolic activities, which are concentrated on living; the finality of reproductive activities, which are fixed on the reliving of the species. But we cannot determine which commands the other nor decipher the meaning of the one or the other...

The artificial machine avoids this problem only up to a certain point. Paul Valéry said, "Artificial means tends toward a definite goal and thereby is opposed to life." In fact, the artificial being is conceived, designed, fabricated of very definite anthropo-social finalities. Thus, a factory has as goal to manufacture cars, which have as goal displacement, which serves in activities which are constitutive of the life of the individual in society and of the life of society in the individual. That given, the ultimate goals of the car—of every artificial machine—are not clearer than those of society and of the individual. What is the finality of the life of a human being? A social being? Here we find once again the double and troubled finality of the life of the individual, of the species, and of society.

Evolution towards still more complexity, up to anthropo-social organizations, has multiplied practical finalities, but has made more and more uncertain, equivocal, indeed concurrent, antagonistic, the two great finalities: on the one hand life polarized on the happiness of the individual, on the other the reproductive work of society and of the species. To be sure, these two finalities are admirably complementary, but can we clearly subordinate one to the other? It is by rationalization *a posteriori* that we give the priority to reproduction, to the survival of the species, and that we interpret in this sense all individual activities. But we can also reverse the proposition: Lupasco has suggested very pertinently that we do not eat only to live, we live also to eat, namely to enjoy. The more individualization there is, the less coincidence and harmony there is between living and surviving, and, among human beings, the search for enjoyment even goes so far as inhibiting the procreating effects of copulation.

To tell the truth, we sense that these two biological finalities shuttle between each other without, however, exhausting themselves “functionally” in each other.



They are drawn along in the great rotative and recursive loop of life where they become alternately or simultaneously ends and means for each other (living to eat, eating to live, living to survive, surviving to live, living to reproduce, reproducing to live). But at the same time, these two finalities each follow their own logic: these two logics, inseparable and complementary, have at the same time an antagonistic potentiality present in every phenomenon of life. And each is insufficient to define a finality for life.

Here arises the paradox: the living being, the most functional, the most richly specialized, the most finely multi-programmed of machines, is by that very fact the machine most purposed in precise goals in its productions, performances, behaviors. But as being and existent, it is not goal-purposed in its first origins nor in its global goals; the double finality of individual living and of reproduction cycle is marked by indecision and uncertainty... *What finally best expresses the finality of living is the tautology: to live to live; this signifies that the finality of life is immanent to itself, without being able to define itself outside of the sphere of life. This signifies that Wanting-to-live is a formidable finality, stubborn, frenetic, but with no foundation and no horizon; this signifies at the same time that finality is insufficient to define life.*

Uncertainties in the Circuit: Relativity of Means and Ends.

In the great retroactive loop every process appears both as the end of an antecedent process and the means of a subsequent process; and the two great finalities, to live to survive, to survive to live, can be considered as both means and ends of each other.

Whence this paradox which Kant had very clearly noted in the *Critique of Pure Reason*: “An organized product in nature is one in which everything is both ends and means.”

Indeed, in the rotation (biological or sociological) of means/ends, there are hierarchies, subordinations, in which finalities, parceled or local, at the level of small units or organs, are subject to the ends of the whole. In other words, the whole *enslaves* as means the particular ends prescribed for the parts. But we will see in the second volume of this work that, unlike the artificial machine, there is no perfect integration of local ends and general ends, of parceled ends and global ends. There is some "play," from the cellular and organismic level to the anthropo-social level, where the phenomena of play then become active factors in the process of evolution. Therefore:

—Complementary ends can become concurrent and antagonistic, as happens between the ends of individual existence and those of reproduction; in the very act of sexual coupling, reproduction and enjoyment, which can be conceived as means for each other (according to the point of view taken, that of the individual or that of the lineage), can also appear as two complementary finalities, which at one moment become antagonistic (conflict between the pursuit of enjoyment and the consequences of that enjoyment); and their conflict can, given the conditions, lead to the exclusion of one finality by the other (contraception).

—Ends are turned into means: thus, the constitution of multicellular beings, starting with an association become organic of unicellulars, instrumentalizes the finalities of the cells, previously autonomous, into means at the service of finalities emerging from the new multicellular organism.

—Means are transformed into ends; thus, with *homo sapiens* gastronomical pleasures and erotic enjoyment become ends to the detriment of alimentary and reproductive finalities; knowledge [Fr. *connaissance*], the means of surviving in an environment, becomes, with the thinking person become thinker, a finality to which he subordinates his existence.

—Finalities are displaced: the nerve cell is a sensory cell which has migrated in depth and whose finality has been totally modified; the parliament, born in England as an aristocratic institution to control the monarchy, is transformed into a bourgeois institution which annuls the power of the aristocracy.

—Finalities degenerate as a consequence of transformations, displacements, permutations of finalities which I evoked above.

—And, of course, unceasingly finalities are created—at each new looping or at each integration of element or new process in the loop¹—and unceasingly finalities die (at each transformation or disintegration of the loop).

The Uncertain Finality.

The Wienerian rehabilitation of finality has been able to be considered as an epistemological revolution with respect to behaviorism (Piaget). Much more, it makes us understand that the human and social sciences clung to the idea of finality (Comte, Marx, Tönnies, etc.), not because these sciences were "behind the times" in reference to the natural sciences, but because the eradication of all finality made their object unintelligible. The ideas of "project" must be considered, not as idealistic residues, but as efforts to recognize an inextinguishable dimension of individual existence (Sartre) and of social existence (Touraine). The progress of the life sciences and human sciences neither can nor must be effected by reducing being to behavior, then by reducing behavior to an external causality.

Thus, the idea of finality is evident. But we must not only temper Piagetian enthusiasm: we must relativize and rationalize the idea of finality.

Even for artificial machines, which are goal-purposed not only at the level of their physical organization but also at the level of the praxic finalities of the society which produces and uses them, the idea of finality becomes cloudy and uncertain as soon as we consider in depth their anthropo-sociological rooting. The idea of finality is evident, clear, without fault, for living, human, social beings, as for artificial machines, only in the median zone of functional specializations, programmations, actions, and utilitarian performances.

The error is not only to reduce the universe of life, of man, of society, to that of artificial machines; it is also to reduce the universe of artificial machines to artificial machines. The error is in the cybernetic rationalization which neither wants nor is able to see in the living being and in the social being only an oiled and functional machine which forever asks to be more oiled and functionalized. This purpose rationalization becomes symmetrical to the former elementary causality, for, like it, it drives out uncertainty and complexity. The error is the very error of technocratic thought which has made the arbitrarily isolated artificial machine the *eidolon* of all life, the new idol, the queen of the robotized world! Finality is indeed a cybernetic emergence of life, but it emerges in *complexity*. Be it at the level of the organism, the individual, reproduction, the species, the eco-system, society, the idea of finality must be both integrated and relativized, that is to say complexified. It is a notion neither clear nor distinct, but blinking. Complexity reinforces it but also obscures it. Practical goals, functional operations are clear and evident, but then enmesh with finalities less and less clear, less and less evident...

Wherever there is finality, in the artificial machine as well as in the living

being, finality dissolves at the roots, becomes hazy at the summit. It always returns to some infra-finality, that is to say to the genenic processes whence productions-of-self and machine-beings are born. It returns to some extra-finality, existence, this non-rationalizable quality, which blossoms in life, which finality can neither encompass nor articulate. It returns to meta-finality, where master goals are concurrent, antagonistic, uncertain, and undiscernible, even non-existent...

Finality is an idea open to its opposite, tied to its opposite. It is born from non-finality. It is dissolved by excess of complexity. It lacks all transcendent support. Uncertain at the base, uncertain at the top, it is unstable, transformable. *Finality is really an emergence*: it is born, it dies, it metamorphoses. It is born with the loop which, at the same time, constitutes the finitude of every machine-like being, and, enclosed in this finitude, it is open to what has no end.

III. Endo-eco-causality

Piaget thought that the introduction of finality in science constituted a paradigmatic revolution and resolved the old quarrel between determinism and finality. In fact, we have seen that the introduction of finality must be subordinated to that of generativity (remained unperceived), must be relativized and complexified.

There is no progress in substituting a new finalist simplicity for the former anti-finalist simplicity, and all the less so that the anti-finalism of science had precisely as virtue to suppress and exclude purposed simplism. The expulsion of finality from scientific method was not only mutilating; it very usefully stopped for a time this hemorrhage of finality which the human mind naively secretes onto all things to give them *meaning*.

Progress is to integrate finality in internal causality, which proceeds from generation-of-self, and to conceive this generative internal causality—endo-causality—in its complex relation with exo-causality. This done, there is no "resolution of conflict" between finality and classical determinism; there is a necessary maintaining of conflict within a complex relation, that is to say complementary, concurrent, and antagonistic, between endo- and exo-causality. We saw this in the example of homeothermia, or of the boiler with a thermostat; internal causality (reheating) is complementary to external causality (recooling), and it is at the same time antagonistic. Complementarity and antagonism even appear as the two faces of the same phenomenon.

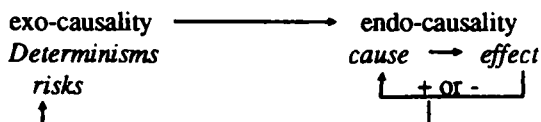
Endo-exo-causality is, in fact, a "mutual causality interrelated." (Maruyama, 1974) This mutual causality constitutes, with respect to both

causalities, a sort of meta-causality made from their absolutely complementary association (the principle of opening obliges us to conceive of no active organization at all without the active and intimate co-presence of external causality).

At the level of living organization, the endo-exo-causal relation becomes an auto-exo-causal relation. This is to say that organization-of-self, become auto-organization, is endowed with a greater autonomy, but also a new dependence with respect to the environment, become eco-system itself obeying forms *sui generis* of generative causality. Which signifies that relations between endo and exo attain therein a very high degree of symbiotic complexity and interpenetration, since the eco-system is constituted by these living beings, which themselves are constituted in and by their ecological interactions. Finally, let us indicate here already that internal causality overflows onto the environment in its products, by-products, behaviors, enslavements, but the eco-system in turn retroacts on the enslaver/polluter by subjecting it to new dependences and to the repercussions of its devastations.

Therefore, the paradigmatic revolution is not in the repromotion of finality; it is in the meta-concept of endo-exo-causality, which corresponds to endo-exo-organization, which with life becomes auto-eco-organization.

Complex causality, therefore, includes:



It takes off and develops an infinite combinatory dialectic:

a) *Like causes can lead to different and/or divergent effects.* In fact, there is difference and divergence when the same cause triggers, here a regulation or reaction which cancels the foreseen, there a positive retroaction which amplifies it. Moreover, positive retroaction can itself entail the ruin of the system in which it develops, or its transformation, or even new morphogeneses by schismogeneses.

b) *Different causes can produce like effects.* Diverse external causes which could cause many similar systems to evolve in a divergent manner find themselves quasi-annulled by the countereffect of negative retroactions under informational control, and the systems, though diverted or deviated from their process, obey an equifinality² which leads to the same effects.

c) *Small causes can bring about very large effects.* A coincidence between a small disruption and momentary but critical failure in a correction

device is sufficient to have a chain process of destructure or transformation entailing enormous consequences develop from a local deviance.

d) *Great causes can entail very small effects.* Inversely, the effect of an enormous disturbance can be quasi-annulled at the end of the entire system's work to regulate and reorganize.

e) *Some causes are followed by opposite effects.* Thus, a cause triggers an inverse counteraction, as recooling provokes reheating in a homeothermal organism. In certain cases the opposite effect resulting from the counteraction becomes the single and true effect of the initiating cause; thus, the principal result of a sickness overcome is to toughen and immunize. The final effect of a revolution can be the counter-revolution it triggers, as the final effect of a reactionary process can be the revolution it triggers by repercussion.

f) *The effects of antagonistic causes are uncertain:* (we do not know if the retroactions which will win out will be negative or positive).

Thus is born and brought forth the range of complex causality which will find development only in life (understood in its full meaning which includes eco-systemic interactions and biological evolution) and especially in the history of individuals and human societies.

And endlessly there arise unintelligible paradoxes of causality in the old simplism of mechanical determinism: causalities interact and interfere with each other in a haphazard way: great causes produce great and/or small effects, small causes produce small and/or great effects and the combination of expected effects, unexpected effects, opposite effects gives to life, and especially to historico-social life, its own physiognomy.

Complex causality is not linear: it is circular and interrelational; cause and effect have lost their substantiality: cause has lost its all-powerfulness, effect its all-dependence. They are relativized by and in each other, they are transformed into each other. Complex causality is not only deterministic or probabilitory; it creates the improbable; in this sense, it no longer concerns only isolated bodies or populations, but individual beings interacting with their environment.

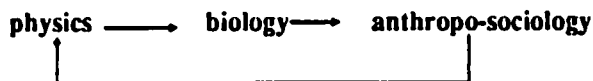
Complex causality embraces a complex of causalities diverse in origin and in character (determinisms, risks, generativity, finality, retroactive circularity, etc.) and always includes a fundamental endo-exo-causal duality. To understand anything at all in life, in society, in the individual, we must call upon the complex play of internal and external causalities: internal events are not teleguided by logic from the outside and are not piloted by logic in a vacuum. Except in extreme cases, we could not isolate with certainty what in a new phenomenon constitutes the "decisive factor," the "determining element." When suddenly disorder, fury is unleashed, we can wonder: is it the

thrust which was too strong? or the resistance which was too weak?

Endo-exo-causal dialogic, dialectics have a haphazard character. This is to say that complex causality includes a principle of uncertainty: neither the past nor the future can be directly inferred from the present. (Maruyama, 1974) There can no longer be any assured explanation of the past nor arrogant futurology: we can, we must construct possible and improbable scenarios for the past and the future.

We must understand that the same causality can have a minute effect, or on the contrary, by amplifying, destructuring, morphogenetic retroactions which it will have triggered, it can avalanche for ever and ever!

5. First Epistemological Loop



I. Articulations and Communications

The Double Articulation

It has been possible to work out the notion of machine only starting from a notion relevant to anthropo-social praxis, which we had to isolate physically, in order to introduce it and have it travel in *physis* and in the cosmos, but which we had to reintegrate socially in order not to fall into irremediable ontological error: to make the machine artifact the archetype of all machine-beings. Therefore, we had to leave our society, return to our society, but in the course of this "inclusive tour" unlike the charter tourist who returns to his point of departure unchanged, the notion of machine had to work on itself, be transformed while being formed. The prodigal concept, at its return, carried the burns of the suns, the intoxication of the whirlwinds, it had known life, made life. It was not returning to retire, it was returning to start out again. The Wienerian machine itself had also taken a trip, but it was the "short tour," from the artifact to the organism, and back, and without the necessary Copernican revolution taking place, namely the satellization of the artifact around the living machine, not keeping the artificial machine at the solar center.

In the course of our trip I believe that not only communication from machine to machine took place, but a first double articulation between the non-communicating, non-articulated domains of physics, biology, anthropo-sociology.

The first articulation is constituted by the generic concept of machine-being, which as we have seen embraces physical organizations (stars, wild motors), biological organizations (living beings, eco-systems), and anthropo-social organizations (notably megamachines which historical societies constitute).

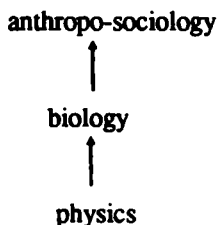
The second articulation is constituted by communicational organization (sy-cybernetics) which concerns physical beings (computers, artificial automats), all biological organizations, and all anthropo-social organizations.

The theory of active organization or of machine-beings covers, therefore, the three empires of physics, biology, anthropo-sociology, among which all common theorization still remains forbidden, because it is inconceivable, *unless it be reductionist*.

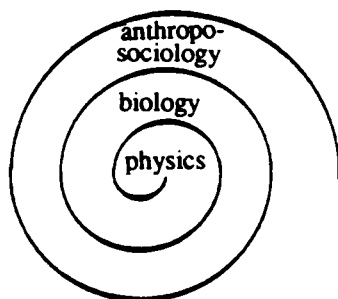
Now, we are talking about a complex and polycentric theory, which does not reduce the diverse machine-beings to the "simplest" model. Neither are we talking about reducing to the idea of machine, even complex and poietic, all that is living and human. And we also know here that if being and existence are beyond the reach of rationalizations, if they are beyond the scope of all "explanation," they can and must be categories absolutely recognized at the heart of theory.

Thus, we are talking here of an effort towards complex articulation.

We are talking indeed, *but not solely*, of founding the biological on the physical and the anthropo-sociological on the biological.



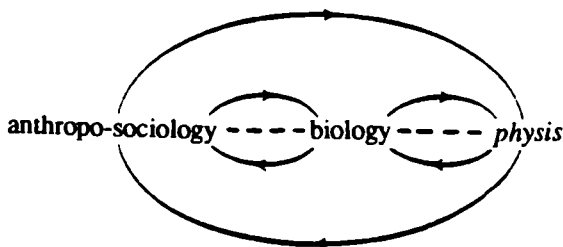
We are talking also, but not solely, of conceiving physical organization inside biological organization, and biological organization inside anthropo-sociological organization.



We are talking also, but not solely, of conceiving the physical concepts of machine, production, work, etc., as concepts emanating from our own culture and based not only on observations of "nature," but also on the organization of our mentality, which returns us not only to the organization of human understanding, but also to the sociology of knowledge.

society $\longrightarrow$ physical concepts

We are talking especially of looking for a point of view which could recognize and articulate the points of view expressed above and establish, on the basis of these articulations, *a circulation constituting a loop*.



Clandestine circulation and deliberate circulation

Now, such a circulation seems blocked because physics, biology, anthropo-sociology constitute three mountain ranges sealed off from each other. But in fact, there has always been clandestine circulation between the non-sciences and the sciences, as well as between the sciences whose customs control are always vigilant for factual experience, always laxist in conceptual verifications. Thus, the circulation between physics and the social experience has not stopped, as the fundamental physical concepts of work and energy which have passed from social praxis to classical physics attest. Better still: the terms communication, information, code, program, message, finality have emigrated from the anthropo-social experience to the cybernetics of artificial machines, then from there to biological organization, and they return under their new cyberneticized form to invade anthropo-social organization.

Now, it is not a matter of considering this circulation of concepts as legitimate *a priori*. I have shown it by strongly criticizing, in the preceding chapters, the modalities of this circulation. It is a matter of replacing clandestine circulation by deliberate circulation, of substituting a new mode of

circulation for the predatory raids, annexations, and enslavements of foreign concepts.

Here are posed the inevitable questions rejected and fractured by disciplinary fragmentation, hidden or ignored by transdisciplinary systemisms or cyberneticisms which do not pose the problems of their own foundation. We can state the problem in a simple alternative. What is the legitimacy of physical concepts which have come from anthropo-social experience? Are they not naively anthropomorphous and sociomorphous? What is the legitimacy of anthropo-social concepts which have come from physics? Are they not naively physicomorphous, that is to say proposing the reduction of anthropo-social dimensions to the one physical dimension?

In fact, from the outset the problem is posed in more complex terms. For we must think, from the outset, that every concept, even the most physical, is produced by a human mind, that therefore there is always an anthropomorphous side, that everything human always has a physical reality. Therefore, there is always, in every physical concept, the clandestine co-presence of an anthropo-sociomorphism: in every anthropo-social concept, the clandestine presence of a physical reality. The real problem, consequently, is to try to overcome *the combination of two naivetes and blindnesses which conjointly reign today, the one of reductionist physicomorphism and the other of reductionist anthropo-sociomorphism.*

We catch a glimpse here of the two impasses: the first is that of the abstract physicism of classical science for which we, anthropo-social observers, have not the slightest existence nor reality in the production of the physical object, which is revealed of itself in objective experiment and verification; the second first took the form of subjective idealism (the mind of the subject has produced an object which exists only in and by it), and today also takes the form of a sociological reductionism, for which the only reality is our society *hic et nunc*, which produces physics and biology among its ideologies; it is equally an idealism since human society finds itself launched in the air, in the clouds, without substratum, and becomes supra-physical and supra-biological; like subjective idealism, this vision locks itself in the vicious circle of solipsism, for lack of opening itself in a loop around the external reality which nourishes and co-organizes it.

Therefore, the problem is: how to join together what each of these points of view comprises of irreducible truth, without hiding what they have which is contradictory?

The Two Entries. The Double Reference System

The paradigm of simplicity imposes on us a drastic alternative between the physicomorphous point of view and the anthropo-sociomorphous point of view. Now, here we will be able to advance only by maintaining both points of view, that is to say by considering them as simultaneously complementary and antagonistic. It is a matter, then, of nourishing a reflection and a theoretical elaboration with a double entry. Consequently, maintaining the double entry in the concept of machine-being is necessary not only for the elaboration but for the very vitality of the concept.

The physical entry: every machine-being, living being, human, social included, must be considered a physical being. By that very fact, our anthropo-social notions of work, production, praxis, communication (and I add enslavement/emancipation) must be conceived in their physical grounding.

The anthropo-social entry: we have seen that the producer concept of machine was, in fact, produced by the society of the industrial era; we have seen that it was aberrant to isolate the artifact machine from its anthropo-social matrix.

Thus, it is not only the social idea of machine which must refer to the physical reality of machine; it is also the physical idea of machine which must refer to the reality of the social machine.

The Necessity of a Theoretical Loop

The problem of the link between the two entries is, therefore, the fundamental problem. How to find the meta-point of view which can consider both entries together, that is to say how to elaborate the meta-system which can integrate the two reference systems necessary, the physical and the anthropo-sociological? Now, here we can let ourselves be guided by what we have previously learned: *the meta-system can only be a retroactive/recursive loop*, which does not annul the contrary actions without which it would not exist but feeds on them and integrates them in a productive whole. *Consequently, the antagonistic character of the physicomorphous entry and the anthropo-sociomorphous entry then becomes not only what obstructs the constitution of the meta-system, but also what is necessary to that constitution.*

Here, then, the problem is to substitute a circuit for the reduction of one of these terms by the other: not

physics $\longrightarrow$ anthropo-sociology,

or:

physics ← anthropology,

but:



It is this recursive circuit, therefore, wherein the socialization of *physis* and the physicalization of society would become co-producers of each other, which should constitute the principle of the new theoretical vision. It is in and by this circuit that a double theoretical rooting could emerge, in "nature" and in "culture," in the "object" and in the subject.

This loop cannot be constructed in a twinkling by the will of the conceiver/theorist. If there is to be looping, random fumbling will be needed, trials and errors, comings and goings, exchanges, migrations, transfers, transformations of concepts; luck will be needed... If there is to be looping, it will not really be able to take shape before the end of the third volume of this work. But here already I have been drawn into a productive circuit by following in their tracks the concept of machine and that of communication. I am already obliged to confront the anthropo-social rooting not only of the artificial machine but of every machine, and the physical rooting of the anthropo-social machine.

II. *Physis* Regenerated

In eliminating spirits, genies, souls from nature, science had thereby eliminated whatever animates, whatever generates, whatever produces; or rather it had concentrated all these virtues into one single notion: energy.

Energy allowed us to radically found the anonymous and atomistic conception of the world, since energy itself constituted an entity able to be decomposed into measurable units, since energy could be inscribed in the impersonal laws of nature; having become the universal generator, energy allowed dispensing with organization, being, existence.

Paradoxically apparently, the nineteenth century installed the physical machine and excluded every idea of machine-being in *physis*. This is because it extracts from *physis*, by its machines, for its machines, the only thing which

interests it pragmatically: *generativity or motor force*.

Energy is the greatest concept which nineteenth century science elaborated, the only one which has not been touched in the routing of classical physics in the twentieth century. It is a notion which has necessitated a very long and difficult elaboration, whence its character both of extreme complexity and of extreme simplification.

It is a complex notion, indeed. Energy is simultaneously indestructible (first law), degradable (second law); polymorphous (kinetic, thermal, chemical, electrical, etc.), transformable (in mass, that is to say matter). Its principle of identity is, therefore, complex since it maintains its identity throughout its metamorphoses, its intangibility throughout degradation.

Now, this complex concept corresponds in fact to an extraordinary simplification of the physical universe, whose forms, beings, existents, organizations, and even finally matter we have suppressed, in order to consider energy as the only *real* entity.

This complex and simplifying notion is at the same time very abstract: no one has ever seen energy. This is why the notion of energy is the result of a very long elaboration: to construct it we had to destroy, that is to say disintegrate, forms, organizations, beings, existences.

Now, this very abstract notion is also terribly concrete. The extraction and manipulation of energy is achieved by the concrete destruction or concrete enslavement of the forms, beings, organizations of which it is part. The localization and measure of energy, that is to say the force to work, is what opens the door to manipulation, transformation, unlimited power! Thus, whereas, in society, machine and energy go together, energy is unaware of organization and natural beings because it is artificial machines which extract and use energy for anthropo-social organization. Thus, energy by achieving in an absolute way the atomization of the physical world, achieves by that very fact the enslavement of nature by man. All progress in the manipulation of energy corresponds moreover to a regression of being and existence: the steam-horse evicts the dung-horse.

Thus, energy accomplishes this marvel of the greatest physical reductionism we can conceive (since all forms, organizations, existences are reduced to an energy entity) and in this sense it is a concept apparently totally physicomorphous. But this concept apparently physicomorphous is in fact integrally anthropocentric, and even anthropomorphous, since energy is defined by the capacity to work.

Energy is a typical cause of what Whitehead called misplaced concreteness. Concrete it is: it corresponds to motricity, to generativity, which are latent or active in all organization, from the core of the atom right up to the

sun; concrete is the manipulation of energy, manipulation by energy.

But true "concreteness" is in human and social beings, in motor machines and in whirlwinds, in the turbulences, explosions which they produce. Natural concreteness is in organizations, beings, existents... And it is this concreteness which finds itself hidden...

Here we can better understand the difficulty of the problem of the relation between science and ideology. The concept of energy is not "false." I have even indicated that it was, in its very simplification, a concept singularly complex, therefore having its own richness which is not only pragmatic. What is grave is the hypostasis of the concept of energy, which hides whatever obstructs manipulation. What is grave is that the manipulation of the concept of energy allows us to cut communications, to rub out organizations, to ignore beings. The ideology of energy is the opposite of the archaic myth. The archaic myth put a soul in the whirlwind. Atomizing ideology has finally devastated the universe, on which the mythology of man was able to unfold, man sole being, sole existent, sole organizer, sole animator, sole creator. In this sense, the concreteness of energy corresponds to the industrial organization of enslavement. The ideology of energy is not to add, it is to cut back, cut, scotomize, hide.

The formidable success of classical physics must not mask from us its basic deficiency. Such a physics has been able to treat the reality of *physis* only by disintegrating it. It is not only deprived of all principle of organization and generation: its very logic destroys organization and generativity; we understand, then, that biological or social beings, which are nonetheless physical beings, are totally unintelligible to it.

Now, generalized machine theory allows us to repopulate and reanimate *physis*, by reviving beings therein, by finding existence once again, by rediscovering the self therein, by restoring to organization its generative and productive truth.¹ Machine-being theory necessarily integrates energy, but it no longer allows us to conceive energy only atomistically and isolatingly. In the same movement the idea of polymachine is opposed to every isolationist conception of machine; the idea of open organization situates every machine-being in an organic relation with its environment. The universe is not only repopulated and reanimated, it is made solidary. There does not follow a euphoric beatification of *physis*, presented as a paradise of harmony. This type of vision grieves me as much as the other horrifies me. Both expel from *physis* and the cosmos the infinite tragedy of destruction and dispersion, that Shakespearean dimension, which is not only in Shakespeare, not only in human history, but which is the history of chaos/*physis*/cosmos.

This understood, we can conceive a generalized *physis*, that is to say

directly concerning all that is organization, being, therefore the phenomenon of life and the phenomenon of man. *Physis* has to be complex at the beginning (in order not to be reductionist), and it has to possess a generative principle. Now, the concepts of active organization, recursive loop, machine-organization show that there is in the universe, present in machine-beings, not only the genesic principle of encounters which organize, but the principle of generativity, *poiesis*, and production. A generalized physics is possible as soon as we conceive a generalized *physis*.

On the other hand, such a physics must be complex, not only in its genesic principle, but in its very conception of machine-being. If the notion of machine is simple, like that of the cybernetic artifact, then all generalizations become denaturing and mutilating. Yet, if it is complex, then we are justified, in principle, in projecting in it anthropo-sociomorphous notions like production, work, organization, machine, as well as projecting physicomorphous notions on the anthropo-social being. In other words, articulation and anthropo-physical looping necessitate generalized complexity.

Such a physics will be able to be much less dominating or imperialistic, since it will forever visibly bear its umbilical cord which ties it to the conceiver-subject, and through the conceiver, to the human mind, culture, that is to say the profound organization of society. And that is what will be able to allow us consequently to conceive a *physis* becoming, through evolution and relays, generative of anthropo-social generativity, itself generative of a science which generates this *physis*...

III. Life: Poly-super-meta-machine

The physical rooting of all that is life is not only in the chemical character of all the operations of an organism, nor, of course, in sole obedience to the laws of Nature, like that of falling bodies. It is especially organizationist in nature: belonging to the Gadget [Fr. *machin*] family. *Living beings can be defined as physical beings, producers-of-self endowed with original qualities called biological*, the term biology returning to the specific complexities of their organization and to the global emergences undissociable from these beings insofar as wholes. Thus, the idea of living machine grounds life in these fundamental categories of physical organization: organization which produces and organization which organizes, looping organization and open organization. Therefore, the idea of living machine, not at all understood in the old clockwork and Vaucansonian meaning, not at all understood in the meaning deformed by cybernetics taking the artifact as a model, becomes of capital theoretical importance for determining the relations between physics and

biology. Life is an organization, we will see, super- and meta-machine-like, super-and meta-cybernetic, but not meta-physical. It brings to prodigious levels—which the word biology encompasses, signifies, and masks—the organizational virtues of permanent reorganization and production, the existential developments of opening and looping... However, and excuse me for repeating but I must be vigilant with regard to reigning dullness, it is not a matter here of reducing the biological to the physical. It is a matter of regrading the physical by restoring its power, not only to organize, but also to produce. By that same fact, it is a matter of founding one of the two primary bases of the unity of the sciences: a complex *physis*. It is even less a matter of conceiving the living being in the robotic and Pinocchioesque image of the artificial automaton. It is a matter of conceiving it as a Petrouchka, automaton escaped from the deterministic strings of the former physics, which lives, suffers, loves, dies, and once dead becomes once more a doll full of sound—I mean of chemical material. It is much more than a matter of considering the living being as an isolated machine (organism), it is a matter of conceiving a poly-machine-like totality (biosphere) constituted spatio-temporally of eco-systems, reproductive cycles, individual beings in which affectivity and intelligence are going to emerge.

Likewise, it is a matter of conceiving life as super-machine. Life is super-machine, super-cybernetic, super-automaton, because it develops, not only some characteristics atrophied or embryonic among artifacts (regulations, homeostases, interplays combined of positive/negative retroactions, mutual enslavements, unheard-of developments of communicational organization, but also some virtues unknown to other machines, among them individual *autos*, self-reproduction and geno-phenomenal organization. (cf. Part Three, ch. 2, and Volume II)

That being said and having to be said, we cannot lock the concept of life in the concept of machine or of automaton. The concept of life contains them, overflows them, goes beyond them, and it is that concept which encloses them. Although we have been able to find in physical organization, not only basic concepts for living organization, but also in a certain way the ideas of being and existence, we are not yet into life, neither organizationally, nor ontologically, nor existentially. Life is a phenomenon meta-machine-like, meta-cybernetic, and as we will see in Volume II, I will look for the "life of life" beyond systems, machines, automatons, while necessarily including the physical ideas of system, machine, and automaton.

That in its turn having been said and having had to be said, we must consider how much life, while being super-meta-machinist, is closer to *physis* which organizes than is even strictly physical artificial machine. In fact, if

artifacts are physical beings, they always need an anthropo-social *deus pro machina* to conceive them, fabricate them, bottle-feed them, change their diaper, maintain them; without human sap or social nourishment, they lose their machine qualities, find themselves reduced to the state of things, deteriorate, and ruin themselves. Life, though, does not need any *deus pro machina*, any superior envelopment, any supra-biological sovereign in order to live. The artificial machine is the Mongoloid daughter of formidable social megamachines constituted of beings with large brains. The living machine is an orphan, born in slime, swirls, accidents, in the genesic play of random interactions. Here we come upon an admirable paradox: the artifact, a strictly physical machine, is much less physical than a living being. To be born it needs the organizing mediations of life, humanity, the industrial society. Its placenta is bio-anthropo-social. Whereas the living super-and meta-machine was born of physical processes and nothing else, life, born from non-life, needs only life to be reborn. Likewise man, born from non-man, without demiurge creator, is closer, in this sense, to *physis* than is the physical machine he has created.

Therefore, here we are, entirely led out of the well-known alternative which summons us to choose between physical reductionism and vitalism. Here on the contrary, the plunge into *physis* is more radical than in all physico-chemical reductionism, and recognition of the irreducible originality of life is all the more solid as it is no longer opposed to *physis*. We must understand that the source of what ties (life to *physis*) is also the source of what separates. To progress in this idea, we will have to examine a mysterious term, which establishes both the link and the separation, a term already evoked in this chapter, but not yet treated, and which will soon necessitate examination: information.

IV. Anthropo-sociological Articulation

Psycho-physical Articulation: the Intelligence of a Machine

The development of computers seems to have been done, from the physical to the psychic, by hopping both feet together over the biological. Machines, even those commanded by computers, have acquired only a few secondary traits of living organization. It is, therefore, all the more amazing that computers have acquired certain non-secondary qualities of the human mind:

—memory (although computer memory is radically different from cerebral memory),

ARTIFACT	LIVING BEING
origin: <i>deus pro machina</i> ; no self-reproduction	origin: interactions and physical encounters, then cycles of reproduction
negative retroactions, positive retroactions, destructive except occasionally	negative retroactions dialogically linked to positive retroactions; complex positive/negative relation
regulating looping, autonomy; automatisms, no permanent self-reorganization	existential looping, automatism, with permanent self-reorganization
functionally open machine; dissociation between being, work, tasks, finality	functionally and existentially open machine; no dissociation between being, work, tasks, finality
the ends are clear, distinct, external, but become obscure as soon as they are confused with anthropo-social finalities	the ends are obscure, ambiguous; the living machine is and is not its own end
disorder and "noise" degrade the machine	the living machine can exist only with disorder and noise in complementary, concurrent, and antagonistic relation
machine-being	existential being super-meta-machine
physical object, with certain biological and psychic traits	objective subject (<i>autos</i>)
dependence with regard to the anthropo-social mega-machine	inseparable from a poly-machine-like whole having eco-systems, reproduction cycles, individual and social interretroactions
communication depends on command	command/communication relation, complex in principle

- computation (not only calculation, but logical operations in the treatment of information),
- pattern recognition,
- learning,
- problem-solving,
- decision-making.

This is of crucial theoretical importance concurrently for physical theory, for life theory, for anthropo-social theory.

First of all, we realize that some key operations of the mind, some intelligent qualities, some traits of thought stem not only from electronic operations, but from strictly physical phenomena of organization. There is a physics of intelligence (Auger, 1966), and I will come back to it. But this intelligence, often superhuman by its computation capacities, has neither the intelligence of life nor the life of intelligence. These computers do not take disorder, do not know how to handle the hazy or the crazy, are incapable of fantasy, imagination, creativity. Now, these are precisely the traits—seeming defects (presence of blur and disorder) and striking qualities tied to these defects (inventiveness, creativity)—which are common to living organization and human intelligence.

That being said, it is clear that a footbridge henceforth connects the physical organization of the computer and the organization of human intelligence. The computer demonstrates that at least certain qualities incontestably spiritual stem from physical organizationist virtues, which can operate without needing biological organization (although they are born thanks only to biological evolution, whence came intelligent living beings, creators of artificial machines).

That certain traits of thought can exist in a purely physical being, not only non-human but non-biological, is of considerable epistemological import; there is no longer this total incommunicability, this absolute disjunction between the world of the physical "object" and the world of the thinking subject. (Gunther, 1962, p.330) For the first time in the modern history of the Western world, the two universes of Mind and Matter, of Subject and Object, forever disjoined, have found a way to communicate. From the seventeenth century to behaviorism inclusively, the mind was judged by science unworthy of science, while metaphysics judged science unworthy of the mind. The mind never seemed to have to reintegrate a science which in its very principle denied the mind's existence and action. The mind has re-entered by the balcony of machines, through the service door of computers, penetrating thus to the very heart of physics. The physical return makes the old materialism triumph, for which there existed nothing which could be above *physis*, but at the same time

it annihilates it since the mind, according to this old materialism, could not correspond to the slightest organizing reality.

Social Physics

The concept of machine directly concerns and challenges us concomitantly by living organization since we are living beings endowed with a neuro-cerebral apparatus, by the very organization of this apparatus, that is to say the organization of the mind (the mind being conceived here as the emergent totality of the brain as organization), and finally by social organization. We have already given a few elements on socio-physical articulation (or "social physics," very different from the one which Auguste Comte had conceived) in the first chapter of this second part where, thanks to Lewis Mumford, the theme of the social megamachine emerged. The theme of the State equally emerged in the third chapter with the theory of apparatuses. In Volume II I will tackle head-on the properly sociological problem of organization.

'We Are Machines'

Thenceforth, a "we are machines" is no longer the technocratic revival, under the aegis of the computer, of the Cartesian reduction of the animal to the machine-like (understood in the mechanical sense) and of the LaMettrian reduction of man to machinalized animal. The kinship between the machine-like and the living is the inverse of what Descartes and LaMettrie had believed: both scotomized from the idea of machine everything which was intelligence, mind, subjectivity. Descartes wanted to debase the animal in respect to man; LaMettrie wanted to debase the mind in respect to matter. Now, here we are upgrading the machine and physical organization at the same time, without in the least degrading the animal, the mind, man. "We are machines" is for man, not the quest for reduction, but the quest for origination. This origination is not in the artificial machine, it is in the living polymachine, itself part of the system of the solar machine. This origination is in depth in *physis* as organizer. It returns us, not to mechanical laws, but to a complex logic. "We are machine" teaches us about the organizational background, praxis, producing, communicational, of our individual and social being.

Besides, in plunging into the physical archaeology of our machinality we plunge thereby into the archaeology of the key notions of the trivial vocabulary which we use unceasingly, never pondered, never grounded, but always molar:

work, transformation, production, praxis, communication, information, apparatus, enslavement, emancipation. Much more: How to talk about the production of man by man without conceiving this machine-being?

Finally, the "We are machines" reintegrates us in the Machin family; I mean our earth and our sun, our winds and our rivers; it assembles and connects us by genealogy to the milk of our nebula, to Elohistic geneses...

V. The Wheel: Vicious Circle and Productive Loop

We are machines—and at the same time we are the ones who produce the concept of machine. This concept of machine, we are the ones who have inscribed it at the heart of physics, we are the ones who have constituted its generativity. Thus, we, sires of the concept of machine, we consider ourselves generated by bio-anthropo-social machines, themselves generated by the producing/organizing virtues of *physis*, that is to say machining and machine-like virtues. Once again we meet the great paradox, but this one is inscribed in the necessity, proper to all knowledge, of generating concepts in order to conceive its own generation, which comes from a praxis anterior to the concept which will designate it. Here, I must conceive myself inasmuch as subject historically and culturally situated and dated: I project the concept of machine in a reality external and anterior not only to me and my culture but to humanity and to life itself. Now, this question must be pursued thus: whence comes the one projecting, whence comes his culture, whence comes his society, his humanity, his life, if not from a *physis* endowed with organizing qualities wherein appear machine-beings? A loop is formed, wherein the machine becomes co-produced by the pressure of the "object" (*physis* organizing) on its observer/conceiver and by the expression of the subject (who draws upon his scientifico-cultural capital). The loop can be constituted only on condition that there be critical reflection on knowledge and science themselves, that there be the possibility of critical distancing with respect to the society of which we are a part (society which is both obstacle to and means of taking stock of the complex concept of machine). Thereon in we can trim the concept of machine on *physis*, and on our society, and on the "object," and on the subject. Thereon in this concept of machine, on the one hand, retroactively, founds us and confirms us in our physical organization; on the other hand, it reminds us that its elaboration is inseparable from our anthropo-social experience *hic et nunc*, which is by no means a scaffolding that we can dismantle once the building has been finished, but which continues to be part and parcel of the structure itself.

Thereon in the artifact, which stopped being the falsifying model of the

concept of machine, becomes the pivotal notion, for it participates closely, both in our most concrete and most immediate anthropo-social universe and in *physis* in what it has of non-biological and non-anthropological. It is both essentially physical, conceived as an isolated being, and essentially human, conceived in its anthropo-social matrix. It is, therefore, the hub of conceptual rotation, and not the idealist center of our thought. Our thought is, on the contrary, rotation, circuit, the plodding organizer of method...

This rotation leads us to physicalize our notions, then to socialize them, then to rephysicalize them, then to resocialize them, then to rephysicalize them, then to resocialize them, and so on *ad infinitum*. It seems to us that this is not a vicious circle, but a productive praxis, precisely because we have seen that the recursive loop of production-of-self, provided it be open, that is to say nourished, is the opposite of the vicious circle. In the productive praxis, the notions of production and machine turn and must turn. Thus, the concept of the *production of man by man* is in fact a recursive concept, which implies and necessitates the social megamachine, which necessitates and implies the nurturing opening on biological and physical nature, for man produces himself in life and with life, in *physis* and with *physis*. Marx had chosen a key concept: production. He had seen that it was in "dialectical" relation with "nature," he had even expressed but not formulated its recursive, rotative nature.² Now here, we can formulate a bit more explicitly the idea already present in the manuscript of 1844, that we are the productions of *physis* at the same time as *physis* is an anthropo-social production. We can understand a little better, thanks to the recursive idea, that these two contrary propositions, far from cancelling each other out, complete each other, but on condition that they be integrated in a theoretical praxis organizing/producing knowledge [Fr. *savoir*].

Here, I repeat, we are only at the beginning of the undertaking. There will still be many trips, exchanges, elucidations, elaborations to try before being able to effect the fundamental and recursive physico-bio-sociological articulation, and more difficult yet, that articulation between subject and object.

We still lack not only knowledge [Fr. *connaissance*] but the knowledge of knowledge (its conditions, characteristics, bio-anthropo-social determinations): what we lack is the very notion of subject, which emerges here only in an ectoplasmic, epiphenomenal way. What we lack is a sociological base, for sociology is far from being an assured science; on the contrary, and I could prove this negative assertion, it is a science which does not yet exist. Besides, to exist it would have to be founded on a new biology, when the latter has still only begun its theoretical revolution; such a biology, besides, to achieve this revolution in theory, needs a physics which has itself been revolutionized,

whereas physics is still in a profound crisis which dislocates it but does not yet reassemble it. Therefore, the terms which must be articulated by the recursive loop of new knowledge [Fr. *connaissance*] are far from being constituted, worse, to be constituted they need the working out of the first goings and comings, the first circuits, the first rough sketches of looping. Therefore, there is no "loop" formula here to replace another formula. The loop must be constituted through constructions, reconstructions, articulations, in which the new anthropo-social science, to be organized, needs the new biology and the new physics, which to be organized themselves need to integrate the point of view of the cultural, mental, and social organization of the scientific. Therefore we will have to work in such a way that all progress in the theory of physical organization and in that of living organization will be able to constitute the foundation of progress in the theory of anthropo-social organization, which in its turn will be able to make the knowledge [Fr. *connaissance*] of the anthropo-social determinations of physical and biological knowledge [Fr. *connaissance*] progress, and so on... The scope of this task is frightening, but less frightening than the barbarous void in the organization of our knowledge [Fr. *savoir*] which believes itself the most advanced: scientific knowledge [Fr. *savoir*].

Part 3

**Organization
Regenerated and Generative**

One of the most powerful tools of science, the only universal one, is misinterpretation handled by a talented researcher. *B. Mandelbrot.*

Information is the most vicious of conceptual chameleons. *H. Von Foerster.*

We took the wrong road in considering information separately. It is indispensable to always examine the whole: information plus *negentropy*.
L. Brillouin

Information is potential negentropy.
C. de Beauregard.

That entropy is tied to information is the greatest discovery in history, for the theory of knowledge and for the theory of matter. *M. Serres.*

1. Negentropic Organization

Introduction

Negentropy. Information. Two enigma-concepts. Both have roamed, migrated, sometimes greeted as master-words, sometimes swept aside as pure mystification, vaguely seeking to put themselves in the orbit of a solar concept, but the latter—organization—still remaining unknown.

I am going to try to show that organization is what envelops and ties negentropy and information together.

We had already seen that there is no entropy without previous organization; we will see that there is no negentropy without organization producer-of-self, namely without generative “loop;” then we will see that there is no information without “negentropic” organization.

Entropy/Negentropy: the Same, the Opposite, Other

In terms of measure, entropy and negentropy are two readings of the same magnitude, one according to the sign +, the other according to the sign -, like acceleration and deceleration for speed, adding pounds and losing pounds for weight. Every macroscopic system, then, can be read according to its entropy S or its negentropy $-S$, according to whether one considers its disorder or its order. In this sense (and the opposite of a bank account), the sign +, indicates organizational debt (disorganization), the sign - indicates organizational credit.

All organization can in fact be considered an islet of negentropy. Non-active organizations and systems called closed can evolve only in the direction of increasing entropy. Therefore, the only sign with meaning is the sign +, which is the sign of their evolution. But everything changes as soon as we consider an organization producer-of-self. In spite of the uninterrupted work carried on by such organization, entropy does not go from - to +; it remains stationary as long as the system lasts; but this stationary tally masks the production of organization which is effected through permanent reorganization. It masks even, if we consider that the sun is in a state of stationary entropy, that the sun not only produces its own being without discontinuity, but also produces heavy atoms and radiation which feed, on our planet, the

organization called life.

More generally, it is all these organizations producers-of-self, including whirls and swirls, which pose for us the problem of the reversal, local and temporary, yes, but real, of the course of entropy. And it is especially life which in the most amazing way takes the forbidden road from the + to the -, in its ontogeneses and phylogeneses, as well as at each instant of existence of organisms which, "living at the temperature of their destruction" (Trincher, 1964), unceasingly restore, make, replace what is unceasingly degraded.

Nevertheless, this paradoxical characteristic was anesthetized for almost a century: in fact, the organism was not perceived as a physical system; furthermore: the permanent infraction of the thermodynamic law which the living being seemed to commit furnished the "vitalist" proof that the "Laws" of "living matter" ignore the degrading laws of "physical matter."

The full insistence of Schrödinger's scrutiny as physicist was needed to finally pose the problem of living organization under the angle of the two meanings of entropy. (Schrödinger, 1945) Immediately there was constituted a dissociation between the negative and the positive of entropy, which nonetheless remain basically "one," and the idea of negentropy takes shape. But it takes shape only for whatever depends on active organization. If we stay within the framework of non-active organizations and closed systems, negentropy continues to not differentiate itself from entropy, except by a negative reading of the same magnitude, a reading which has not the least interest because it does not indicate the direction of the evolutive process. On the other hand, within the framework of active organizations producers-of-self, negentropy looks like an original process, which, while supposing the process of increasing entropy, becomes antagonistic to it. In other words, the negentropic process returns to an entirely different *Gestalt* of organizational configuration than the one wherein the entropic process reigns alone, although this configuration necessarily produces entropy.

Thenceforth, we can define negentropy in active, productive, and organizational terms. In static terms, all organization is an islet of negentropy, but this islet, if it is not fed with generative organization or regenerated by active organization, can only be eroded at each transformation. The term negentropy in this case is a tautology which signifies that an organization is organization. In dynamic terms, an organization is negentropic if it is endowed with active organizing qualities, which as a last resort necessitate a recursive loop producer-of-self. The concept of negentropy, thus understood, is the thermodynamic face of all regeneration, reorganization, production, reproduction of organization. It springs from and takes shape in the recursive, cyclical, rotative loop, which rebegins endlessly and endlessly reconstructs the integrity

or/and the integrality of the machine-being. Thenceforth, there is an indissoluble relation:

$$\text{NEG(entropy)} = \text{GEN(erativity)}$$

NEG
GEN

Now, we cannot understand the active dimension of organizational negentropy if we remain in the static terms of Boltzmannian measure; to suppose that we could measure the entropy of a living system during a time T , we would observe only variations oscillating around a state of stationary entropy; now, the results of stationary entropy, far from revealing a zero state, are in fact the zero sum resulting from two antagonistic processes, one disorganizing (increasing entropy), the other reorganizing (negentropy). This zero sum masks, thus, these two processes. Here, the results of stationary entropy hide the original and generative process, which produces and regenerates the stationary state. Therefore, we must distinguish negentropy,-process, which refers to an organization endowed with generativity, from negentropy-measure, which quantifies states. Negentropy-process is a concept which in no way contradicts negentropy-measure, which is born from an evolutive concept Clausius named entropy to signify *regression*. The negentropy-concept is situated at the same evolutive level as that of Clausius, whose complementary antagonist it becomes (*regression of regression through regression*). The difference is that negentropy-process is not universal like entropy; it cannot be installed in the general framework of the "system;" it has existence only in the specific and original framework of organizations producers-of-self. Therefore, the negentropy of which I am going to speak is always a trait of complexity in machine-beings.¹

In nature there are many negentropic *states* outside of organization, like the imbalance between a hot spring and a cold spring, but these states become negentropic *processes* only if there exist organizations which use these states for their productions: thus, the negentropic state of solar radiation on the surface of the earth becomes negentropic process with and by vegetal organization which transforms it for its production-of-self and its permanent regeneration. Likewise, the static negentropy of coal and petroleum, which is measured in terms of magnitude, becomes negentropic process only by and in the activities of anthro-po-social extraction, transformation, utilization.

Finally, we can even say that the solution of Maxwell's paradox by Brillouin deserves to be completed by the introduction of the idea of negentropic organization.

We know how Brillouin found a solution to the paradox of the demon by which Maxwell introduced the theoretical possibility of a reduction of entropy within a system staying "closed."² He noticed that the demon needs light to perceive the molecules, that is to say interactions between photons and molecules, therefore energy loss. Whence an increase of entropy, invisible if we consider only the system containing the gas, but which is visible in the group system/environment. Consequently, it is because it pays necessary tribute to entropy that the demon can a) acquire information on the molecules, b) transform information into negentropy.

I will examine further on the problem of the equivalence negentropy/information, which is linked intrinsically to this demonstration. I want to retain here this aspect of the reasoning: the paradox of Maxwell's demon, unsolvable in the framework of only the recipient, finds its explanation in a meta-system integrating the system-recipient and its environment, since the intervention of light ceases to isolate the recipient system. But what is missing in this demonstration is the organizationist dimension. This absence hides the fact that the meta-system is constituted not only by the recipient and its environment, but by the set recipient-demon-environment. Now, this meta-system is radically different, by its complex organizational nature, from the primitive system-recipient. The latter was nothing but a closed system, in a state of non-organization; the presence of the demon transforms the recipient into an artificial machine animated by a negentropic machine-being *ad infinitum*, since, as demon, it cannot degenerate. Thus, we passed from the kingdom of the generative organization of machine-beings and even of an ideal machine-being. Thereby, the solution of Maxwell's paradox includes, not only the intervention of information, but also the transformation of a closed system into a generative machine. Thenceforth, negentropy emerges both as active process and as organizational quality.

The Probable Improbable

We can wonder what interest the idea of negentropy can present in reference to the idea of organization producer-of-self, the idea of generativity, recursive loop; we can wonder, in sum, if the idea of negentropy is not organizationally superfluous. I am going to try to show here that it is quite useful in order to understand the relations between active and thermodynamic organization, to better understand the complexity of active organization, to understand the notion of information, and finally to understand the complex meaning, still hidden, of the word progress.

ORGANIZATION PRODUCER-OF-SELF: NEGENTROPIC PROCESSES	NON-ACTIVE ORGANIZATION: PROCESSES ONLY ENTROPIC
degradation and renewal of energy transformations and work transformation and work necessary to organization meta-disequilibrium, meta-instability organizational order (distribution of constitutive elements according to organization) internal heterogeneity and heterogenization reorganization, regeneration constitution of a local and temporary probability	degradation of energy transformation and work degrading organization until the final impossibility to transform and work irreversible tendency to equilibrium organizational disorder (random distribution of constitutive elements) internal homogenization and homogeneity disorganization, degenerescence physical probability

First of all, we see that the idea of negentropy inscribes all organization producer-of-self (therefore negentropic) in physical improbability; it brings out better the improbability "in general" of organizational activity and the transformation of this general improbability into temporary and local probability by precisely this very activity. Thus, each moment of the existence of a living being is improbable from the physical point of view, in this sense that each metabolic or reproducing event corresponds to a very rare occurrence among an immense number of possibilities of interactions between molecular micro-states. Living organization constitutes its fundamental processes with, by, and in the marginal processes of the physico-chemical universe: polymerization, catalysis, duplication. And by that very fact it transforms the

general (physical) improbable into the restricted (biological) probable. The difference between a dead dog and a living dog is that the dead dog returns to physical probability; it decomposes, its constitutive elements are dispersed. But this dead dog had been alive, and, between certain thresholds of security, food, etc., it had a certain probability of existence. Thus, we number demographically, for the living, and notably humans, their probabilities of life in the framework of such and such a society, a class, a place, an environment, a historical period. And it is very evident that beyond a certain age depending on these variables, survival becomes more and more improbable, until the generalized triumph of physical probability. However, if the being—the individual—always succumbs, the cycle of multiplicative reproduction—species—continues, indeed is developed, builds itself a more durable and ample zone of probability, but always between certain thresholds and certain geo-thermic, ecological, energy conditions. Thus, living organization, which is the improbability of an improbability, the deviance of a deviance, the marginality of a marginality succeeds, once constituted, in emerging and perpetuating its improbability, that is to say in creating islets and networks of probability in the ocean of disorder and noise. And it is the idea of negentropic organization, which bears in itself this idea of re-ascent against the current of entropy, but also, and this is the complexity of the concept of negentropy, in following and feeding this very current.

The Dialogical Complexity Negentropy/entropy

Entropy and negentropy, although constituting positive and negative characters of equal magnitude, correspond to antagonistic processes from the point of view of organization; disorganization and degenerescence on one hand, reorganization and regeneration, indeed development and complexification, on the other.

Processes within closed systems or non-active organizations correspond to a simple concept of entropy, which ignores every process contrary to negentropy. But negentropic processes cannot do without the processes of increasing entropy; that is to say that the idea of negentropy is complex (including its antagonist) and thereby makes complex the global concept of entropy (which includes the two processes). We know henceforth that all organizational negentropy is necessarily paid for by an increase of entropy in a meta-system which inscribes the system in its environment and opens up, beyond, on the universe; we know likewise that negentropy, in the measure in which it always corresponds to active organization, namely work, can only by-produce entropy. Therefore, as soon as we take the point of view of

negentropic organization, the opposition term for term between entropy and negentropy does not suffice; we must necessarily include it in a complex relation, namely, not only antagonistic and concurrent, but also complementary and uncertain. We must, therefore, find the meta-point of view which simultaneously incorporates the relation negentropy/entropy and the relation active organization/environment (where organization draws in negentropy and drains out entropy). At the same time we must link the thermodynamic relation negentropy/entropy to its equivalent relation reorganization/disorganization proper to machine-beings.

Living organization produces negentropy starting on the one hand from a "genothèque" (information inscribed in DNA), on the other hand from the praxic exchanges with the eco-system which constitute the "phenothèque."³ Proteins, which play the active role of transformations and exchanges, are unstable, are subjected unceasingly to degradation (entropy) and are unceasingly reconstituted by the fabricative actions of enzymes, thanks to the informational action of genes whose existence depends on the exchanges and transformations of proteins. Thus, in this recursive circuit, proteins are subjected more particularly to the effects of entropy, genes rectify more particularly these effects by their informational role. Let us admire the fact that protein is the anagram of entropy (Rosnay),⁴ and that the three letters of generativity are the anagram of the three letters of negentropy:

PROTEIN = ENTROPY

GEN = NEG

the set gene-protein being precisely neg-entropic (including the process of inceasing entropy),

$$\begin{array}{c} \boxed{} \\ \downarrow \\ \text{GENE} + \text{PROTEIN} = \text{NEGENTROPY} \end{array}$$

The relation negentropy/entropy cannot be classified by a sort of compartmentalization: negentropy rules inside the system and empties entropy outside the system, as a by-product of its activity. In fact, and already the idea of disorganization/permanent reorganization suggests it, the relation neg/entropic is extremely intimate. It is not sufficient to say that negentropic organization corresponds to the degradation which all work causes, in renewing its energy and permanently restoring itself. We must understand that the relation neg/entropic also has itself a recursive character: the very process which fights disorganization renews the causes of disorganization. As permanent reorganization is itself work and transformation, it thus works equally at its disorganization, which in its turn works for this reorganization,

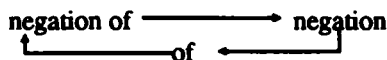
and so on, in an infernal cycle which is at the same time the loop producer-of-self; negentropic organization creates what it combats; it renews the evil which it represses; it cannot stop, under penalty of death.

And in fact, in the long run, under the effect either cumulative or brutal of external accidents and perturbations, regeneration degenerates, reorganization is disorganized, *we grow old fighting against growing old*. The living being does not die only by accident, he does not die only by statistical fatality; he is also pledged to death from birth because he must work to not die.

The short-term task is liberty, the long-term task is death. There is dialectical tragedy in every negentropic being. The sun, our meganegentrope, lives off agony, as we have seen, by burning its own substance, its own being, until death. The living being bears dialectical tragedy in a different way. It nourishes its death by developing and blossoming. This formidable complexity wherein entropy/negentropy, disorganization/reorganization, degenerescence/regeneration, life/death are so intimately, so Gordianly linked and blended, in a manner evidently complementary, concurrent, and antagonistic, finds its densest and most complete expression in the formula of Heraclitus: "Live to die, die to live."

All negentropic organization works for its death while working for its life, but knows how to transform the death process into a life process. To understand negentropic complexity is to understand the complexity of the double envelopment (as the Yin is enveloped in the Yang which it envelops), the double development, the double scrolling, unscrolling, interscrolling of the relation negentropy/entropy.

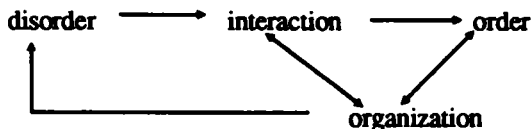
Already the semantic examination lets us glimpse the nature of this complexity: if entropy was named by Clausius to signify regression, negentropy is the regression of regression in and against this regression. It is not the Manichean opposite of entropy; it is its inversion, by turning around becoming going around, but a going around which continues to be inscribed in the current, necessitates it, feeds it... Therefore, contrary to the opinion of most physicists (very little Hegelian, we suspect) who judged bad the negative connotation of the term concerning a "positive" phenomenon like the development and progress of organization, the word negentropy is excellent: its negativity is "negation of a negation," and that is what has made its positivity expand. Negation of negation does not annul what it denies; it transforms it, is formed in it, and is also deformed in it. Thus, the positivity of life is founded on the negation of what denies it, but without being able to do without what denies it. This is to say that the idea of negation constitutes a recursive loop, which Hegelian logic had not conceived:



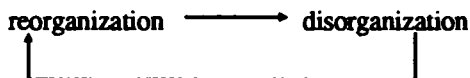
This loop, consequently, has us effect a leap of complexity with respect to the old simple idea of negative entropy. Here we are far from feeble substantialisms, dull ontologisms, simplistic organizationisms.

We are likewise far from the linear and smoldering idea of progress, idea in fact obscurantist. Progress is born from a regression of regression and is effected through regressions. Progress can only be negentropic, that is to say bound body to body in coitus and fighting to the death with its opposite. Negentropic organization is inscribed in the current of the development and complexification of organization, while being inscribed in the current of entropy and dispersion. But this current of organization, I repeat, returns and deviates the latter against the current, like an eddy or whirlpool, and I again find here the genesic *imago*, the matrix form of all that organizes in *physis* and the cosmos.

Thus, all negentropic organization inscribes its own complexity in the genesic tetralogical loop and in the relation: chaos/*physis*/cosmos. It is in fact the loop:



which we again find in permanent activity at the very heart of negentropic organization. It is the passage from chaos to *physis* which is reborn every instant in the Gordian relation *in which each feeds off the other*:



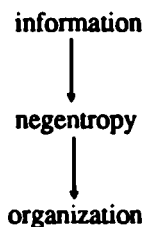
Therefore, living organization, though hypermarginal in the evolution of organized phenomena (who knows? it has perhaps appeared under this form only once and only on one planet?), is inscribed in what *physis* and cosmos have most fundamental in their being and their becoming, as evidenced by billions of solar negentropes which radiate in the indefinite diaspora.

Precedence: Organization → Negentropy → Information

To be conceived and comprehended, the negentropic organization of life

necessitates the introduction of the idea of Information. Living beings can be conceived as negentropic machines constituted by communicational organization of chemical reactions and having a universal informational mechanism inscribed in the DNA of genes.

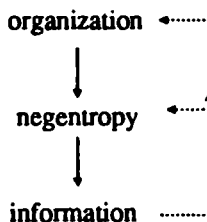
As we are going to see, the reigning informationist Vulgate tends to subordinate negentropy and organization to information, conceived as master entity of everything which is organizational:



Now, and this will appear more and more sharply to us, the "informational" organization of living beings must not be posed as preceding their negentropic organization. On the contrary, the negentropic character precedes, produces, envelops the informational character. Schrödinger had clearly seen it. But the idea of negentropy, which occasioned so much fever and interest in the 50's and 60's, was forgotten and abandoned. That is because on one hand the atomistic idea of information supplanted it; on the other hand, it lacked the organizationist context which could define it as other than a measure of state.

Now, let us repeat, negentropy precedes information. We must not forget what we have learned here in viewing vortices, eddies, suns: living beings are not the only nor the first negentropically organized beings. Life is only a particular form of negentropic organization.

As for the idea of negentropy, we have tried to show here that it must be subordinated to the idea of organization:



2. The Physics of Information

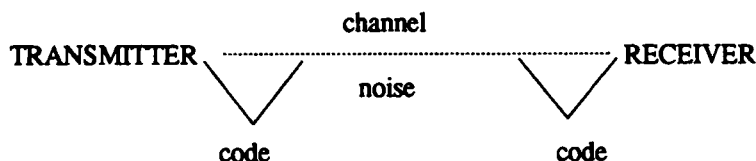
We must discover error, not truth.
C.Suarès.

I. Shannonian Information

Entry into the World

Information is a new physical concept arising in a technological field. Following the work of Hartley (1928), Shannon establishes information as an observable magnitude (1948), and it becomes the main support for the communications theory which he elaborates with Weaver (Shannon and Weaver, 1949).

This theory was born from practical concerns. Bell Labs wants to transmit messages in the most economical and reliable way. Therefore, the originating framework of the theory is that of a communications system wherein a transmitter transmits a message to a receiver over a given channel. Transmitter and receiver have by hypothesis a common index (code which contains the categories of usable signals); thus, the coded message is transmitted, from the transmitter to the receiver, over the channel, under the form of signs or signals which we can break down into units of information called *bits* (*binary digits*).



The bit can be defined as an event which undoes the uncertainty of a receiver placed before an alternative whose two solutions are equiprobable to it. The more numerous the possibilities this receiver can handle, the more

informative events the message has, the more the quantity of bits transmitted increases.

It is clear that no receiver measures in bits the information obtained in a message. One must, then, call into the communicational relation a new and essential actor: the observer, who possesses the theory and measures the information, on the basis of binary calculation, starting from the probability of the occurrence of an event with respect to the total number of possibilities.

Information is not in the word, nor in the syllable, nor in the letter. There are letters, indeed syllables, which are useless for the transmission of the information that the word contains; there are, in a sentence, words useless for the transmission of information or facts that the sentence contains. The theory calls *redundance* everything in the message which appears as extra. Consequently it is economical not to transmit redundance. In the classifieds or in telegrams, given the high cost of signs, we eliminate articles, we shorten words, and the message, "I am a young lady, fine in every respect, Catholic, who would like to meet, with the idea of eventual marriage, a young man, preferably Catholic, having a stable situation," can be easily shortened to "Y. l. f. ev. resp. wants to meet y. m. pref. Cath. stab. sit." One transmits the message "please" by eliminating as redundance the letters beyond s.v.p. The elimination of redundance, therefore, allows the saving of cost, space, and time in the transmission of a message. But inversely the elimination makes the message very fragile, reduced to its informational skeleton, in this voyage through the "noise" which is communication.

Information makes its way through a medium (telephone wire, radio wave, etc.). Now, along the way, information meets "noise." The noise is constituted by haphazard disturbances of all sorts which arise in the transmission channel and tend to scramble the message. Thus, in a telephone conversation, sounds are converted into electrical oscillations which, at reception, are reconverted into air vibrations which correspond to the original voices of the speakers. Now, in the telephone wires and amplifiers which at regular intervals mark out these lines, there are haphazard movements of electrons, caused either by external electromagnetic phenomena or by the amplifiers themselves; these disordered movements interfere with the oscillations, and, deforming them, tend to degrade the information. More broadly, everything which disturbs communication is noise: thus, the interference of two distinct conversations, transmitted by mistake over the same line, degrades the information of both, each one being "noise" to the other.

Though one can formulate the purely ideal hypothesis of a medium without noise, no physical communication medium can escape mortgaging by noise, beginning with the atmosphere which radio waves and the sound of

speech cross. The problem of the degradation of information by noise is then a problem inherent to its communication.

Here, the idea of redundancy presents a new face. While it appears as a useless extra from the point of view of economy, it becomes from the point of view of the reliability of the transmission a fortifier against noise, a preventive against the risks of ambiguity and error at reception. Thus, the redundancy brought by the pleonasm "useless extra" which I have just written in the previous sentence is not necessarily useless for the expression of my idea if it reinforces it. We often repeat the figures, telephone numbers, or prices of merchandise which we communicate to an interlocutor; a radio communication will be repeated, and, if it is of great informative importance or transmitted through loud noise, we will ask the receiver to repeat in turn the message received in order to confirm the correctness of the message. Consequently the conveying of information at maximum economy and reliability poses the problem of an optimal use of redundancy.

Thus, the notion of information is necessarily associated with the notions of redundancy and noise (we will see later how intimately).

The Shannonian concept of information hinges on the meaning of the message: in fact, the use of a code and an index, the need to communicate, the precautions against the noise suppose and concern the meaning of what is transmitted. And yet, the bit is not a unit of meaning. Shannonian information is even totally deaf or blind to the significance, quality, value, and importance of the information for the receiver.

Isolde waits for the return of her Tristan; she knows that a white sail will announce the return of her lover, a black sail his death; for her the two branches of this alternative are equiprobable. Now, what will pass into Shannonian information of the ups and downs of Isolde's hope and despair, her emotions and expectations, her boundless love, of the specter of death? When, out of the infinite sea, a sail appears, white or black, the Shannonian observer will invoice: a bit!

Here is a poem, "The Cassis River." It is an original assemblage of letters and words, complex therefore improbable in their succession, and it can be detailed in a total number of bits, equivalent to the number of decisions the receiver should make to identify the letters or words constituting the poem. However, such a tally tells us nothing about the meaning of the poem: the latter would carry the same quantity of information if the letters were arranged haphazardly, that is to say became pure noise. The quantity of information does not even give us an indication of the originality or beauty of the poem: the increase of bits tells us only the arithmetic increase of improbability, which is not directly tied to the poetic quality. Given the equal number of letters, a

poem with a smaller or larger number of bits would not be any more or less poetic.

Looked at in this way, Shannonian information is *senseless*: blind to the meaning, interest, truth of the information, it can consider as very large quantities of information the conglomerates of letters or words, assembled incoherently but highly improbably. This deficiency has been clearly seen and denounced. I am going to try to show that it is not as grave as it seems, but that it hides another deficiency, much more important, much less noticed.

The deficiency of Shannonian measure in what concerns the meaning, scope, etc., of information has not at all hindered any use of the theory in communications. Why not? Because the sender who pays to send a message knows that he has something to say to someone capable of understanding what he has to say. If the characters on the page of a newspaper or a book are dispersed then reassembled at random, no chief editor, no publisher will dream of letting them be printed as is under the reason that the quantity of information has not been altered. *This means that meaning functions outside of theory.* Theory is businesslike: it is interested only in the cost of information; all the rest is useless. Meaning is voided by theory because meaning is decided in anthropo-social practice. Besides, Shannon's theory has solidly set the relational framework in which the meaning of information must be sought and found: this is the relation between the sender of the message and the receiver, a relation which can be psychological, affective, professional, etc. The question of meaning is, therefore, sent back to the context, that is to say the anthropo-social meta-system wherein is effected not only communication, but also production of meaning. Therefore, the absence of meaning in information would not be serious if Shannonian theory, a theory of the physical quality of information, were capable of communicating theoretically with anthropo-social reality. Now, there appears here a deficiency which I will come back to further on: *the Shannonian theory of information hides the anthropo-social meta-system which it supposes and in which it takes meaning.*

But nevertheless, it remains marked by the negentropic character of anthropo-social organization, of which the circulation of messages is one aspect. The improbability attached to Shannonian information translates, without ever explicating, the negentropic character of discursive organization producer of meaning, which in fact constitutes the message. As the inventory in bits reflects only the improbability of this organization and not the organization itself, it makes us incapable of discerning the difference in an identical improbable group of elements (letters, words), between an organized arrangement (speech, poem) and a haphazard juxtaposition. Whereas it is

extremely lucid on the external threat to the integrity of information and on external noises, Shannonian information is blind to all noise internal to the message which would destroy the meaning. Blind to meaning, it can only be blind to meaninglessness.

Thus, information comes into the world in the framework of a theory born from the developments of human communication in advanced industrial societies. It develops as physical theory, whence its fecundity, but in hiding its anthropo-social substratum, whence its deficiency. Information, in these conditions, appears under a discrete form, quasi-particle. However, it does enlighten some aspects of the organization of communication, which in their turn cast strange, ambiguous glimmers on the newborn.

Entry into the Machine.

Cybernetics was born by jumping on nascent information to integrate it in the universe of machines. Thus, Wiener founded cybernetics by linking command to the communication of information. Information, processed in computers, becomes restraining and is transformed into *program*. Indeed, there existed previously, in machines, devices with perforations or serrated edges which constituted actual programs. But here, it is Shannonian information which is programmatized, and, in this way, acquires a new character. Henceforth, information is no longer only an entity whose trade we organize between partners. It becomes organizing and ordering. The message-program has the force of obligation.

Consequently the information-program harnesses, controls, allocates, stores, triggers energy. It seems to have become a master notion. In fact, when we forget the context and the problematic of organization itself, when we have as key concepts only matter and energy, then information enters like a sovereign to dominate these concepts and manipulate them like slaves. That is the information which is going to take off to conquer the world.

Entry into Physis

Information seems meant to rule matter and energy. But this notion seems supra-physical: information is not materially localizable, like mass and energy; it has no dimension. What is it then? The primary virtue of Shannonian theory is to give full physical status to the notion of information (its primary vice being its inability to conceive the anthropo-social characteristics of information).

In fact, information acquires the fundamental characteristics of all

organized physical reality: left to itself, it can evolve only in the direction of its disorganization, namely an increase of entropy; actually information undergoes, in its transformations (coding, transmissions, decoding, etc.), the irreversible and increasing effect of degradation. Shannon very explicitly defines the measure H as *information entropy*.

In an astonishing way even, the equation by which Shannon defines information coincides, but in reversed signs, with the Boltzmann-Gibbs equation defining entropy:

$$\begin{array}{ccccccc} \text{Shannon:} & H & = & K & \ln & P & \\ & \text{information} & & \text{constant} & \text{Naperian} & \text{equally} & \\ & & & & \text{logarithm} & \text{probable} & \\ & & & & & \text{states} & \end{array}$$

$$\begin{array}{ccccccc} \text{Boltzmann:} & S & = & K & \ln & P & \\ & \text{entropy} & & \text{constant} & \text{Naperian} & \text{equally} & \\ & & & & \text{logarithm} & \text{probable} & \\ & & & & & \text{states} & \end{array}$$

Certain people, like Couffignal, have maintained that the coincidence is without significance: "The application of Shannon's function to thermodynamics and information is...a chance encounter of the same mathematical formula." (*Concept*, 1965, p.351) Certainly, two equations of probability coming from different universes can meet. But Brillouin could already establish a logical relation between the H of Shannon and the S of Boltzmann. (Brillouin, 1959) In unknotting the paradox of Maxwell's demon, Brillouin shows that "we can transform negentropy into information and information into negentropy" and that "a decrease in entropy can be taken as the measure of the quantity of information."

Let us recall that Maxwell's demon needs to see the molecules; this spending of energy provokes, as we have already said, an increase of entropy in the global environment receiver system. Thus, first point of the demonstration: the demon acquires information which it pays for with entropy. Second point: information acquired on the speed of the molecules allows us consequently, by simple binary operation (open/closed), without modifying in the least the movement of the molecules, to effect a selection and choice which entail a lessening of entropy in the receiver. Thus, the demon transforms information into negentropy.

More fully (Atlan, 1972, p.186), the demon behaves as transformer of negentropy (the negentropy of the total system which it constitutes with the receiver) into information (on the speed of the molecules), then as transformer of information into negentropy (in the receiver). Atlan reestablishes the natural priority of negentropic organization over information: negentropy must first be transformed into information to then allow information to be transformed, elsewhere and differently, into negentropy. The equivalence information/negentropy is established at the heart of negentropic organization; it signifies neither identity nor symmetry.

Here equally, to understand information we must pass from the system of explanations in which entropy is a simple, univectorial quantity to a meta-system where entropy becomes a complex concept, having simultaneously a positive and a negative process (becoming complementary, concurrent, antagonistic) in and by generative organizations producers-of-self.

In fact, Shannon had conceived the system transmitter/medium/receiver as a closed system, non-generative, and not as a negentropic organization. He had seen the law of information entropy (degenerescence), but not its law of negentropy (generativity), which indeed can operate within the framework of the negentropic organization transmitter/medium/receiver, which is obviously part of anthro-po-social organization. Brillouin revealed the two faces of information. Costa de Beauregard insisted on the negentropic character of information. (Beauregard, 1959) Finally, Atlan put his finger on the generation of information, which necessitates the introduction of disorder, namely *noise*, at the heart of the system. Thenceforth we can fully inscribe information in a *physis* which includes its immanent principle of organization and its principle of negentropic development.

The physical citizenship of information is of considerable importance. Henceforth a relation *in principle* (I emphasize since the principle has not yet developed its potentialities and often even remains masked) establishes communication, scientifically, between what science imperatively disjoined until then: the realm of physics and the realm of the mind.

Information grounds in *physis* what was looked for until then only in metaphysics, under the auspices of Idea or Mind. It becomes, not only a physical quantity, but a notion inconceivable outside of interactions with energy and entropy. Information must always be carried, exchanged, and paid for physically: "You can't have something for nothing, not even information," said Gabor, and Brillouin had added: "It is surprising that so general a result has gone unnoticed." (Brillouin, 1956; trad. 1959, p.162)

Information is grounded in *physis*, but without our being able to reduce it to the master-concepts of classical physics, mass and energy. As Wiener said, "Information is neither mass nor energy; information is information." And

Boulding: "[Information is the] third basic dimension beyond mass and energy."

But already, in Boulding's formulation, a too haughty solitude intoxicates the idea of information. Once again, an atomistic and simplifying mental structure masks the reality which information precisely must reveal and which gives it its meaning: organization. The concept of organization is the fundamental concept which makes information intelligible, installs it at the heart of *physis*, breaks its isolation, recognizes its relative autonomy. The most remarkable and strangest traits of information can be physically understood only by passing through the idea of organization: if information, unlike mass and energy, is of zero dimension, it is because of its relational nature, and relational character is a fundamental character of organization which is also itself of zero dimension because it is multidimensional; if information is measured in function of its probability of occurrence, it is because of its event-full character, which corresponds to an organization constituted of events and producing events, namely negentropic. Therefore, information shares in the sphere of negentropic organization. And, indeed, the information which Shannon grasped concerned an anthropo-social sign, that is to say an event-full performance of negentropic character; a human discourse, that is to say a word whose organization is productive of meaning.

Thus, to conceive information outside of negentropic organization is both an insufficient recognition of its physical reality and a source of confusion and reification. *To conceive information in its physical fullness, we must not only consider its interactions with energy and entropy; we must not only consider negentropy and information together; we must consider information, negentropy, and organization together, by incorporating information in negentropy and negentropy in organization.* In this framework, then, information is part of negentropic organization, which alone produces and reads information. It is because it shares in organization that information undergoes physical disorder and degradation; it is because it shares in negentropic organization that it can resist an increase of entropy by using redundancy and especially that it can be transformed into negentropy, which fact, unknown to Shannon, was established by Brillouin.

Finally, it is because information is an organizationist and negentropic reality that it has been able to be applied with success, for the past twenty-five years, to the phenomenon of life..

Entry into Life

While the idea of negentropy was preparing to be introduced into the living organism (Schrödinger, 1945), it was upset and warped by the idea of

information which in one shot occupied the genetic command post. In fact, Watson and Crick (1951) united in one single and great discovery the elucidation of the chemical structure and the informational structure of the entity called gene.

Genes are carried by the DNA macro-molecule arranged in double helix in which sequences of nucleotides are set; these nucleotides differ among themselves according to the nitrogen base which constitutes them: adenine, thymine, guanine, cytosine. These bases are analogous to the letters of an alphabet of four signs which, combining among themselves, constitute the equivalent of a word, a sequence of several quasi-words forming thereby a quasi-sentence. The organization of the chemical molecule carrying the gene could then be identified with a coded message. We even discovered in this "genetic code" redundancies or quasi-synonymies. It appeared then that genetic organization constituted, like human language, a system with a double articulation, having, like phonemes or letters of the alphabet, discrete units devoid of meaning (the four bases), which units combine into complex units analogous to words; whereas words are carriers of meaning in human language, these quasi-words, in genetic organization, are apparently carriers of instructions and are thenceforth assimilated into a program. Thus, what is simultaneously the hereditary patrimony of the living being, its principle of organization and its principle of reproduction, is of informational nature.

We cannot, therefore, underestimate the importance of the introduction of information into biological theory. It swept away purely mechanistic and energetic conceptions as well as the mysticism of the "vital principle."

At the same time, information made a formidable organizational leap in passing from the artificial machine to the living machine. The "program" not only manages the functioning of the machine, it generates both the reproduction and the phenomenal existence of the living being, namely all the organizational activities of the individual and the species. Information, therefore, has a *generative* and anti-degenerescent character (preventing, retarding aging and death) quite unknown and ignored in the Shannonian theory. Once again we find the problem of the organizational link negentropy/information. And we suspect that there is a relation: INF/GEN/NEG.

But the extrapolation pure and simple of the Shannonian notion of information and of the cybernetic notion of program brought at the same time an obscuration at least equal to their virtue of elucidation. In fact, the neo-Darwinian theory associates the rise of the new characteristics within a species with the mysterious phenomenon of genetic mutation. Now, information theory explains the phenomenon thus: the duplication of DNA can be

conceived as the copy of a message, which despite precautions, is not absolutely sheltered from all chance perturbations or "noises" (quantum accident, cosmic ray disrupting electron transfer). Consequently, noise provokes an "error" in the copy of the message; most of the time the error is translated by a degradation in the organization of the living being, which fact is conformable to Shannon's theorem; but it sometimes happens, and this is exactly the case in an evolutive biological mutation, that the error provokes an increase in organizational complexity. How then can noise in this case, instead of degrading organization, develop it? A gaping problem, stupendous, is therefore laid bare and which can be treated only by the introduction of disorder or noise at the very heart of informational generativity, which necessitates a complexification of the idea and a renewal of the theory of information. It is in this pioneering sense that, developing and transforming the Foersterian idea of 'order from noise,' Atlan introduced at the heart of information theory and consequently of life, the idea of "noise as organizer." (Atlan, 1970a, 1972a, 1972b)

Entry into the Brain

Information ruled over the computer. As the computer accomplished intelligent operations more and more developed, it was natural that we conceive of the human brain as a biological computer.

Information ruled over life. It was normal that it occupy the organism's command post: the brain.

The idea of information, therefore, was supposed to invade the human brain (whence it had come...). But information got lost in the steppes of a mental Asia. Certainly, the brain "processed information," but not like a computer. The bit did not help the brain to compute the brain. Information could not furnish the key to the hypercomplex organization of the human brain. The latter guards and even deepens its mystery. Nonetheless, information planted its banner on the brain, and people conceded that it was becoming its owner.

Entry into Society

Information, born of anthropo-social reality, returned to it and began to infiltrate the social sciences. But penetration remains difficult and uncertain. Is it because ideas cross with great difficulty the vast desert which separates the natural sciences from the human sciences? Is it not rather because the notion of information, though born of human communication, had taken right from the beginning a closed form and physical status?

Sure, we have already formulated the idea that information must be put at the heart of anthropology (Katz, 1974) and sociology (Buckley, 1967; Laborit, 1973). But nothing can really continue to progress in the framework of both an insufficient concept of information and an insufficient concept of society. The deficiency of Shannonian information in conceiving anthropo-social reality joins the deficiency of sociological theories in conceiving the reality of information. In fact, the organizational concepts of sociology do not manage to rise to the level of the machine-being, of production-of-self, of negentropic organization. They can only vomit bits, singularly undigested besides, for the bit is incapable of measuring anything whatsoever in social organization. Sociology discovered, therefore, the insufficiency of the bit. But Information discovered the insufficiency of sociology and puffed up with self-sufficiency.

The Informational Empire

Information has become a notion which claims dominion over all things physical, biological, human. It intends henceforth to rule from entropy to anthropos, from matter to mind. It gives no more importance to the islets which do not let themselves be absorbed than did the Great King to the little Greek towns which flouted him at Salamis. They are only local delays to its universal sovereignty.

It is indeed legitimate that information, notion originally not only physical but mental and anthropo-social (communication between human senders and receivers), link a vast field which goes from *physis* to mind, with biological organization as keystone. But a true link cannot be founded on an astounding scission, both effected and hidden by Shannonian theory, aggravated by the cybernetization of programmed information, between on the one hand the physical character of information, on the other its anthropo-social character. Triumphant information mutilated, unidimensionalized; it is the program of artificial machines. We saw in a previous chapter that cybernetics had perverted its own theory by reducing living machines to the schematic and inadequate model of artificial machines, whereas these artificial machines are products of the anthropo-social megamachine. It is the same type of mutilating reduction which has been effected under the guise of information.

Information which claims supreme power is a barbarous conqueror. (Every concept which claims supreme power is barbarous.) It has lost the relational and event-full character which comprised its virtue.

Here it is, isolated. but this is precisely what allows us to reify it, to hypostasize it, to make it an entity capable of ruling everything. This

reification was already in germ in Wiener. The formula, "Information is neither matter nor energy; information is information," had the merit of affirming the originality, the non-reducibility of information. But already it carried in its tautology the risk of the closed concept, self-justified on itself. Afterwards it was too easy to explain everything, return everything to the primordial virtue of an Information *deus ex machina*. Thus Buckley: "The fact that some...systems are open, in dynamic exchange with the environment, self-organizing and adaptive, the fact that they learn, have memories, are aware of themselves and pursue goals *stems from the unique character which is information* (italics mine) and from the process of its communication between systems, their components, their environment." (Buckley, 1974)

Reified information is, furthermore, quasi-reduced to the idea of program, imperative notion whose authoritarianism overdetermined informationist imperialism.

Thus, information becomes a master-notion, a master-word. It is master of the energy which it manipulates, leashes, unleashes (but who manipulates information?). The program which rules the machine is king (where are man and society that wrote the program?). The genetic code is the program which rules the cell and by extension the organism, life (but whence comes the program? Who formulated it? Why does it need the products it executes in order to exist?). Information rules society *via* norms, rules, interdicts (on condition of forgetting the relations of domination, exploitation, solidarity between the groups which determine the rules, norms, and interdicts as much as they are determined by them).

Thus, information becomes imperial precisely by hiding the multidimensional, recursive, retroactive, concrete characteristics in and by which we must understand the machine, life, society. From then on it claims the universe, at the junction of the two kingdoms whose heir it says it is. In the first Matter reigned, in the second Mind reigned. Information claims the first by its physical character, the second by its psychic character, both by its universal aptitude to command. Its virtue, its efficacy are guaranteed, proved by the machine and the computer. The moment the bit functions it has universal value. Everything which is good for an artificial machine is good for nature. Everything which is good for the computer is good for man.

Once again, *we see how a notion, enlightening at the outset, becomes brutalizing as soon as it finds itself in a mental and cultural ecology which ceases to feed it in complexity*. Thus, information becomes closed by repercussion, whereas it is relation and event. It becomes abstraction, whereas it is always reference and context. It becomes reductionist, whereas it is a complex notion tied to a complex reality: negentropic organization.

II. For More Ample Information

What Shannon gave rise to is not information as answer; it is information as question. What looms up here, after this first panoramic view, is the problematic of information.

The notion has become chameleon, since it concerns the most diverse human messages, cybernetic programs, biological organization; since it can be metamorphosed into negentropy, then retransformed into information; since it can be conceived as a radical notion, that is to say generative, at the root of all the organizational processes of life, and also as an epiphenomenal notion, carried off by the wind which disperses radio broadcasts hardly listened to, images hardly seen, newspapers hardly read, books forgotten...; since, finally, it sometimes presents itself under the digital aspect of a measure, sometimes under the aspect of a sovereign concept which holds the secrets of life, the brain, society...

We must, therefore, confront this very "vicious conceptual chameleon" according to Foerster's expression, and that at the three levels where the problematic is gaping:

- that of the bit,
- that of generativity,
- that of physical/biological/anthropo-sociological articulation.

A. The Insufficiencies of the Bit

The bit is the elementary unit suited to information conceived as magnitude; the quantity of information contained in a message or program can be evaluated in the result H (from the name Hartley) in the equation already cited.

1. *The Bit Measures Nothing but the Transmission of Signals.*

Let us see the limits of this instrument of measure. First of all, "the only information measurable is strictly tied to the sending of signals." (Sauvan) Even in this domain, the measure is of limited scope. It remains at a statistical level: the probability of occurrence of discrete units. Thereby it neutralizes or rather bulldozes what is specific, original, irreducible in those diverse informational modes: memory, knowledge [Fr. *savoir*], know-how, rule, norm, program, phantasm, etc. Information thus uniformly measured is not only meaningless: it is undetermined.

When we transport information outside of the transmission of signals, the

Shannonian measure disappears. Some have been able to think that information measures organization, given that organization is a divergence with respect to the random distribution of constitutive elements; but even informational organization cannot be only translated, that is to say reduced, in terms of information. Thus, the organization of the living being is too complex for the non-complex Shannonian measure to be precise, pertinent, interesting (which in no way forbids the possibility of elaborating a complex measure, as Atlan suggests). Thus, the genome of *homo sapiens* contains fewer bits than that of wheat or triton. Likewise it would be useless to measure cultural or cerebral information. The numbering in bits of the Ten Commandments, the Code of civil law, the thoughts of Pascal, the Communist Manifesto has neither intrinsic nor comparative meaning. It is not the quantity of information which is important, it is the organization of the information. Thus, the originality of generic organization like that of human language, namely the double articulation, is totally ignored by Shannonian calculation. The bit, therefore, cannot measure a degree of organization, a degree of negentropy, a degree of life, a degree of intelligence. It can only reveal the event-full/relational/improbable nature of information, a dimension until then totally unknown.

2. Digital Insufficiency

Shannonian information is digital (*binary digit*), that is to say dependent on binary calculation for all or nothing. This digital aspect is irreducible: the transfer of information, like every physical transfer, including light, has a discontinuous aspect. But just as light cannot be reduced to its discontinuous aspect (corpuscle), neither can we reduce information to its digital aspect. I think that the digital character, considered alone, reduces information to its "particle" aspect of discrete unit; it seems clear that there is also, complementary and antagonistic, a "continuous" dimension in information, which would be sort of "ondulatory" in relation to the corpuscular aspect. Digital computers have taught us at least one thing about the brain: it is that the brain does not function like a digital computer. We can entrust to a digital computer the copy of the Mona Lisa: expressed in discontinuous dots, like a television image, it will perhaps be perfect. But Leonardo da Vinci did not compose it solely in a digital way, namely by working with dot choices. He indeed lived moments of choice and decision between alternatives, but these moments are blended with *continua*. Here again we are brought back to the mystery of the cerebral apparatus, whose functioning does not obey only a digital logic, but which integrates the latter in a complex polylogic. The integral digitalization of the Mona Lisa is a by-treatment, a by-product, starting

from a model which was formed in a way including but going beyond digitality.

Here we again find the paradigmatic problem of reduction to elementary countable units— here units of information. Such reductionism ignores, destroys, scotomizes something different, continuous, *Gestaltic, analogical*. It ignores properties which depend on the action of the totality as totality. Thom states very accurately that all information is first of all a form which we cannot reduce to its scale measure. (Thom, 1972, p.164) Not only do many bio-psyhic phenomena have a mimetic component (the mimetism being not at all limited to the homeochromes and homeotypes of certain animal species), but more broadly all negentropic/informational activities obey a dialogic between digital and analog, problems I will come back to in Volumes II and III. This is to say that digitality, notion indispensable to information, is incapable, by itself, of explaining information, and, considered as the only character of information, becomes mutilating.

B. Generative Deficiency

1. Shannonian information is always degenerative. It can only diminish, from emission to reception. What has been received can never be superior in information to what has been emitted. Shannonian information obeys, therefore, the principle of increasing entropy, and what it allows is, by a proper use of redundance, to delay perhaps the unavoidable effect of noise. Shannonian information is always pre-generated. It springs up like Athena armed from head to toe. We can understand neither its birth nor its growth. And yet, information had to be born: it is increasing in the world, therefore it continues to be generated.

Therein lies a problem that not only the theory but the logic of classical intelligence prevents us from understanding: how information, to be generated, needs non-information, that is to say necessarily needs redundance and noise!

It is astounding that a problem so enormous has been almost totally invisible. Only a few, among them Foerster and Bateson, have understood the genesic role of disorder, and it is Atlan who has plainly posed this problem in informational terms.

2. Shannonian information becomes generator of negentropy in becoming program inside the cybernetic machine. Brillouin shows that we can, on the Shannonian base, pose a principle of information in which the equivalence between information and negentropy allows the transformation of one into the other. This principle by no means denies the theorems of degenerativity. The reader knows now that, in complexity, there is no alternative between the terms

of entropy and negentropy, but simultaneously complementarity, concurrence, and antagonism. But this is also to say that we must elaborate a complex information theory; this necessitates, as we will see, the update and elucidation of its principle of generativity, which confronts us head-on ever since information has been identified with the *gene*.

Shannonian information clouds up the moment we plunge into its generativity (negentropic organization) and is dislocated the moment we search for its own origins (participation of "noise" in the genesis of information). These are the obscure zones which, for eight years, Henri Atlan has undertaken to explore, and it is evidently he who has awakened me to these problems.

3. The adoption of the informational thematic in the theory of life has contributed powerfully to the progress of life, but this progress, to be pursued, should have enriched and complexified the informational thematic.

Thus, from the moment that gene and information are identified as one, the origin of life, evolution as creator of millions of vegetal and animal species pose more and more insistently the problem of the birth, growth, development of information.

The theory of life, for which the idea of code and program have been fortuitous, should start looking to walk on its own feet by interrogating those notions: the notion of code is very strange when there is no real language, no real receiver, and no real sender; it has a little something too much, maybe a big something missing. The notion of program is useful but insufficient: whence comes this program without programmer? What does this program signify, which to function and reproduce needs the products it orders made? What is this program which can vary its answers in a same situation? We see: *the introduction of information in life, instead of being only a cybernetic-Shannonian application, should have been, should be, is beginning to be (with the work of Atlan, much more "revisionist" than he thinks) the occasion for a revision and complexification of theory.*

C. Theory Deficiency

Information inoculated into DNA has retained the idea of code from human communication; with the idea of program it introduces the model of the artificial machine.

Thus, what is introduced in the gene is: a) an anthropomorphic idea of code, b) a technomorphic idea of program; the first excessive perhaps, the second insufficient probably. This inoculation had a heuristic aspect, but also an aspect doubly deforming: we erase from information, after cybernetic soaking, all anthropo-social complexity, while keeping a formal anthropo-

social schema (code, quasi-sender, quasi-receiver); from the cybernetic idea of program we erase the programmer and the insertion of the machine artifact into the social megamachine, and this abstract machine becomes the model of the living machine.

Finally, this artificial model comes back to the organization of the brain and the organization of society, forgetting that it had started out from there, forgetting that it is one of its little particular by-products, having lost along the way all its fundamental anthropo-sociological components, having simplified and falsified the theory of life. And so it is that the potentially civilizing idea of information, which would have allowed sociological theory to complexify itself, has arrived as a barbarian.

Here appears the crucial theoretical paradox. Information is a concept which has succeeded in establishing an organic link between the physical universe, the biological universe, the anthropo-social universe. From the beginning, there has been a link between physical theory and the anthropo-sociological framework. Shortly afterwards information took root at the heart of biological theory, and the triple articulation seemed therefore assured.

But in fact, there has not yet been any true articulation; there is, as we have seen, the hegemonism of a dissociated, simplified, mutilating concept.

Now, we must reconsider the key problem of the triple articulation:

physis ——— *life* ——— *anthropo-sociology*

The physical reality of information is not concretely isolable. I mean that there is, to our knowledge and on our planet, no extra-biological information. Information is always tied to negentropically organized beings which are the living beings and the metabiotic beings which feed on life (society, ideas). Furthermore, the concept of information has an anthropomorphic character which seems to me non-eliminatable. (It has even needed, in order to affirm its negentropic fullness, Maxwell's little anthropomorphic demon.)

We arrive at this key proposition: the physical concept of information is inconceivable without the biological concept of information and without the anthropo-sociological concept of information. We mutilate the reality of the physical concept if we claim to isolate it totally, since *it exists only in physical beings which have the quality of being alive, and it develops its potentialities only in the communication between social beings having the cerebral aptitude to exchange information.*

Whence the necessity of a theoretical mega-system, which, locating itself at the level of the triple articulation, integrates, transforms, and surpasses the concept of information born from Shannon.

It is not purely and simply a matter of rejection. Shannonian information has key virtues (relationality, event-fullness [Fr. *événementialité*], improbability, originality, and especially the possibility of being articulated on negentropy). But it is insufficient in its form (particle/digital), it has enormous deficiencies, it risks being reified and simplified under its programmatic form, and finally denatured under its Vulgate or ideological form.

Shannonian information is only the emerged tip of a deep iceberg. The dominant idea set forth by my critical interrogation is that a true information theory can only be meta-informational, that is to say only develop if integrated, articulated, and "surpassed" at the heart of a complex theory of organization. It is really in this direction that Atlan has naturally gone: from information to organization. (Atlan, 1974) Here, I can only limit myself to sketching a problematic of information in negentropic organizations and processes.

III. Genealogy and Generativity of Information

Information appears to us as a complex concept, become indispensable as soon as it appeared, but still not elucidated nor elucidating. It is a matter then, here first of all, of trying to plumb its origin. The problem of origin leads directly, we are going to see, to that of generativity.

A. The Genesis of Generativity: Birth of Information

The equivalent relation negentropy/information risks masking the antecedent and enveloping character of negentropic organization with respect to information (cf. previous chapter, notably pp.305f).

Given that, the informational complex (and I say complex because information supposes circulation, communication, engraving mechanism, apparatus) must be conceived, not at the origin, but at the end of a very long and complex process in which a negentropic organization producer-of-self is transformed into a living cell.

There is an extraordinary distance between what we know about the start (the production of nucleotides and amino acids in laboratory "restitutions" of "primitive soup") and what we know about the arrival (a unicellular procaryote having cytoplasm and genes inscribed in a RNA), and this organizational distance must correspond to a very great temporal distance, maybe more than a billion years.

This period is called pre-biotic; it is generally conceived as a process of chemical interactions and reactions between elements encountering each other

at random in favorable conditions (Oparine's "primitive soup"); this process would be the combinatory association of large chemical assemblages more and more complex, which would finally lead to a self-reproducing organization endowed with living qualities: the cell. Such a conception ignores or underestimates the possibility of the very precocious upsurge of one or several organizations producers-of-self, of vortical form, and whose developments and mutual proto-symbiotic integrations would lead to a communicational-informational organization. From then on the idea of a proto-biotic period becomes very important; it is interposed between pre-biotic and biotic, links them, and overlaps one on the other. From the moment we become aware that life cannot be born from the miraculous apparition of information, then we have to think that information is born of the complexification of a proto-biotic organization, which, thanks to this complexification, is going to be organized into life.

Just as we had underestimated until the prehistoric discoveries of these last years the very long period of hominization (today evaluated at several millions of years) which, from a little two-legged hominid goes to *homo sapiens*, because we were unable to conceive the paradigm which allows us to connect and not disjoin primate and *homo*, so the domination of atomized information and molecularized life prevents us from conceiving the very long proto-biotic period of the development of an organization producer-of-self, and becoming, by creating its informational organization, self-organizing.

We must, then, start, not from the atomizing paradigm which struggles to conceive the assemblage of a grand mechanical game, but from a paradigm of active organization founded on the recursive, retroactive, negentropic properties of the loop producer-of-self.

We know, since Prigoginian thermodynamics, that spontaneous organizations of a vortical type are constituted and maintained in certain conditions of instability. Given that the living system, as Atlan correctly says, is a system whose elements are not the chemical components, *but the chemical reactions between the components* (Atlan, 1975, p.95), we must therefore imagine that the game begins, not only by encounters and reactions, but by the formation of currents of chemical reactions.

Let us imagine, then, Oparine's "lukewarm soup," with not only oxidations, reductions, acidifications, photo-reactions, but also fluxes colliding and combining in swirls. It is in fact in such a soup, teeming, chaotic, that we can imagine the play of the genic dialectic disorder/interactions/organization taking place, organization being not only the molecular structure of the nucleotides and amino acids, but already of the chemical loops stirring and encycling molecular transformations into clouds. It is in this dance of

exchanges, reactions, transformations, that molecules endowed with duplicating properties are drawn in; thus are multiplicative processes triggered, and triggering processes multiplied.

The conditions of instability break and decompose the currents but also favor encounters. From then on, from processes which overlap, interfere with, and oppose each other, we can envisage proto-symbiotic loops constituting a machine-being producer-of-self, nucleo-proteined by nature. Let us have fun with this scenario, since our goal is the bit.

Proto-symbiotic/parasitic Looping

Active associations are made, unmade, and remade in the stirring. Duplicators can operate very well as viruses (which are nothing more than a duplicative matrix) in favorable surroundings; they extract therefrom the elements of their own proliferation by degrading those surroundings, namely by decomposing the unstable molecules which "breed" them. They can be combined in a "parasitic" relation with reactive molecules, but for the latter to be able to reconstitute or recompose, the presence of catalytic molecules is needed. Behold then, in a semiparasitic and pre-enslaving symbiosis, a "ménage à trois:" duplicating entities are associated with catalytic entities, which trigger the reconstitution of unstable reactive entities.

This proto-symbiotic association combines in a loop the sequential movements of chemical exchanges (which thenceforth prefigure future metabolic activities) and of quasi-crystalline duplications (which prefigure the mechanism for self-reproduction). This looping, if it actively reacts against dislocations and dispersions, is already the constitution of a:

Nucleo-proteined Being Producer-of-self

The recursive loop of myriads of chemical interactions and reactions which is constituted is, by its nature, and no doubt by its form, already far from the aquatic swirl. The on-going production, the on-going reorganization are of chemical nature: the reconstitution of proteined molecules which degrade. The energy supply is effected perhaps by photo-reactions, that is to say direct plugging into solar radiation. This symbiotic loop is surely fragile. Suppose the loop breaks: the symbiosis collapses, the entities are dispersed. The duplicator, which is the most stable entity (RNA or DNA), ceases to divide in two and is maintained until it is linked anew, in the superactivated swarming and proliferation of meetings and interactions, to catalytic and reactive entities, with which it reestablishes the "ménage à trois."

Thenceforth new loops are constituted, some of which are reinforced more than others, and this reinforcement is reinforced with the insertion, on the occasion of encounters, of every element whose reaction will have the property of stabilizing and reinforcing the looping.

Reinforcement of the Looping

From the beginning a "natural selection" (of molecules *intra-muros*, I mean intra-looping) takes place. (Eigen, 1971) In fact, the least sociable, least endowed molecules are rejected outside the great adventure. The organizational logic of the loop plays as soon as it is formed and it does so through its symbiotic developments: the incessant retroaction of the whole as whole on the parts in order to remain whole *protects the parts which protect the whole*. Therefore, whatever favors the survival of the whole will be preserved, integrated, developed in this process both selective and morphostabilizing.

This reinforcement of the reiteration necessarily includes the development of productive activities: the more the system integrates new elements, that is to say variety, the more the manufacturing capacities must, *via* catalysis, be diversified; thus, the loop can be enriched from very diverse elements, some more and more apt at metabolic exchanges, others—enzymes—more and more precise and operational in the manufacturing operations. A dynamic of repetition, reorganization, and production is complexified.

Constitution of a Regulatory Complex

We have seen that the most complex machine-organization we know, that of suns, is spontaneous, that is to say non-informational. It is the permanent global resultant of interactions in incredible numbers, prodigiously complex, diverse, and divergent, complementarized in the counterbalancing of multiple antagonisms. *Regulation and regeneration are indistinct from the total process*. It is licit to think that the proto-biotic nucleo-proteined being, organizer and producer-of-self, which has been constituted can function very well, even at a high stage of complexity, on the basis of spontaneous regulations, that is to say on a recursive/retroactive logic of concurrent, complementary, antagonistic interactions. *At its origin, life is a micro-sun feeding on macro-solar radiation*.

But whereas solar destiny plays in a manner quasi-independent of its environment, proto-biotic destiny is woven through interactions with the environment. The latter condemns it to insecurity and dependence. But at the same time, if we continue to suppose the "soup" simmering, teeming with

encounters and exchanges, this environment furnishes it riotous and verabundant variety, which allows the loop to develop and complexify, when it integrates functionalizable elements. Internal complexification, namely growth in the variety of components and reactions, is tied to a complexification of exchanges with the surroundings: the loop has incorporated in the future cytoplasm varied and unstable proteins, enzymes with very diversified activities. The problem of the organization of the metabolism is posed, then, in a more and more acute way. The machine, more and more varied and delicate, would be more and more fragile if this fragility could not be compensated for by an organization regulating the metabolism.

But this organization is still fragile, and we must suppose countless ruins, ruptures, cracks, that is to say redepartures from scratch. However, it is not always necessary to start again from scratch. Duplicators get out of trouble and will start over elsewhere, later. The more they will have taken with them components capable of exchanging and producing, the better this will be for their multiplication. Thus, there are not only hecatombs of proto-cells, but there are also selective re-beginnings, starting with duplicators which know how "to save their skin" and then constitute a new proto-cell.

Therefore, the "failures" at the level of the large loop can at the same time play a selective role in favor of little loops of parasitic/enslaving duplicators, which, in new conditions, are integrated in the constitution of large new loops (from this era, perhaps, viruses—beings purely parasites/exploiters—are differentiated from social duplicators which accept mutual harnessing, without which life is not possible).

But everything depends finally on the global problem. For the definitive jump towards living organization to take place, an organized generativity must be constituted: the harnessed proteins which breed the duplication of the duplicators must themselves harness these duplicators, since by reproducing them they reproduce what breeds their duplication. *Therefore, the restrained duplication (of the duplicator) must be transformed into the generalized replication (of the whole).* Thenceforth, there is generated and regulated a generating and regulating proto-apparatus, situated in the most stable entities, the RNA duplicators, capable henceforth of self-reproduction while triggering the reproduction of the degradable elements associated with them.

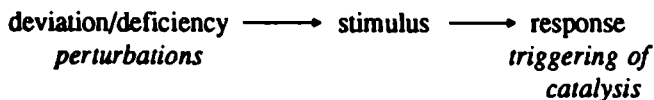
The Process of Informationalization

The process of informationalization does not follow upon what we have just said; it is initially associated with it. It is effected in the prodigious

interference of factors on each other. As hominization is a total process of ecological, genetic, organismic, cerebral, sociological transformation, a process of life style, with the creation and development of technology, of culture, in which the constitution of language with a double articulation is an aspect both total and partial of this process, so we must conceive "biotization" as a process of unheard of interferent developments, wherein arises the informational apparatus with double articulation.

Let us recapitulate: the loop producer-of-self reorganizes itself by extracting from the environment chemical elements which it needs to survive and by reproducing those of its molecules which degrade. We can suppose that each deficiency or deviation retroacts on the loop in a wave of alert until one molecule reacting specifically to such and such a deviation or deficiency triggers a catalysis. We suppose that in a first state of the regulating, regenerating, pre-informational complex the molecules thus reactional are in stable sites, buttressed on a large RNA scale.

Starting from these interactions:



a process/cycle stimulus/response is created, in which the mediatized stimulus acts as a signal for a molecule or a molecular group which responds by another signal for an enzyme, which triggers the manufacturing.

Thus, inter-retroactions become communicational. But there is no code yet, no information yet. Patience! Let us consider here the situation in which such and such an alert, deficiency, or need triggers such and such a molecule, which triggers such and such an enzyme; there is mutual intergrammatization as soon as one agent (the base in RNA) becomes a signal for the other agent (enzyme), and conversely. Here we must think not only of the four bases of DNA but of the 20 fundamental amino acids which constitute the letters of another "vocabulary." We must imagine that the "coding" in RNA then DNA has its counterpart in the stereospecific "coding" proper to the enzyme. Therefore, a first informational phase is constituted in a dialectic of mutual engrammation term for term.

This first pre-informational double engrammation defends and fortifies the chemical machine. But, with the developments of complexification, the combinations between the bases of RNA are not numerous enough to respond to the protein demand and a phenomenon of saturation appears. To understand, let us take up again the hypothesis formulated by Hockett and Asher (1964) on

the formation of human language (with a double articulation) in the course of hominization. At a certain development in hominian social complexity, given the increased needs for communication, there was probably phonic saturation of a *call system*. It is thus, under the pressure of a non-satisfied demand for variety, that a language with a double articulation could be constituted, our language, semiotic meta-system allowing henceforth the combination *ad infinitum* of words and sentences, endowed with meaning, based on phonemes become units deprived of meaning.

We can imagine, likewise, a pressure for variety, emanating from phenomenal needs ever more varied and complex, by the trickery of proteins whose combinations can vary *ad infinitum*, on a restrained number of "saturated" bases which could respond to the increased needs only by constituting a meta-system with a double articulation, in which these bases, becoming the equivalent of the letters of an alphabet, will be able in their turn to be combined *ad infinitum* on the level of the second articulation.

It was enough that this "double articulation," situated evidently in the duplicating entity, be constituted once, in an unimaginable way, like every passage to a meta-system, that it reproduce itself, and that this "genetic code," tied to the reproduction of the whole as whole, guarantee the multiplication of life *ad infinitum*, transforming its initial improbability into strong terrestrial probability.

Thus, the "word" is not "in the beginning." It is the end of the (proto-biotic) beginning.

From then on, the metabolic group entered into the reproducing circuit, the reproducing group entered into the metabolic circuit.

A geno → phenomenal loop was constituted, simultaneously producing and



reproducing an *auto-(geno-pheno)-eco-re-organizing* machine-being, whose generative complex constitutes an informational proto-apparatus and whose phenomenal complex constitutes a communicational organization. The genesis of information corresponds, therefore, to a metamorphic development of a negentropic organization becoming informational/communicational. Information, henceforth necessary to this organization, *just as this organization is necessary to it*, emerges under the form of engram. It already contains in an indistinct and potential state all of its ulterior differentiations.

From Non-information to Information

The genealogical conditions of information are of theoretical importance in

every direction, among which this one, which we have already singled out: information is born from non-information. This means:

- information is born from a negentropic organizational process which develops from event-full chance interactions;
- information is born at the same time as there is constituted a generative/regenerating complex:



and it can thenceforth regenerate in its turn what generates it:



Highly improbable in its occurrence, information, in inscribing itself on a generating complex of duplicative nature, multiples and proliferates. We can, therefore, conceive both the improbability of its appearance and the probability of its diffusion. And, for the development of information, non-information intervenes anew, this time in the form of "noise," that is to say perturbation. But it is not noise which creates new information: it is the conjunction of negentropic organization/information/interactions/noise.

B. Archaeology of Information:

Re-generation and Generative Information

1. Machine and Machine. Information and Information. Program and Program

We have been able to liken the sequences inscribed in DNA to a message, formulated according to a code, constituting a program. Indeed, the hereditary patrimony is a quasi-message which is transmitted from generation to generation. But the idea of message is a little too clear. Here the transmitter and the receiver are the same doubled as one; the message is both transmitting and transmitted. This is not so clear.

Code? In fact, a quasi-code emerges from the constitution of a system with a double articulation.

Program? We have seen the valid objections that can be made to this term. What is this program which comes, not from the outside and above, but from the inside and below? What is this program which determines, not sequences of rigidly stereotyped action, but random varieties of behavior?

Some people reject even the term. Nevertheless, the word program is not totally impertinent: in static terms and according to a restricted framework, everything happens just as if from information coded in the genes there emanated, *via* RNA, extremely precise instructions. But we can keep this idea of program only on condition that it be integrated and not integrating, dominated and not dominating; this is to say that it be conceived as an aspect and a moment of informational generativity. The whole of a genome represents rather an *organizational competence* whence emanate *strategies* (plurality of behaviors developing and modifying themselves in function of random circumstances, in order to attain finalities), *at the interior of which* the execution of punctual operations takes on a programmatic character, in the sense that a program predetermines *ne varietur* strictly stereotyped performances.

Thus, "message," "code," "program" seem to clearly reflect and translate something of informational generativity. But what they leave in the dark seems more fundamental and fascinating than what they light up.

2. Generative Complex and Informational Apparatus

To isolate "generative" information, we must first of all not isolate it. Information emerges at the same time as a generative complex and communicational organization. This generative complex is organized from stable duplicative molecules, maybe RNA before DNA. In the most archaic cells we know, called protocaryotes, there is no concentration of a nucleus yet; the generative complex is dispersed, polycentric. The generative complex is reassembled as nucleus in eucaryote cells. As I have indicated (Part Two, ch. 3), we can consider the cellular nucleus as an informational proto-apparatus, since it responds in large measure to the definition already given of apparatus: an original arrangement which centralizes information, processes it, and ties this information processing to actions: in fact the nucleus is the principal storer of information, the principal center of communication, the principal transmitter of "instructions;" it constitutes the organizational competence which I have just evoked, capable of elaborating strategies and *a fortiori* of transforming information into "program." But there is reciprocal harnessing, and more deeply recursivity, in the relation between the informational proto-apparatus and the cytoplasm. The apparatus organizes (generatively) (phenomenal) organization, which in turn is necessary to (generative) organization. *Its organization organizes an organization which in turn organizes it.* Therefore we can neither isolate the information from the apparatus wherein it becomes form and action, nor isolate the apparatus from the global recursive process

which is the life of a cell. We cannot, therefore, make the apparatus the sovereign of the cell, nor information the sovereign of this sovereign. But the mystery of the nature of generative information is now only more puzzling.

3. *The Face of Information*

Information is inscribed, preserved, protected in the genes. But what is it? DNA is not information, but a molecular structuration in double helix in which information is inscribed. The four bases are not information. Information is in the combinatory configurations of the four bases.

These configurations are evidently not haphazard and improbable. The relation that each establishes between the elements which constitute it (nitrogenized bases) is a deviation or a difference in respect to the probable allocation of these elements in a non-informed DNA molecule.

The originality and the improbability of the genetic/informational mini-configuration, (without any more resemblance than between the word cat and the being cat), correspond to the complex and concrete maxi-configuration of a living being. In this sense, it is very much a matter of a system of signs, and, the same as the word cat evokes the being cat, but only in an imaginary way, likewise this system of signs is necessary to the production and reproduction of a real process, in a way not imaginary but praxic.

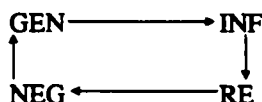
The marvel is that as sign, information allows reproducing; as relation it allows organizing; as micro-configuration it is necessary to the general configuration; as the difference, it allows differentiation.

But we would miss a major dimension if we forgot the key characteristic inherent to all producing-of-self: *the dynamic of rebeginning*. It is in this sense especially that we must understand the *engrammed sign*; this sign is *Archive*, that is to say an inscription bearing the mark of antecedent negentropy, and going back from antecedent to antecedent, the mark of arkhé-events founders of this or that characteristic of present or future organization.

Consequently, the sign appears to us as *guardian (engram) and source (program) of organizational negentropy*. Therefore we can read information only in the dynamic of the RE-starting, of the RE-beginning, RE-organization. It is present at each instant, active in each operation, without however being consumed or wasted, since it remains engrammed, and it can serve indefinitely, that is to say in a way indefinitely multiplied, even multiplying (biological reproduction, then reproduction in printing, photo, etc.).

Consequently we can begin to both isolate and connect generative information: *it is the improbable and stabilized configuration, engrammatical*

(sign) and archival in character, which at the heart of the generative proto-apparatus, is necessary to the repetition or exact reproduction ad infinitum of the processes of regeneration and re-generation.



4. The Rebeginning

We have already encountered the key problem of the RE, in the uninterrupted rebeginning of the recursive loop, the permanent reorganization of active organization, the permanent production-of-self. We have encountered a different type of repetition in the duplication of crystals. Generative information is the knot wherein the duplication (which is going to command and entail the multiplicative reproduction of individuals) and the dynamics of rebeginning are tied. Its preservation (engram) always allows rebeginning (at least as long as the engram is not altered); its activation (program) allows the generative complex to orient and control, allows the entire cycle to effect, *faithfully*, and potentially infinitely: permanent RE-organization, permanent RE-generation; RE-production of the components which degrade; periodical RE-production of the being in its integrality.

What rebegins is by no means the inexorable cycle of the planet around its sun. No physical law whatsoever commands it. This rebeginning even goes against physical "laws," while remaining at the heart of *physis*. This rebeginning reiterates, revives, regenerates a cycle of improbable and singular antecedent events. And thus life continues: it is reborn at each instant, that is to say endlessly revives past events, but recombined and rearranged in the present cycle.

If we watch the organism in its phenomenal activities, everything happens as if the informational engrammation of events which produced in the past constituted a sort of "memory" from which the informational apparatus draws, according to its needs, combining synchronically resurrections of events which emerged diachronically in the past. I will come to this in the following section. At this point, I want to first illuminate the logic of rebeginning by taking the onto-phylogenetic relation.

It was noticed a long time ago that the ontogenesis of an individual is like a recapitulation of phylogenesis, a sort of analogical repetition of the organizing events of the phylum, and this in a way so much the more striking because a long and complex ontogenesis corresponds to a very rich evolutive past of the species. As this repetition is neither complete nor exact, certain

people have limited the effect of onto-phylogenetic parallelism. Now, these weaknesses in rebeginning confirm that the transmission and reproduction of information navigate on the ocean of noise; like a message which has knocked about a lot, it has been impoverished and enriched through evolutive mutations; whence scrambles, confusions, reconstructions; consequently, ontogenesis, read as rebeginning, includes oversights, lapses, summaries, inexactitudes, deformations, overlappings, and recombinations. "It is perfectly exact that embryogenesis recapitulates, for certain organs, ancestral types of embryonic organization...or even adult...; but for many organs this recapitulation seems only broached, incomplete, or inexistant." (A. Dollander, 1970, p.31)

This makes us understand that the relation species/individual, contrary to trivial conception, is not the one of a whole and its parts, of a model and its copies, of an intemporal and general mold whence singular and temporal individuals would proceed. The observer, in contemplating the succession and the multitude of like individuals, conceives a *pattern* of species, but this model is the static and statistical unidimensional projection, in an abstract understanding, of the dynamics of reproductive rebeginnings.

Thus, the new being is formed in rebeginning, the onto-phylogenetic relooping, and once formed, it is the resurrection of the founding ancestor. It has the identity of the ancestor, that is to say for us the identity of "its" species. But, even identical, it is different because its informational patrimony has undergone, in the course of reproductions, random variations, and because this individual is living a singular phenomenal experience according to a self-referent logic; by that fact, it is distinguished from its begetter as its begetter was distinguished from its begetter. Through reproduction, therefore, informational generativity creates alterity in identity, identity in alterity. *The same history*—and that is what the identity of the species is—is reincarnated through the different, indeed divergent, histories of individuals. It is neither the species which gives existence to the individual nor the individual to the species; they reciprocally give each other existence by rebeginning, repetition, reproduction.

This complexifies, thereby, the idea of becoming and of future. The becoming of living organization passes through recurrence: *tele*, finality turned towards the future, is a return towards Arkhe, which finds itself catapulted onto the present. But the future is not an "eternal return." Arkhe is not an unalterable model, like the Platonist Idea: everything rebegins anew, with new possibility. Sometimes a new event enters the cycle, which modifies the loop (genetic mutation), and it is these perturbing events which, by introducing transformation into recurrence, cause evolution. Rebeginning is a spiral movement, which distances itself from its source each time it returns to it.

5. Generative Mnesis

It is in function of the dynamics of rebeginning that the informational sign very strongly takes on its character of archive. Thenceforth, *everything happens as if the chemistry of rebeginning obeyed an alchemy of rememoration*. Once again, we are no longer in the "digital" framework of programmatic instructions; we are also in a sort of analogical or mimetic replay of what has already been played.¹ Such an analogy suggests, not that information is already, properly speaking, a memory but that what we call memory, and which supposes our cerebral apparatus, allows us to better conceive the organization of the generative informational apparatus (of which our brain is an epi-genetic development) in its relation with the past which it preserves, translates, reproduces, *re-presents*.

Let us remember. The ontogenetic process can be justly conceived as a repetition of what has already lived, a re-production of an organism in the *image* of the generating organism, which itself was in the image, etc. In other words, reproduction is the *production of a phenomenal and material double, a real copy of the original*.

In this sense, ontogenesis can be conceived of as an organizing and productive rememoration. But what relation can we make with mental memory?

Certainly, the informational archives of the living being are chemically inscribed in the DNA of a nuclear apparatus, and our mental archives are chemically inscribed in the neurons of a cerebral apparatus, but two fundamental differences are immediately very evident:

1. the memory of our cerebral apparatus is principally furnished by the events which happen unexpectedly in our phenomenal life, whereas generative memory, blind to these events, is furnished by the organizing events of a past anterior to the individual;

2. mental rememoration is imaginary: it revives an image, an *eidolon* of a physical event or form; the praxic competence of the mental act of rememoration is for us² totally void. On the other hand, genetic "rememoration" is praxic and not at all "imaginary."

But it is in this extreme difference that the extraordinary resemblance appears: *our mental memorization and generative rememoration are both producers of a double, but in the first case, this double is imaginary, in the second case, the double is a real act, a real product, a real being*.

Let us recall, first of all, that the analogy between the memorized information of our brain and the archived information of our genetic apparatus goes further than mere chemical engrammation. In both cases, what is

inscribed is not a "fact," its representation, its "image," its model; what is inscribed is a sign, "a steno," a mark of recall of the event. Our cerebral memory does not put "perceptions" into a box, it engrams signs, in connection with other mnemonic inscriptions, recalling other events. In both cases, the image here, the "model" there are only present virtually. In both cases, there must be activity of the entire apparatus for the regeneration to take place; we have seen this in what concerns genetic information; in what concerns mental rememoration, there must be activity of the entire cerebral apparatus; not of all the billions of neurons which constitute it, *but of its activity as whole in as much as whole*. For the engram does not contain the memory-image. The image is reformed at the time of the rememoration, when the psycho-cerebral set remembers, thanks to the engrammed outline. This memory is a resurrection or imaginary re-production of the event remembered, according to processes still unknown, but where, in my thinking, analogico-mimetic processes and digital processes are combined. It is really a question of the present revival of the event, as an imaginary, not a real, copy.

Like genetic reproduction, cerebral memory reproduces what otherwise would have returned to oblivion or been dispersed, that is to say it re-generates the improbable, the deviant, negentropy, but only under the form of image.

Memory is a duplication of event, under the form of image. This remembered image is of the same nature as the perceived image: a brain, animal or human, always perceives, starting from stimuli transmitted by the senses, only an image, a representation of events or things. *It is this perceived image which is engrammed, then rebecomes image*. Thus, rememoration translates the generative potentiality of our brain: to transform the phenomenal real into image, and to reproduce, re-generate this image.

The two reproductions, imaginary (mental) and praxic (genetic), clearly explain the nature of generative information: the latter is simultaneously preserving/recording (engrammation; archive) and resurrection/reproduction: the imprint then becomes matrix, when the apparatus and negentropic totality come into play. Thereon in, *the machine for making doubles is at work*. But, whereas the genetic machine reproduces being and existence, the cerebral machine reproduces the spectral "double," the *phantom-ghost* of beings, events, things. (Morin, 1970) Mental rememoration is an integral regeneration, but integrally imaginary.

We underestimate, in its dormant state, the force of this imaginary duplication. It is sort of toned down by the fact that our consciousness treats the image as a non-reality, not as a double of reality. But in fact, the memory-image has a force equal to the perceptive representation; this is evidenced in the extreme cases of hallucination, where the mental image has

presence and real existence, as well as in the experiences of electrode stimulation of certain cerebral regions, which make the memory emerge with hallucinatory virulence and quasi-perceptive precision. (Delgado, 1972)

Thus, in psychic rememoration, there really is a *duplication*. But whereas, in biological reproduction, the double is physical and takes on autonomous life outside of its begetter, the copy of the mental memory cannot survive outside the rememberer. Cerebral rememoration can, therefore, be considered as a *degenerated form of reproduction or as a degraded form of regeneration*. But it is also a metamorphic development of generative information, in a new domain and reign, which with man is going to suddenly expand the domain of the imaginary and the ideal! And, just as the neuron is a degenerated cell which has lost the praxic power to reproduce but thanks to which we can compute, think, imagine, dream, so the existence of a mental memory, which engrams the phenomenal experience lived by an individual in his *Umwelt* and regenerates it by memory, brings fabulous negentropic possibilities. For, the mind's rememorative information remains regenerative; it remains reproductive; it remains, therefore, generative information, but in this new field of generation and production: the ideal and the imaginary.

6. Multiplication

The same engram serves for several repetitions. It has, therefore, the strength of multiplication. The duplication continues: the duplicates are duplicated in their turn and so on: duplication is multiplicative. Each reproduced double is a reproducer, that is to say possesses the generative powers of the original. There is, therefore, an indefinite multiplying potentiality in the very principle of generative information; it is thus that life spread on land. Human history, from apprenticeship to writing (which already has multiplicative value, before printing, in function of the number of its readers) then especially from printing to radio, movies, television will multiply informational multiplication at the same time as it diversifies it.

7. The Memotheque

Let us now leave genetic reproduction and consider the very organization of the phenomenal existence of a cellular being. Here again, the idea of archive and memory are enlightening. Informational archives constitute a memotheque from which the apparatus draws diversely according to the needs and problems signaled to it and which concern reorganizations, internal productions, behaviors, etc.; namely all phenomenal activities. The apparatus evokes,

thenceforth, partial or exact rememorations, which, by their praxic nature, trigger actions or productions answering needs or problems. In the case of the internal fabrication of new molecules to replace degraded molecules, everything happens automatically and takes on programmatic form. When a set of complex activities is concerned, the apparatus draws from its memotheque in function of the strategies and combinations which it elaborates to adapt them to the circumstances, and the memotheque becomes mnemo-praxis, by producing what suits the strategies which it co-elaborates.

Thus, the face of generative information is seen a little better when we shed light on its archival character. But this archival character itself needs to be illuminated in and by the praxis of the nuclear proto-apparatus (and *vice versa*), and the praxis of this apparatus can only be illuminated in relation with the total praxis of the being. Solitary information, left to itself, is no longer information but a provisional deformation or a myth of the person processing the data.

The primordial face where information emerges and which information makes emerge is rightfully called a gene: generativity! It is active interaction among information, apparatus, and being, conceived as recursive totality, that information becomes generative and organization becomes negentropic. Then the archive becomes word, and the word is made flesh.

8. Event-full Generativity

We have seen that there is a difference in principle between the repetition of general physico-chemical laws and the repetition of rebeginning in any production-of-self, that is to say in any negentropic organization. What is remarkable is that by the production of *events* which organize, informational organization organizes the rebeginning which founds it; it provokes events precisely in order to annul or thwart those events which disturb, which ceaselessly arrive from the outside or arise from the inside. Thus, paradoxically, the invariance of anatomy, of physiology, of models of behavior are maintained only by events which reorganize, produce, regenerate. One originality of informational organization, compared to other negentropic organizations, is in the functional production of events which organize and order. The fundamental between the cycle of rotation of the earth around the sun and the cycle of biological reproduction is that the repetition of the first, if it produces events on earth, is not produced by events which generate, whereas the repetition of the second is the product of an event-full regeneration.

Just as the improbable is, in and by negentropic organization, transformed into the local and temporary probable, so the properly event-full character of the generative event (its improbability, the surprise and the deviance which it constitutes) is transformed into elemental character, namely necessary and orthodox for this organization: the event becomes element, without, however, ceasing to be an event. Whence this double face of informational generativity: it keeps the event-full character of Shannonian information, but the event has changed character, temporarily and locally, without however changing nature. It has henceforth a double face, that is to say a complex face.

As we shall see (v. II), life, and, beyond that, man and society, are prodigious constructions of events; they are castles and palaces made from whirls of events. Informational organization reproduces past arkhe-events, ceaselessly triggers events which organize, produce, performance-events, and the more it is complexified the more it is capable, as we shall see, of integrating and utilizing an event which disturbs. We had already seen that everything which is physically order and organization had, under a certain angle, a character of event. Here the relation is extremely intimate, uninterrupted. The living being, born from singular chain events, is an organism constituted of events, an individual vowed to live an event-full life, and it reproduces itself in event-full form: from all that, there is born the *order* of life, the *logic* of life, the *laws* of biology. And in fact we can speak of genetic, demographic, ecological, organismic, behavioral laws. And human Societies, equally event-full in texture, not only obey sociological laws, but produce laws which must be obeyed.

Thus, we see this remarkable property stand out: *generative information generates events, generates only events, but transforms them into order and organization, without, however, their ceasing to be events.*

9. The Conceptual Chameleon

There is not only the word code to express the nature of information nor the word program to express the generativity of information. It is not a matter of rejecting these terms; it is a matter of not being locked up in them. Alone, the program masks strategy, competence, the apparatus, recursive totality; it masks the dynamics of rebeginning, regeneration, reorganization. If there were only the idea of program in generativity, there would not be, there would have never been life. The latter is a genodrama, that is to say a representation, haphazard each time, which is re-played, re-lived, rememorated, in a development in which simultaneously the inexorable ritual, the *commedia dell'arte*, the convinced recitation of the text mix with and interpenetrate each

other. It is in this process that we must situate the play of information, and not in the assemblages and manipulations of the artificial machine. Information in its generative nature is not easy to grasp. It is polyscopic; it is already, in its radicality, chameleon. It invisibly changes color according to the conjuncture in which it finds itself, according to the gaze of the observer: sign, engram, program, archive, memory are aspects, some of them still embryonic, all of them still indistinct from one another.

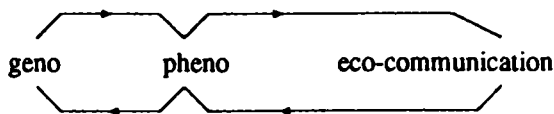
Already we see other faces sketched: knowledge [Fr. *savoir*], since in the memotheque is found inscribed the knowledge that a lineage has of itself and of the world; know-how [Fr. *savoir-faire*], since its praxis includes methods, techniques, strategies which permit a living being to be constructed and to live. These diverse aspects and still others are going to be differentiated, deployed in and from the most astonishing epigenetic informational apparatus there is: the human brain.

IV. Information Circulating

Living beings are organized in a communicational way. We cannot dissociate the phenomenal activity of a cell from the process of communication, where the circulation of chemical elements plays the role of quasi-signals, of triggers or inhibitors according to the circuit DNA/RNA/proteins.

We must imagine that the least cell includes billions of molecular units, and that communication between these units, between generative sphere and phenomenal sphere (which overlap) blends with the permanent activity of reorganization, production, exchange, transformation in a formidable micro-chemical factory which is unceasingly occupied in producing its buildings, its machines, and its personnel. The communication of information triggers or inhibits fabrications and transformations which maintain and produce unity, heterogeneity, homeostasis, originality, improbability, the *life* of the cellular being.

Information, therefore, "circulates" (Laborit, 1975) in phenomenal organization. It develops according to new modes, with the constitution of a multicellular organism in which, with complexification, diverse networks of communication (blood, nerves) coincide. Communication is not only intra-organismic. Any living being, the unicellular included, interprets events in the environment as signals. From the beginning there is:



At first very embryonic, communication with the exterior, eco-communication, is going to develop. Organisms more and more evolved, beings more and more cerebralized are going to discern more and more the events of an eco-system more and more diverse, and translate more and more events into information on nourishment, danger, etc. Thus, the phenomenal being—the individual—will draw its information in an *ecotheque* complementary, concurrent, and antagonistic to its *geno-memotheque*. With the apparition and development of sexual communication and social communication, the individuals themselves will emit signals to indicate their presence, to look for their partner or congener, to warn them of risks or chances which may befall.

Social communication develops somewhat in all the evolutive branches and especially in insects, ants, termites, bees. The brain, epi-generative apparatus, real machine for capturing, storing, processing information, develops in vertebrates, fish, birds, mammals. Eco-systems, that is to say complex unities spontaneously organized starting from interactions between living beings populating an ecological nook (cf. v.II, ch.1), become extraordinarily complex communicational universes.

Thus, multiple coinciding developments of life (development of individuals, of their cerebral apparatus, of their behavior; development and complexifications of sociability and of societies, development and complexification of eco-systems) constitute a formidable and multiple development of communication.

The supports and systems of communication multiply and complexify. The signals emitted or exchanged are no longer only chemical, but sonorous, visual, chromatic, gestual, mimetic, ritual. Communication no longer has only a constraining value of incitation or inhibition; it also transmits calls, suggestions, alarms.

As information becomes more and more grasped by the enemy becoming more and more intelligent, as the enemy extracts information from our trails, marks, odors, etc., to get a fix on us, then camouflage, lure, ruse develop conjointly with the art of detecting camouflage, lure, ruse. Information becomes henceforth equivocal and ambivalent: it warns and betrays; it perhaps informs the one who must not be informed: the enemy, the competitor. Great "progress" in the history of life: the entrance of trickery in communication. Henceforth victory no longer belongs only to strength and skill, but also to ruse, then to lies (*homo sapiens*). The human lie, by being sociologized, ideologized, blossoms, fructifies, triumphs, since it is adorned with the virtues of truth. The more the universe is informationalized, the more it will be thus, until the supersaturation of lie and hypocrisy trigger a reversal of the tendency, as I want to hope.

The more communication develops, the more information is multiplied, the more it is dispensed and dispersed haphazardly to all horizons, in search of a hoped for and often unknown receiver.

Thus, information which circulates is spread, multiplied, polymorphosed in a pheno-eco-organizational circuit more and more vast, more and more diverse, more and more haphazard, more and more complex.

We must clearly understand that generative information and circulating information are linked; I mean that information which circulates is generative information which is transformed, having signaletic form, circulating *grosso modo* according to the Shannonian schema, with this corrective addendum that often there is no sender, but that the receiver extracts information from the environment by transforming events which the eco-system furnishes into signs or signals which its cerebral apparatus processes thenceforth in an *ad hoc* fashion.

Generative information and circulating information can be transformed into each other, but the transformation of circulating or signaletic information is possible only if it encounters an apparatus capable of registering and processing it.

Generative information is much better protected from noise than circulating information. Genetic information is stored in very stable nuclear chains of DNA; cerebral information is stored by a stable chemical mark; anthropo-social information is stored in books, magnetic tapes, themselves protected against alteration and danger. On the other hand, circulating information has to travel through clouds, through noise. Therefore, the classical problems of transmitting information traveling in noise, namely the problems of non-arrival (ignorance) and bad arrival (error), are *vital problems*.

The noises which intervene in the intracellular and intraorganismic circulation of information are sources of error which, accumulating, lead to aging and death. Eco-systems are sarabands of true and false noises, of false information which leads into error better than the noises. The vital problems of error are very definitely mortal problems. Now, vulnerability to error, the Achilles heel of every living organization, would have been fatal to organization if life had not possessed the ruse of Ulysses, namely the aptitude to treat error on its own terms, to play with it, to lead it into error.

Generativity and circulation are two moments of information. In circulation, information can be operational, that is to say be transformed into negentropy, but on condition that a generative apparatus offer it the conditions of this transformation: *only clearly received information or clearly perceived error can be transformed into negentropy*.

Generativity and circulation are two moments of information. This means, in other terms, that the problem of information, of any information, must be situated in the context of the geno-phenomenal totality of negentropic/informational beings *where organization is always a phenomenon of communication, where communication is always a phenomenon of organization.*

We must situate the problem of information, not only in the geno-phenomenal circuit, but also in the geno-pheno-ecological circuit. Information and communication are deployed, from the reproduction cycle to the individual, from the cell to the organism, from the individual to the society, within restless eco-systems where everything and everybody meets. In developing, far from its original double scale, information tends to be *liberalized*, that is to say to lose its force of constraint; it tends to be complexified—to play strategically with ambiguity, error, to make use of ruse; it tends to diversify (knowledge [Fr. *savoir*], *savoir-faire*, norms, rules, interdicts); it tends to swarm, disseminate, diasporate... Until the apparition of the enormous brain of *homo sapiens*, of a new type of society, endowed with its own generative informational complex (culture), finally of the enormous State apparatus of social Megamachines in the historical era.

V. Anthro-socio-informational Spread

If there is a domain where both an evident continuity and a formidable change between the biological universe and the anthro-socio universe are plainly marked, it is clearly the domain of communication and information. In fact, in considering the anthro-socio field we are struck by these innovating characters:

1. A cerebral apparatus of unheard-of hypercomplexity, comprising more than twenty billion neurons, possessing an enormous memory, endowed with prodigious logical, constructive, imaginative, oniric potentialities. It is not only a super-computer processing information (much of its computational performances are inferior to those of computers). It is an apparatus whose imaginary and ideal generative possibilities are potentially universal. It is like a Turing machine capable of producing and reproducing everything, not biologically but noologically (ideas, dreams, phantasms, myths) and, with the help of hands, technologically (tools, machines, objects, dwellings, monuments).

2. A language with a double articulation, the only system with double articulation which has been constituted in the history and the development of life outside of the genetic code. The aptitudes of the human mind and the possibilities that language offer allow us to construct *ad infinitum* very varied

and complex noological edifices, narrations, discourses, mythologies, theories, ideologies, etc.

3. A geno-phenomenal social structure, namely the first and only one among all living societies to have constituted for itself out of its own complexity a generating/regenerating complex: culture.

In the most archaic human societies (on all these problems cf. Morin, 1973, pp.87-91,98-100,181-189), culture constitutes a generative, informational, quasi-procaryote complex, that is to say not yet possessing any institutional nucleus; it is spread out in all the brains of the members of society, its secrets being more or less accumulated, concentrated in certain members (the elders, the king/chief, the priest/sorcerer).

Culture is actually the generative matrix complex which perpetuates the negentropy, the complexity, the originality, the identity of each society by being transmitted from generation to generation, that is to say by being reproduced in a quasi-invariant fashion through the brain. Cultural anthropology had not succeeded in giving the unity of a generative organization to what it presented as a bric-a-brac of data [Fr. *savoir*], rules, prohibitions, etc. Now, given what we have said of the chameleonism of information, simultaneously one and diverse, we can understand that culture is for archaic society its memotheque and genothèque, its source of negentropy, furnishing information for all technical, practical, social, mythical operations. Thus, archaic culture is the collective memory of data [Fr. *savoirs*], (concerning the environment, the climate, fauna, flora, the world, man); of know-how [Fr. *savoir-faire*] (the techniques of hunting, making tools, building houses, preparing meals, of magico-religious operations); of *rules, norms*, and *interdicts* which govern the organization of society and are guides to codes or programs for individual and collective behavior.

4. The formidable rise of the State machine proper to the historical megasociety. This metamorphosis in relation to archaic societies is for organization the anthropo-social equivalent of two key biological metamorphoses: the passage from the procaryote to the eucaryote and the passage from the unicellular to the multicellular organism.

The State machine and its dependent machines (army, religion) are inter-nucleated. Provincial and local machines set themselves around as satellites. Then, machines are going to emerge and proliferate in economic life (banks, staffs of enterprises, trusts, holdings) and in political life (party machines), up to the very modern symbiosis of the Party machine and the State machine.

There remains, nevertheless, relatively independent of the Machine, a cultural cloud (ways, customs, data [Fr. *savoirs*], beliefs, visions of the world),

and cultural spheres are created with professional and specialized aspects. But the State machine concentrates in itself the generative power of social rules. (All these problems, here evoked incidentally to the concept of information, will be considered head-on in v.II.)

5. The development of urban agglomerations where the interplay of informational communication is effected in a more and more stochastic fashion; the pressure of the development of exchanges and interactions entails the creation of writing, arithmetic, manuscripts, mail, then of printing, of the book, the newspaper, the rotary printing press, offset printing, the telegraph, telephone, cinema, radio, record, magnetic tape, television, etc.

Modern evolution includes a real informational tidal wave: it creates ever more varied supports and vehicles, multiplies information in a quasi-unlimited and instantaneous fashion for a more and more restricted energy cost.³

And, in its ultimate avatars, information becomes diasporated and degraded. In fact, there is on the one hand multiplication of "information" in the journalistic sense of the term, none of which in principle carries any explicit trace of injunction or inhibition, that is to say which apparently serves only "to inform" (of course, on a statistical and global level such information fits into the organization of society, better still, into its cultural system of norms, values, interests, etc.); on the other hand there is a multiplication of playful, fanciful, mythical, etc., negentropy *via* the media. These informational proliferations spread out, without necessarily having effects, without even necessarily having receivers; they can purely and simply be dispersed, vanish and, even once received, immediately be forgotten after absorption... How many words, discourses, songs, poems, fables are thus dispersed in the ethers of the planet earth? For sure, let us repeat, this system of communication is part of social organization and corresponds to strategies of dissemination, which, like all dissemination, depend on chance and include an enormous waste in dispersion.

We can wonder whether, beyond a certain threshold, the fabulous multiplication of information does not provoke an increase of internal entropy which surpasses the increase of informational negentropy. Certainly this multiplication of information should in principle contribute to increasing the variety, therefore the complexity, of an organization founded on communication. But on condition precisely that there can be communication, articulation, between the myriads of information which pour down like cloudbursts. But let us suppose that there is overload in heterogeneity and in number, that there is no longer any coordination or articulation in the enormous cloud of bits agitating among themselves like the molecules of a gas; then diversity is

transformed into dispersion, disorder, incoherence, absurdity. This is perhaps what happens in our society, with these quanta of information more numerous than the sands of the beach and the drops of the ocean, which spurt out into myriads of books, newspapers, magazines, radios, television sets; which intersect and bump each other in Brownian fashion, which fall like rain, evaporate and diasporate. The largest part of this nebula not only is broken up into noise, but in the enormous mass of "information" taken in the journalistic sense, *makes noise*, that is to say drowns, disarticulates, confuses any possibility of understanding the world and society. Thenceforth, we can wonder whether this noise is not our basic sociological noise, worse, *if this is not the noise which rises from our culture, a culture already decomposed, gangrenous, in large segments of generative tissues*.⁴

And we understand that Shannon detected information in this sector of modern communication inexorably subjected apparently to the growth of entropy. Shannonian theory has suffered the weight of its own context: *it seized information at a point farthest from generativity*.

Nevertheless, the most diasporated information, the freest of all constraint or suggestion, the most degraded, can still be regenerated, if it encounters the *ad hoc* negentropic context. In the same way as those photons which suddenly shock an electron and are transformed by transforming it, so diasporated information can suddenly strike an ideology at its point of rupture and radioactivate an intellectual process. It is often a final drop of information which breaks the vase! Look at all those films, seen, consumed as entertainment; they have produced imaginary negentropy, they have sustained phantasms, they have allowed us to live by proxy, and then only a few residual memories are left. But take this film of little orphaned vagabond bandits that I saw at the age of fourteen, in the empty Bellevilloise theater: it changed the course of my dreams and pointed towards revolution...

The Noological Sphere

The noological sphere, constituted by the set of phenomena called spiritual, is a very rich universe which comprises ideas, theories, philosophies, myths, phantasms, dreams. Isolated idea and great theoretical system, phantasm and myth are not "unreal." They are not "things" of the spirit. They are the *life* of the spirit. They are beings of a new type (P. Auger, 1966; J. Monod, 1970), informational existents, of zero dimension like information, but which have the fundamental physical characteristics of information and even certain biological characteristics since they are capable of multiplying by drawing negentropy from human brains, and, through them, from the culture which

irrigates these brains; our minds and more so our culture are the eco-systems in which they find not only sustenance but chance, risk.

The great theoretical systems are organizations of concatenated, hierarchized ideas, endowed with their own generativity and regulation, capable therefore of being regenerated and of resisting exterior aggressions. Ideologies can remain latent, or deviant, crouched in a little minority isolate; but suddenly the rupture of a negative retroaction or any other favorable event permits their epidemic multiplication.

Such and such an idea, in its opportune encounter with such and such a spirit, is going to provoke unexpectedly an ideological mutation. Such and such an idea is introduced into the cultural patrimony, and its insertion chain-modifies an entire ideo-generating device, which, reorganizing itself in a new way (like DNA after genetic mutation), modifies by that very fact an entire aspect of the phenomenal being of society.

Just as life presents very diverse beings, from viruses to elephants, from millenary sequoias to ephemeras, so there are phantasms which are dislocated as soon as they are formed, and great religious mythologies which perdure for milleniums, so strongly enrooted in the anthro-social tuff that they regularly draw negentropy therefrom, in spite of the radical transformations of society. On the contrary, dreams and phantasms are whirlings of imaginary negentropy, which are dispersed almost immediately into vapors. It is precisely because it is of an extreme diversity, carries almost no redundancy (whence the mysterious, Sibylline character of each piece of information which it brings), that the dream is ephemeral, that its variety crumbles into disorder as it moves to build up, that it is dissipated into noise, and even on awakening, when we remember it, it seems to us most often nothing but noise, a chance assemblage of incoherent images...

Nevertheless, it is at the antagonistic/complementary encounter of the imaginary and the idea that imagination spurts forth. And it is imagination which, in and by phantasmic turbulence, invents and creates. Brillouin has accurately said: "Thought (imagining) creates negative entropy." (Brillouin, 1962, p.220) The cultural broth of creation is oniric bubbling in which pulsions, obsessions, memories, ideas, desires bump up against each other. It is even sometimes in the great oniric Sabbath that is born the idea looked for in vain in hard long nights. Thought is always bipolarized between the imaginary ebullition and the hard core wherein its paradigms are crystallized...

The crazy world of phantasm is endlessly dissolved; but it has nourished the great myths, the gods, the spirits of archaic and historical religions, that are like the imaginary paradigmatically crystallized, which rites and consecrations

unceasingly regenerate. These myths and religions are not only "superstructures," *they are part and parcel of the physical and praxic tissue of societies.*

Finally, since the apparition of social megamachines, phantasm and myth have erupted, intoxicating spirits, unleashing conquests; the gods have been fought furiously by interposed humans—and the *Iliad* is much more profoundly true, as history book, than the treaties which explain the economy of the gods or which have economy as god. Unceasingly the imaginary or the dream is metamorphosed into negentropy, golden, diamond, marble, bronze; they become a palace, a mausoleum, a tower. A few ravings survive in the Egyptian desert, because a formidable energy power has transformed them into pyramids of stone. An enormous part of the social praxis takes the form of rites, cults, ceremonies, funerals. The bourgeois era is not only prosaic; oniric furor is vested in money, profit, and rejoins the millenary ravings of ambition and power. Obelisks are reborn even taller, in Eiffel Towers and World Trade Centers.

Dreams have programmed the social praxis, and the naive are unaware of it, the naive for whom the economy is only economy and dreams are only dreams; they are unaware of the transmutations of negentropy, the conversions from the imaginary to the "real," from the "real" to the imaginary, from phantasm to praxis (the airplane), from praxis to phantasm (the cinema). Society does not manipulate its myths so well as its myths manipulate it. The imaginary is at the active and organizational heart of social and political reality. And when, in virtue of its informational character, it becomes generative, it is from that time on capable of programming the "real," and, negentropyizing itself praxically, *it becomes the real.* (Castoriadis, 1975)

The Information Universe

The noological sphere, ultimate avatar, finally allows us to conceive the concept of information in its unity, its plurality, its plenitude.

Information can be *decomposed* into bits, but it *composes* informational beings and existents: living beings, generative apparatuses, noological beings.

From thermodynamics, where negative entropy arises, to culture where sublime poetry flourishes, from the nitrogenized bases of nucleotides inscribed in the double deoxyribonucleic ladder, to the dreams and phantasms of the human spirit, we see the unity, the diversity, the chameleonism of information being deployed.

But everywhere, with the living being, in eco-systems, in animal society, and finally in the anthropo-socio-noological universe, it is the same fundamental physical concept, and it is the same fundamental character: *the*

potential equivalence between negentropy *and information* at the heart of or starting from geno-phenomenally organized beings.

Information can always be transformed into negentropic organization, but only in the sphere of a negentropic organization informationally organized which can reciprocally transform negentropy into information.

Information, even forgotten and lost, can, on condition of remaining inscribed, be regenerated, if it finds the *ad hoc* generative apparatus. If we retrieve the lost inscription, if we reconstitute the code, like Champollion deciphering hieroglyphics thanks to the Rosetta stone, then the message, dormant for milleniums, is awakened. The manuscripts of the Dead Sea live again; the inscriptions of the Mayas speak. And these texts snatched from death are even going to know a new life, a new negentropy, by entering our libraries, by being reproduced, printed, translated, photocopied, commented. In a new mode, that of historical culture (and no longer that of mythical belief), the same process continues: *that of the transformation of information into negentropy and of negentropy into information.*

VI. Small Relationality, Big Relationality

Let us recall: since Shannon it is evident that information is neither a thing nor a purely formalizing concept. Information is a relational physical concept; it is in this sense that it has zero dimension. The ontological error is to localize information in the sign which inscribes it or the signal which transmits it. The great virtue of Shannonian theory is to have defined information as an event-full relation in situation. It takes on existence in the relation sender/receiver at the moment of the act of reception. It takes on existence in the regenerating event, that is to say the active relation among the gene, the generative complex, the entire cellular activity.

Information is, therefore, always actively relationed and relationing. It is a self-sufficient and closed concept only in informationist ideology. In fact, it is the least closed of the concepts we have encountered here. Whence the enormous difficulties in attempting to discern its form. We had to relation it, not only with the notions of organization and negentropy, but with that of apparatus, and to interrelation these notions among themselves. Outside of this multi-relationality, information is either the measurement of a hollow improbability or a hollow entity. In order to understand information we must make this notion oscillate between the active totality of negentropic organization, or else it fogs up and drowns, and the engram or bit, or else information, dries up and loses life.

The Relation: information



negentropy

organization

Let us summarize: The notion of information takes its base and its meaning only in reference to negentropic organization. It is not sufficient only to consider information and negentropy together; we must consider information/negentropy and organization together, negentropy always in reference to organization, information always in reference to negentropy.

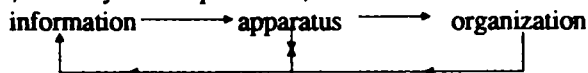
Information does not circulate only in an organized communication, it circulates in a communication which has an organizational character; and especially, information is not only communicational, it is also generative at the heart of a generative complex. Information must, therefore, be conceived at the heart of an organization as having a double character, generative and phenomenal.

Let us recall, therefore;

1. Negentropic organization genealogically precedes information.
2. Negentropic organization becomes informational when there is constituted therein a complex or generative apparatus including engram/archive and strategic/programmatic competence which permits repetition/reorganization, resuscitation/reproduction.
3. From that time on a geno-phenomenal organization of informational/communicational character is constituted, whose prodigious biological (organismic, ecological, societal) and anthro-po-social developments we have seen.

Informational organization allows a more and more complex, precise, and economical utilization, manipulation, transformation, control, etc., of energy. If a communicational organization expends a lot of energy because it is negentropic (permanent reorganization), the same organization economizes a lot of energy because it is informational; for information not only fixes very little energy in order to survive, but consumes very weak energy in order to circulate, and its controls allow dosing the energy put into play. The economy of communication counterbalances the expenditure of negentropy.

4. Information can be active and reproductive only within the activity of a generative apparatus. This generative apparatus can be active and reproductive only within the global activity of communicational organization. There is, therefore, not only interdependence, but recursive relation among



of the whole. Information is what allows negentropy to regenerate organization which allows information to regenerate negentropy. Thus, in the double geno-phenomenal circuit, in order to be generated and to be reproduced, information needs the products that it generates.

5. Information always needs a negentropic organization in order to have existence and effect. An inscription exists as *information* only if it is read. The reading of road signs necessitates minimal activity in the mind of the reader (energy expenditure, negentropic activity) and minimal lighting (sunlight in daytime, headlights at night), namely an energy source. To say: *an inscription needs to be lit and read*, is not as trivial as it appears; the text you read requires the lamp, your eyes, your mind, so that what is the inscription of information becomes information on the inscription.

6. Information allows negentropic organization to create negentropy or to increase its information.

7. Any degenerated information can be regenerated if it finds a deciphering mind and a generative matrix. In other words:

—“information in any and every state is potential negentropy” (C. de Beauregard, 1963);

—information is always potentially generative.

8. The great equivalence negentropy/information is not, therefore, an identity relation, but a relation of mutual transmutability in given energy/organizational negentropic conditions.

The transformation into negentropy means that the development of information allows the still more complex development of negentropy, and *vice versa*.

The transformation of negentropy into information first of all allowed archiving, then allowed memory, the registering of all knowledge [Fr. *savoir*,] of all know-how [Fr. *savoir-faire*], right up to scientific experience which “represents a transformation of negentropy into information.” (Brillouin, 1959, p.110)

9. The engram, the code constitute discontinuous aspects which allow us to consider and manage units of information. Under this angle, information has only one aspect: discontinuous, discrete, digital. Now, conceived in its relational activity, information takes on a continuous character and presents analogical/mimetic aspects quite rebellious to digital atomization. It is today with information as it was with light in the Newtonian era, where corpuscular character, alone conceived, excluded its ondulatory character.



Let us repeat: we cannot conceive informational organization without referring to a generative *apparatus*. As has just been said, "Organization becomes informational when a generative apparatus is constituted therein," and "Information can be active and reproductive only within the activity of a generative apparatus."

A second time there arises the problem, always crucial, of the apparatus. It is exactly the same problem that appeared to us when we examined organizational communication. And it is precisely by hypothesizing information that cybernetics hides the apparatus. I envisaged it a first time (Part II, ch.3) more under the angle of communication. Here, I envisage it more under the angle of information.

The apparatus is the original arrangement which concentrates and *capitalizes* in itself memory, computation, programming, elaboration of strategies of the organization of *the whole inasmuch as whole*; its aptitude to transform information into program, that is to say into action, centralizes in itself a power of organizational constraint.

We have seen that the apparatus emerges with cellular beings. With protocaryotes, there is polycentrism and not yet concentration of informational operations. A relative centralization is effected with the formation of the nucleus, and we can consider, as I have already maintained, that the nucleus of eucaryotes constitutes a proto-apparatus. In this cellular proto-apparatus the organization of phenomenal life (metabolism, exchanges) and the organization of reproduction are undifferentiated.

Many multicellular organisms, vegetal for instance, self-organize without a neuro-cerebral apparatus or even a nervous system; this self-organization is the product of interactions among the innumerable proto-apparatuses of the cells which constitute these vegetal beings. It is in the animal kingdom and very clearly in the lineage born from fish and which goes to reptiles, birds, mammals that two differentiated apparatuses are constituted: one, the sexual apparatus, strictly generative, devoted to reproduction; the other, the neuro-cerebral apparatus, epi-genetic apparatus or, to use the vocabulary proposed here, geno-phenomenal, because devoted to the phenomenal problems of the individual and notably the organization of its relations with the environment; *geno* because it is apt to generate, regenerate information, to transmute negentropy into information, information into negentropy, evidently capable of elaborating strategies of behavior. We know that this neuro-cerebral apparatus is going to prodigiously develop its competences in mammals and

primates, until the apparition of the hypercomplex apparatus: the big brain of *homo sapiens*, having more than twenty billion neurons.

Archaic societies, and it is their fundamental originality when compared to animal societies, constituted a *generative complex*, culture, which exists and functions starting from interactions between the cerebral apparatuses of individuals constituting a given society. The capital event, inseparable from the formation of social megamachines, is that of the constitution of a cerebral geno-phenomenal apparatus: the State; then the emergence and development, in social life, of multiple geno-phenomenal apparatuses within military and religious organizations; then economic (banks, staffs of enterprises, holdings, trusts) and social organizations. A key event of world history is the apparition of the first *apparatus* of a modern party, with the birth of the German Social-Democrat Party at the end of the last century.

Now, and I have not been able to prevent myself from already singling it out, if there are developments of communicational organization and formations then developments of apparatuses from the biological sphere to the anthro-po-social sphere, these relations between State apparatus and society are of an entirely different nature from those which, in the integrated recursive totality of the cell, bond the nuclear proto-apparatus to cytoplasm. In a megasociety (empire, nation) there is no longer any One Whole as in the cell or organism; there are human beings of which each one, even enslaved to the mechanical or specialized tasks of execution, possesses the same strategic and creative competences as those of the masters and directors; there are heterogeneous groupings, ethnicities, classes, arranged according to relations of hierarchy, oppression, subordination. From that time on, every monopolistic social apparatus, and in the highest degree the State apparatus, poses a key social and political problem, that of force, power, domination, enslavement.

Every State power possesses programmer/computer power over society (power to rule, legislate, decree), strategic power (to elaborate and decide the policies to be followed) and power of command/control. The State called "totalitarian" goes farther: it concentrates in itself the official memory (the power to write the History of the past and to dictate the history of the present); the control of all the means to express and communicate information; the monopoly of true knowledge [Fr. *savoir*] at least in what concerns sociology and politics, possibly in matters of science and the arts; the direct control of all apparatuses, economic and other.

Thus, there is first of all a chain problematic of social apparatuses, more particularly of monopolistic apparatuses, of the central State apparatus very particularly, and finally of the hypermonopolistic State apparatus called totalitarian, which achieves the supreme level in the monopolistic capitalization of Information.

This problematic is doubly masked, both in its properly sociological basis and in its cybernetic organizational basis: sociological theory is unaware of communicational organization and informational power; cybernetics and information theory finally reveal the power of Information (Information as "master of energy"), but in hiding the apparatuses, they hide the power of the apparatuses and power by the apparatuses.⁵

The key idea that power is in production must be read and understood, not in the restrained economist sense of the term of production, but in its organizationist/informational sense. It is not power over the "means" of production, it is power over the production of production, that is to say social generativity. It is not only the ownership of things, of goods. Mastery is in the mastery of the means of mastery, enslavement of the means of enslavement, control of the means of control: *the informational power of the apparatus*.

We see here the accuracy and the error of Marx. Marx looked for what was generator in society, and it is with admirable correctness that he had put forward anthropologically the notion of *generic being*, and sociologically the notion of *production*. But the only foundation the physics of his time offered was energy: work; likewise, he had seen the power of class in society, not the power of apparatus.

Now, the theory of the geno-phenomenal Apparatus of a Society conceived as informational/communicational can only renew and enrich the sociological problem of domination and power. It leads us to detect the key problem of the monopolization of information. Power is monopolized as soon as it is an apparatus, and by that very fact a caste or class of apparatus monopolizes the multiple forms of information, directly links power and knowledge [Fr. *savoir*] (he who rules controls truth), links the gearshift to the scepter, the sacred to politics. Exploitation and domination coincide with the relegation of the exploited and the dominated to tasks requiring only energy, excluding them from the generative/programming sphere. They have a right only to the signals informing them of what they must do, think, hope, dream.

VII. Small Relativity, Big Relativity

A. Small Relativity: Information/Redundance/Noise

1. *The Absolute and the Relative in the Shannonian Framework*

Information, redundance, noise are distinct and contrary in the framework of Shannonian theory: the communication of a piece of information from a receiver to a sender each having a common repertory and code.

Thus, the message "good kisses," in Tibetan, is noise to my ears while still representing Tibetan information. The Chinese language, which is redundancy for eight hundred million Chinese, for whom it constitutes the common code, is noise for me. We clearly see, therefore, that information and redundancy turn to noise as soon as there is no longer any common code between receiver and sender, since the key to their distinction resides in this code.

As for noise, it concerns not only "objective" disorders like thermal noise, but also phenomena, possibly organized, which are perturbations only in reference to a given message. Two coinciding communications can constitute noise for each other. As I listen to my radio, static is physical noise, but the coinciding of multiple messages sent on the same wavelength provokes a mutual jamming which affects each of them. Likewise, when two different conversations meet on the same telephone line, one degrades the other.

Therefore, outside of a relational framework where the *quid*, the *quod*, the *hic et nunc* are very delimited and determined, the notions of information, redundancy, noise lose their clarity and distinction, are confused, even permuted.

We must add another form of relativity which appears even between common detainers of this code which is ordinary language. Let us take two militants A and B of adverse parties, who follow a television debate between their respective leaders. Each of these perfect militants knows that any honest observation on political reality confirms the analysis and action of his party, nullifies everything that comes from the adverse party, and knows that everything that contests his party is base calumny. Thus, for A, the message of his leader will be redundancy in the sense that it confirms the excellence of his cause; the message of the enemy leader will be for him both redundancy (not announcing anything new) and noise (babbling, ineptitude, error), noise which at the same time will have the redundant function of confirming his hostility to B's party. It will be exactly the same for B, but inversely. We can certainly calculate in bits, in function of the occurrence of phonemes, the information sent by both leaders, but the information received, in fact, is almost null in the not imaginary situation which I have just evoked. This indicates to us that in fact real situations of communication do not depend only on this common code and repertory, which is language: they also depend on another type of code, tied to ideology, which depends on a paradigmatology, *always implicit, always hidden, always present, and always dominant*. In real situations the very logic of the receiver is intermittent; he can pass from an empirico-rational logic to a magico-affective logic; his decoding can vary, from the decoding of the letter to the decrypting of the hidden meaning, etc.

Certainly, information, redundancy, noise remain clearly definable notions in simple communication and information, as: "Will arrive flight 807 Air France Tuesday 12" or "Mother deceased," but as soon as we come to true communication, where beings, at the same time as they communicate, do not communicate, where perturbations come from other than the "channel," from culture, personality, from an ideological, logical, magical, etc., complex, fixed in each mind, as soon as we do not forget that every human message carries in itself a complex multiplicity of potential messages, that every message is in fact multi-connoted and multi-decryptable, finally that connotation, and not denotation, can be the true message, then information, redundancy, noise are fogged up, lose their clarity and distinction. Complex communication, to work optimally, necessitates that the interlocutors have the same knowledge [Fr. *savoir*], share in the same vision of the world, obey the same logic and the same paradigmatic structure. Besides, this is what happens in fact in the living organism: each cell, even specialized, integrally has the same genetic message as every other cell. This is why communication therein is effected in an optimal and complex fashion. But among human beings, such an optimum would become anti-optimal, because it would suppress ambiguity and misunderstanding in communication, which are one of the principal sources of progress and invention—while remaining sources of error and regression. It is really this general fecundity of misunderstanding which illustrates, on the very plane of scientific development, and precisely of information theory, Mandelbrot's phrase cited at the head of this chapter: "One of the most powerful tools of science, the only universal one, is misunderstanding handled by a talented researcher," the mind of the "talented researcher" evidently being the generative apparatus needed to transform "noise" into creation.

What we have just said does not contradict the Shannonian framework; it situates it. Information/redundance/noise have in effect an absolute sense in a relative situation. But, considering the limited and poor character of the conditions which allow us to define the three terms without equivocation, we are led to reverse the vision, and the most important thing, for a complex theory of information, becomes the relativity of the concepts of information/redundance/noise. This relativity is fundamental; their clear distinction is only local and conditional.

2. The Relativity of Organizational Information

When we isolate the genetic code of the organizational circuit and of temporal becoming, then information/redundance/noise have a clear and distinct meaning: information returns to a "message;" redundancy returns to

the synonymies and punctuations which the message includes, more widely to the organization of the message, an organization which is the same, *ne varietur*, for all cells of an organism and all the organisms of a species, and, still more widely, to the genetic "code" itself, which is common to all living beings from bacteria to the elephant.

In this sense, the organization which informational activity produces, by becoming probable *hic et nunc*, is manifested for an observer *hic et nunc* essentially by its traits of repetition, regularities, reproductions, multiplications, and seems to obey an invariant pattern, that of the "species." Thus, what under the angle of negentropic production, of permanent reorganization, is perceived essentially as informational organization and as such remains event-full, singular, improbable, is perceived, under the exterior angle of observation in a given spatio-temporal framework, as an essentially redundant organization. Whence a relativity, according to the frame of reference, between information and redundancy.

Reproduction can be envisaged under one aspect as a phenomenon of redundancy (multiplication of the same) and under another aspect as a process of transmission of information. It can and must also be considered under the angle of noise: dissemination is confined to chance, to the wind, to the forces of dispersion, namely to "noise," whence, besides, a huge waste. Thus, once again, by displacing the angle of view of the observer, we see the notions information/noise/redundance softened, fogged up, osmosed, relativised in the same phenomenon.

The problem of noise takes on a still more paradoxical scope when we ask ourselves: Whence is information born? How does it increase?

The origin of information returns us to the universal rule of the collaboration of disorder in the birth and progress of organization. As I have attempted to envisage it, information is born from the chance development of a negentropic organization constituted of chemical reactions (which fact leaves intact the mystery of its emergence). Once born and engrammed at the heart of a generative complex, information could increase and develop only with the collaboration of chance and disorder, that is to say of "noise." And this is clearly what genetic theory reveals to us in a way both blind (because it cannot explain it) and blinding (because it makes it the central and evident phenomenon): mutation, through which an hereditary modification arrives, therefore an evolutive change, can be conceived only as the consequence of a "noise" (cosmic ray, quantic accident, some other unknown cause) provoking an "error" in the copy of the hereditary message at the moment of duplication. *Thus, information can only be born starting from an interaction between a generative organization and a chance perturbation or noise. Ergo, informa-*

tion can only be developed starting from noise. Of course, at the birth of information, an organizational aptitude of negentropic character is always necessary, which goes beyond itself by transforming the event into novelty, the "error" into "truth."

Correlatively, we must suppose that, under the effect of noise, as Atlan indicates (Atlan, 1972), redundancy is transformed into variety. This can be considered as the informational expression of a very general principle: *every organizational complexification is expressed by an increase of variety within a system*: the increase of variety can be conceived as a start of dispersion, which is counterbalanced by a more supple and complex organization.

All progress of generative information is translated by a progress of diversity and heterogeneity, by the apparition and expansion of novelty, where there was repetition of the same. Thus, we enter a new relativistic cycle: under the triggering influence of "noise," informational complexification transforms redundancy into variety, and this variety is found immediately inscribed and integrated in the process of repetition (and becomes, for the exterior observer, an apparent redundancy). We see, therefore, that we need to dialectize the whole relation noise/information/redundance, in a process where noise is not only destructive but perhaps cooperative, where redundancy, under the effect of noise, can be either dissolved into noise or transformed into variety and information.

Thus, when we consider its becoming, we see that information is born in noise, navigates in noise, dies from noise, in noise; and under another aspect it emerges by breaking redundancy, then is stabilized in relative redundancy. Therefore, there is not only relativity between information/redundance/noise; *these notions generate each other*, which is easily understood as soon as we desubstantialize them and plunge them into negentropic organization, where the paradoxes of their mutual relativity are posed and resolved.

3. Redundance and Noise Relativised

The relativity of information in reference to redundancy and noise signifies, by the same token, the relativisation of redundancy and noise.

Redundance can seem to be a very poor concept if, limiting itself to designating all that is repetitive order, it confounds in a global envelopment the repetitive regularity of physico-chemical laws and the repetitive regularity of biological phenomena which, not only are not reducible to the first, but are in a sense, antagonistic to them. But the concept becomes more interesting if it

indicates that organization can only advance by stabilized stages, the stages of negentropic stabilization being maintained by the permanent activities of reorganization and regeneration. Thus understood, redundancy indicates to us that *the new can only be inscribed on the already known and the already organized*; otherwise, the new does not succeed in being new and returns to disorder. Redundancy indicates at the same time that the durable inscription of the new allows the constitution of a new redundancy, which is ready in its turn to receive a new newness.

Noise, on its side, becomes an enriched concept. Its poor and confusionist aspect takes in all the disorders, whatever they may be, perturbing the communication of information. But this confusionist aspect becomes relativistic as soon as we understand that it is useful to have a concept which includes, not only "objective" or absolute disorders (like thermic noise), but everything, even not disordered, which constitutes a chance perturbation with respect to a given informational organization.

Still more interesting is discovering that noise, which destroys information, is also a necessary ingredient for its generation. Finally, we are going to discover more and more (v.II) that everything which is living organization functions *despite, against and thanks to noise*.

B. Big Relativity: Observation and Observer

The small relativity information/redundancy/noise which we have just seen completes the ruin of the ideal observer of Laplacian determinism, not only on a universal scale, but on the scale of local observations, since information, redundancy, noise are unstable, transformable, permutable in function of the angle of observation and the knowledge [Fr. *savoir*] of the observer.

We are going to see that the observer is much more physically invaded than we had been able to believe:

— at the level of the relation between the knowledge [Fr. *connaissance*] of organization and the organization of knowledge [Fr. *connaissance*].

— at the level of the transforming praxis which every observation constitutes.

1. The Knowledge [Fr. *connaissance*] of Organization and the Organization of Knowledge [Fr. *connaissance*].

The Disorder of Ignorance and the Order of Knowledge

Entropy which had revealed a certain number of striking characteristics

proper to physical objects, reveals with Brillouin, when it is tied to information, an ultimate characteristic, but one which concerns the human subject: entropy becomes an observer's lack of information on the system he is considering; to maximum entropy corresponds maximum ignorance. In other words, entropy, in its most classical sense, measures:

—not only disorder or absence of organization at the heart of a physical system,

—but by that very fact, the decrease of the possibilities of an observer's information on his observation; *entropy becomes, therefore, the measure of our ignorance.*

Entropy signifies ignorance; inversely, information makes disorder regress in a mind: in fact, in the mind of an observer/receiver the bit transforms a pure disorder (an equi-probability of occurrence between two events) into pure order, and it is this order which is called *knowledge* [Fr. *savoir*]. This gain from order allows him to complete, enrich, indeed complexify his vision of the world.

While the observer measures the real, the real reveals the measure of the observer's mind.

At that moment, the epistemological question is posed: are these two aspects of entropy/information, one psychic returning to the observer, the other physical returning to the object, reciprocal? Does the absence of all possibility of information in an observer's mind reflect the real disorder of the world or only the limits of his understanding? This question is going to be asked henceforth...

The Principle of Equivalence

In order to understand the correspondence between the organization of knowledge [Fr. *connaissance*] and the knowledge [Fr. *connaissance*] of organization, we must first of all remember that the relation negentropy/information is not one of identity but of equivalence in the framework of an *ad hoc* negentropic organization. That given, it is no longer a matter of looking for the "reflection" of the real in the mind of the observer, nor for the "reflection" of the mind in the real: the organization of knowledge [Fr. *connaissance*] is perhaps a translation of, but not the "reflection" of, physical organization. It is a matter of looking for the nature of the possible transaction which is effected, *via* the principle of the equivalence negentropy/information, between the physical and the psychic.

Now, this principle of equivalence can only be truly conceived if we conceive *physis* according to the fundamental "tetralogical" relation disorder/

interaction/order/organization. *From that moment on, there is a possible correspondence and translation between the physical game:*

disorder/interaction/order/organization (physical)

and the psychic game:

noise/information/redundance/organization (psychic)

Thus, for the observer, noise is ignorance psychically (and thereby unknown, mysterious) and disorder physically; for the observer, redundancy is certainty psychically and order physically (invariance, law, repetition, pattern, regularity, stability); for the observer, information is knowledge [Fr. *savoir*] psychically acquired from events, understanding [Fr. *connaissance*] extracted from noise, and it is physically the event-full and diversely haphazard play of the interactions.

And, just as physical play finds and produces its organization in physical systems, psychic play finds and produces its organization in theoretical systems. Just as there are, in the physical tetralogue, unceasing permutations and transformations (organization in disorder, disorder in organization, etc.) so in the tetralogue of ideas, noise/redundance/information/systems, there are permutations and transformations: information is born from interactions between organization and noise, gives birth to redundancy at the heart of an *ad hoc* organization, dies in noise like this organization itself. Knowledge [Fr. *connaissances*] reputed sure—redundance—can be overthrown and disintegrated into noise under the irruption of new knowledge [Fr. *connaissances*], starting from which a new redundancy is formed; thus, one theory is broken and another one emerges; knowledge [Fr. *connaissance*] is transformed into ignorance in the very movement in which ignorance is transformed into knowledge [Fr. *connaissance*]...

The progress of knowledge [Fr. *connaissance*] is not only a conquest of information on noise, of redundancy on information. The progress of knowledge [Fr. *connaissance*] brings about in fact a redistribution of redundancy, of information, of noise. The discovery of a great natural "law" for example, allows an increase of redundancy, by integrating a large amount of information in an assured determinism and pattern; it allows extracting new information from the uncertainty of phenomena; it therefore reduces the domain of noise or ignorance; but at the same time, the big discovery causes the collapse of entire sections of redundancy (disintegration of the Ptolemaic-system brought about by the Copernican revolution, then revitalization of the

Copernican system brought about by Einsteinian relativity, etc.; it gives rise to "new problems," that is to say to new sectors of ignorance. Paradoxically even, I will come back to it, the greatest progress of modern knowledge [Fr. *connaissance*] consists in discoveries of insurmountable limitations of knowledge : Therefore, we suspect that the progress of knowledge can only be the dialectical progress of the certain, the uncertain, and the unknown, that the progress of knowledge is at the same time the progress of ignorance. What is true of every organization is also true of the organization of knowledge: the more complex it is, the more it is apt to receive and integrate disorder. Complex theory allows us to embrace and articulate, in its vision of the world, simultaneously disorder, order, and organization, that is to say noise, redundancy, and information. We are far from the purely redundant ideal of absolute determinism.

Noological Translators

We have just seen that there is really a principle of equivalence, not only between information and entropy, but also between the psychic play of the categories noise/information/redundance/organization (of knowledge [Fr. *connaissance*]) and the (physical) play of the categories disorder/interaction/order/organization. This principle allows us, therefore, to envisage psycho-physical transactions and translations.

Here, we must make the noological mediators or ideas intervene; these informational beings bring about the translations from physico-thermodynamic order to psycho-informational order and *vice versa*, notably between the knowledge [Fr. *connaissance*] of organization and the organization of knowledge. Thus, *physis* can be translated into ideas; its physical organizations and linkings are translated into linkings of ideas, which, looping on themselves, constitute theoretical systems. These informational systems are *ipso facto* negentropic organizations. They are physical in this sense that they are tied to micro-states and to the physical processes of our brain, which is a generative apparatus. Thus, our ideas on the real are neither a reflection of the real in the brain, nor a pure reflection of the schemas of our brain; they are informational mediator beings which allow the communication and translation from *physis* and *psyche* and inversely; as with everything which is translation, ideological operations are subject to error; certain even are nothing but errors... But noological beings are as indispensable to our minds as the bacteria of our intestines are necessary to the transformation of nourishment.

2. Physical Transformation and the Praxis of Observation

We have now constituted the structure of welcome in Brillouin's great discovery, which includes the observer in a physical transformation and the observation in a psychic praxis: *every relation of observation is a praxic relation, in which negentropy can be transformed into information and information into negentropy.*

Brillouin (1956) revealed the transforming character, not only of every experimentation, but of every measurement. In fact, from the principle of the negentropy of information it follows that every observation which includes measurement physically modifies the global system constituted by the measured phenomenon, the measuring device, the observer; information must be paid for; therefore, this simple cost already modifies physical reality.

Classical physics, by positing the observer and the observation as non-communicating entities, had ignored the role of the experiments of measurement in the definition of the phenomenon. Of course, this incidence could be neglected, given the infinitesimal cost of information in these experiments, at least until the apparition of micro-physics. But it is not sufficient to consider the problem of energy and entropy only as small change. We must envisage the theoretical and practical consequences of the transaction which is brought about.

The Cost of Information

The first theoretical and practical consequence concerns the cost of information. All that we gain in information (psychic) can be gained in organization (biological, anthropological, noological, sociological), but is paid for by disorder (physical) somewhere. Every increase of information, therefore, increases both the organization and the disorder in the world.

Suppose we want an exhaustive observation on an object; we would be led into the infinite spiral of interactions in which this object participates and from which it proceeds; if it is a question of a living being, we would have to grasp the myriads of interactions between the constitutive micro-states and the myriads of ecological interactions associated with them; this complication goes beyond all possibility of conception for a human mind (Ashby). In Brillouinian terms, an exhaustive observation necessitates infinite information, which necessitates infinite energy, which would cost an infinite negentropy, which would entail the dilapidation of the whole universe. Niels Bohr used to say that in the final analysis, we would have to kill a dog to know what makes it live. (Bohr, 1958) Brillouin could have said that we would have to mobilize such a

quantity of energy, knowledge [Fr. *connaissance*], and organization to know what makes this dog live, that the universe, including the dog, would be thereby disintegrated.

Knowledge [Fr. *connaissance*] *carried to the absolute is self-destructive.* This proposition holds for every observation, every science, concerning every object, every phenomenon, every being, and of course, the universe as a whole.⁶ We will be able to tackle head-on the problem of the limitations of our knowledge only after the examination of the bio-anthropo-sociological conditions of knowledge (v.III). The important thing here is the original illumination which Brillouin brings to this problem by tying, in a Gordian knot, the physical enrooting of knowledge to an enrichment of knowledge (which becomes a notion both physical and psychic), and to a limitation of knowledge (which loses all pretention to exhaustivity). I will limit myself here to indicating only that we need to complete the physical illumination by a symmetrical psychic illumination: the psychic enrooting of knowledge also brings us its limitations and uncertainties, which come evidently from the bio-anthropo-psycho-socio-cultural limits proper to all knowledge; among these limits, we can now distinguish the one which is inherent to the informational character of knowledge: it comes from the fact that *the real takes on substance, form, and meaning only under the form of messages which an observer/conceiver interprets*. We have only translations of reality, never the original version. There is, therefore, an original uncertainty, typically "informational," on the reality of our reality and on what, in Reality, is without form or information, that is to say is untranslatable into messages...

We are indeed condemned to know only a universe of messages, and, beyond them, nothing. But we have at the same time the privilege of reading the Universe under the form of messages. These messages, we are the ones who make them up, under the blow of impulsions whose true nature we are unaware of, even though we have a code to name them. These messages crackle on our mental telescriptors; they become confused, interferent, with fading and with black holes; we amble along, we wander, in the forest of symbols, "which observe us with familiar looks"...

Observation-praxis

The praxic character of the relation of observation entails capital consequences.

We used to believe, we continue to believe that scientific experiment knows its object by isolating it, that is to say by subtracting it from the "noise" coming from its environment. It certainly provokes a relative isolation

by inhibiting certain interactions, but *it provokes, by and of itself, new types of interactions*. Thus, scientific experiment is not only an operation of the abstraction, that is to say the isolation, of a phenomenon outside its real context (this hides the ecological interactions which are part of the phenomenon); it is the triggering of a new type of interaction between the phenomenon and this time the experimenter, interactions of which he remains unconscious. The experiment, therefore, subtracts an object from its real physical context, a being from its real biological ecology, but introduces it into a new real context, of anthropo-sociological character, whose abstract ideas are an integrating part.

The experimented objects are going to be integrated forcibly into the categories of the experimenter. Living beings, flies, guinea pigs, rats, dogs, chimpanzees are going to undergo horrible tortures and die in inexpressible sufferings (which will be entirely neglected in the observation and hidden in the theory). And, especially, from experiment to experiment, experimental science produces transformable information which allows the development of this universal manipulation which we call technique.

Brillouin introduces us to the praxic root of Western science, which is founded on measurement and experiment, and constitutes by that fact a production of information which is far from being neutral.

Brillouin's proposition concerns information acquired through measurement and experiment. May we not generalize it to every observation, all knowledge, even when it includes neither experiment nor measurement? In fact, every observation on the world, which is accompanied by thought and reflection, corresponds to modifications in cerebral micro-states and, correlatively, to rearrangements and regroupings in our systems of ideas, which, insofar as these ideas are informational beings, they are also physical beings. This is negligible as energy *but not as organization*: the neuro-noological modifications being at the same time transformations in ideas and theories, which can trigger modifications in action and behavior, we come to chain transformations of information into negentropy and of negentropy into information, in cultural and social praxis.

Thus, all information, all knowledge [Fr. *connaissance*], every idea, in accordance with the principle of equivalence and generativity of information, includes, not only a physical mini-modification, but also, as the case may be, a potentiality for praxic chain developments, through transformations of information into negentropy, of negentropy into information, and so forth. A well-placed word, said at the right time, can give birth to or crumble a world.

Thus, there is not and there will never be a pure observer (he is always tied to a transforming praxis); no absolute knowledge [Fr. *connaissance*] (it

would have to be paid for with an infinite price which would destroy it). But, with the loss of the absolute, we gain in communication and in complexity. Because what Brillouin establishes as positive and new is the circuit of communication between the physical and the psychic, the possibility of translation/transformation of the psychic/informational into the physical/thermodynamic/organizational. This communication, therefore, is inseparable thereby from a dialectical praxis between observer and observation. Certainly, by establishing relation, Brillouin establishes relativity, that is to say also the uncertain and aporetic. But, and we will see it again often, uncertainty and aporia can and must constitute progress in complex knowledge, progress being founded, if we reflect, only on the regressions of simple knowledge. What we already perceive, therefore, through this translating, transducing, transforming, relativizing relation between the psychic and the physical, between the observer and the observation, is a first emergence of the relation between subject and object, because all knowledge, in an observer, is both subjective (self-referent), returning to its own interior organization (cerebral, intellectual, cultural) and objective (hetero-referent), returning to the exterior world. We can, therefore, perceive that *it is never by excluding the subject that we must look for the object, that it is not outside of praxis, but in a meta-praxis which is a new praxis, that we must look for knowledge, that it is never outside of noise that we must look for complexity.*

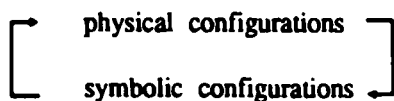
C. Generalized Relativity and the Loop of Physical Knowledge

Information theory, and thereby every theory of knowledge [Fr. *connaissance*], can be considered as an appendix of physical theory since all information can be translated into physical terms of entropy/negentropy. But we can turn the proposition around and consider all physical science as an appendix of information theory, since the physical universe is read, by the observer/conceiver, in terms of redundances (invariances, laws, regularities), information (diverse uncertainties and improbabilities) and noise (chances, contingencies, disorders).

The translation, henceforth possible, between physical configurations and symbolic configurations opens up the question: is the first reality of knowledge [Fr. *connaissance*] in the material character of the physical configurations or in the ideal character of the symbolic configurations? Atlan posed the problem in its aporetic intensity: "Symbols called abstract would only be symbols more general than those which constitute the physical micro-states of a system..., that is to say that every abstract symbol should be able to be brought back to a set of physical micro-states... This appears to be a profession of faith in the

most extreme materialism, but as the physical micro-states are themselves perceived as symbols, we find ourselves pushed towards the positions both of the purest materialism and the purest idealism, which, besides, seems to us the state most compatible with the will to take into consideration *all* aspects of our experience of the world." (H. Atlan, 1972, p.185)

Rather than pose the problem in terms of the alternative idea/matter, we can attempt to bind these two antagonistic propositions in a loop:

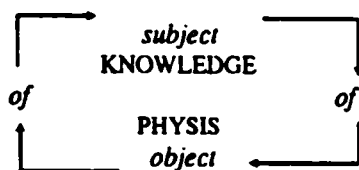


We can conceive this loop so much better as every piece of information, whatever it may be, is translatable into physical terms which, whatever they may be, are translatable into informational terms.

We have, therefore, a rotative complex with a double entry:

- the physico-thermodynamic entry of the phenomenon,
- the psycho-informational entry of the observer/conceiver.

The first is referent to the object; the second is referent to the subject. The categories of the subject and the object communicate, therefore, while remaining antagonistic:



All knowledge [Fr. *connaissance*] of physics returns, therefore, to a physics of knowledge this would risk going around in circles forever, if this very movement did not lead to a search for the meta-sysstem where the observer observes himself observing his observation, that is to say observes at the same time the organizational and praxic relation which is created between him and his observation.

That given, there is imposed on us once more, and more strongly than before, the fundamental necessity of knowledge [Fr. *connaissance*] with a double base, object and subject, of a looped knowledge where physical knowledge necessitates anthro-po-social knowledge as much as the latter necessitates physical knowledge, and just as every object must be integrated in its physical reality, so every subject must be integrated in its anthro-po-social

reality; the integration of the observer in a scientific community, far from neutralizing the subject and annulling subjectivity (as in classical science where the consensus of scientists has value of objectivity), on the contrary situates it in a culture and a society. And, of course, anthropo-social reality itself needs to be integrated in biological evolution, which needs to be integrated in the organizational evolution of *physis*, which returns again to the observer-subject, and so forth...

And, thus, the first recursive relation tying the physics of knowledge [Fr. *connaissance*] to the knowledge of physics calls us again to the impossible and fabulous spiral voyage, where we run all the risks of going around in circles and being dispersed, but where we see the only chance of producing a method...

Conclusion: Information and Information

Information is a very contestable notion and justly contested when it constitutes the ultimate conquest and accomplishment of the paradigm of simplification.

On one hand, that information is reduced to the size which Shannon's equation measures; on the other hand, it is elevated to physical Sovereignty. It claims to occupy the enormous hole left in science since the expulsion of Mind and Idea, now become metaphysical vagabonds. From that time on, this Queen-information, streamlined in its cybernetic coach, explains Nature, Life, Society, and just as Mind and Idea once dominated and shaped matter, it now masters and manipulates energy.

Thus, a new master-slave couple has been constituted, the information-energy couple. It presents an abstract mirror of nature, life, society: every form, every existence, every being is excluded, all complexity is absent, all organization is subordinated to them. This information/energy couple is in fact the operational physical translation of social domination: that of power which monopolizes generative information and programs the action of executors reduced to energy tasks.

Such is the slope on which informationist information is spread out and developed, which I call informationist because it encloses information on itself in order to make it a closed, primary, terminal notion. It is the slope of simplification/manipulation, not only techno-scientific but also socio-political. It is on the other slope that I have attempted to receive and irrigate information sprung from the same source, but become different.

There is even inversion of perspective between the two versions of information. In one, organization is an informational notion; *in the other, it is*

information which is an organizational notion. In one, information is articulated on a thermodynamics which ignores organization; in the other, information is inscribed in the dialectic thermodynamics/organization. In one, information reigns intemporally over *physis*; in the other, information emerges tardily and locally in the history of organization.

In one, information confirms the atomizing vision in which it is inscribed. *In the other, it is inscribed, not only in a relationism and relativity, but in the principle of the loop.* It is, in fact, in recursive organization producer-of-self that I have inscribed information. Whence this original definition: *Information is what, starting from an engram or sign, allows negentropy to generate or regenerate negentropy on contact, in the framework or at the heart of an ad hoc negentropic organization.*

From that time on, information is inseparable from the activity of the totality as totality. Nevertheless, it is not drowned in holistic confusion. On the contrary, *it becomes one of the constellated concepts in the idea of geno-phenomenal, negentropic organization informational/communicational by nature.* Thenceforth, information becomes inseparable from a generative complex which takes the form of an *apparatus*. We will see in the following volume how information is necessary, not as a supreme concept but as bonded concept, in order to understand the geno-phenomenal organization of life or auto-(geno-pheno)-eco-re-organization.

Information which is neither myth nor bit, that is to say information become complex, is very difficult to grasp since it can no longer really be isolated or immobilized. It oscillates between the not-much (a sign, a signal) and the turn-table; it is very difficult to grasp because it participates in both digital discontinuity and in *continua*, some of which are analogical in character: it is very difficult to grasp as soon as we plunge into its radicality, since it cannot be dissociated from the apparatus in which it is inscribed, which apparatus cannot be dissociated from the geno-phenomenal set; it is very difficult to grasp because it is metamorphosed: latent as engram, it is actualized as signal: it can be archive or program, *savoir* or *savoir-faire*; it can be transmuted into negentropy (organization, action, performance) which can be retransmuted into information; it can be dispersed and vanish, it can be indefinitely preserved, it can degenerate and be regenerated in *ad hoc* conditions (a generative apparatus, a source of energy, a head reading etc.). It is very difficult to grasp because, born from noise, it can create redundancy, *via* organization, and it dies in noise... It is very difficult to grasp, in sum, because we must run after its jumps and transformations. But it is also very difficult because it is a physical notion which has no existence outside of life,

and which is deployed only in and by the anthropo-social sphere. It is, finally, very difficult to grasp because it is inseparable from an observer/conceiver...

The complexity of information and the difficulty in isolating it are linked. Uncertainty and confusion are always the first tests which self-searching complexity must undergo; moreover, complexity will never be totally free from uncertainty, it will never accede to the universe of clear and distinct ideas, since on the contrary it left this universe for that of the clear in the obscure, of the obscure in the clear, of the multiply related, of the not totally separable and isolable, of the always opened... Thus, we are, with complex information, in an inextricable and crucial theoretical Gordian knot. There are, in the chameleonic, polyscopic, metamorphic characters which stir under the concept of information, enormous riches which would like to take on form and body. Though still hardly elucidated and elucidating, this concept is already indispensable, and the gaps and uncertainties which it includes lead us not to reject it but to question it.

In order to understand it, we must exorcise the Platonist, Aristotelian, Cartesian shadows which still circulate in the unconscious of the concept of information. The idea of information is close to the Platonist idea of reminiscence, certainly, but the Platonist Idea is an eternal form above time, chance, phenomena, whereas in informational generativity it is a matter of a reminiscence of founding events, born of chance, in the course of time, at the heart of phenomena: at the origins, there is, not the incorruptible Idea and its perfect Order, but the disorderly interactions of the tetralogical loop. Likewise, there is opposition between Aristotelian information, redundant mold forced on amorphous matter, and information which participates in a complex process of generation of forms, here again, in disorder and noise.

Finally, post-Brillouinian information is inscribed diametrically against Cartesian dualism, which had quartered Western thought, between on one hand physical scientism where everything was reduced to so-called material properties, and on the other hand metaphysical idealism or spiritualism which took charge of everything corresponding to organization and information, but in a supernatural fashion, of everything corresponding to complexity, but in a simplistic fashion. Now, the very emergence of the concept of information at the heart of *physis* suddenly calls up the inversion of the movement which disjoined in repulsive universes the physical (materialist) principle and the psychic (idealist) principle; the highest theoretical energy will be needed so that, in collision, the two principles will disintegrate one another and that, from this disintegration, a new concept of *physis* will be born.

Meanwhile, we must posit information as *a concept with two bases and multiple entries.*

We have seen that complex information necessarily has two bases, one of them physical which is that of object, the other psychic which is that of subject. It is starting from exchanges between these two bases that there can be translation, transformation (of negentropy into information, and *vice versa*), praxis.

At the same time, information is a concept with multiple entries: physical (entropy, negentropy, organization), biological (communicational geno-pheno-eco-organization), anthropo-sociological (cerebral apparatus of *homo sapiens*, culture, ideas, language, society). Its foundation is physical, its *arkhe* is biological, its development and diversification are anthropo-sociological. Thenceforth we can inscribe information *simultaneously* in a small loop (generative apparatus, informational/communicational geno-phenomenal organization) and in a large loop:

(physico-bio-psycho-anthropo-sociological)



It is then and only then that the concept of information can spread its wings, and, from entropy to *anthropos*, from object to subject, traverse the universe, not to subjugate it but to survey the mystery in it.

While informationist ideology claims to explain everything, complex information both reveals and brings mystery. Like every complex concept, it brings mystery, which illuminates and does not mask what in reality is inaccessible, inconceivable, and inexpressible. Information, which opens up the universe of communication for us, encloses us therein in the sense that we learn that we are blind to the incommunicable...

At the same time, information leads us to the threshold of a mystery which perhaps can be elucidated. It is the mystery of the relation between in-formation and form. There is a formidable twilight zone between, on the one hand, the engram/archive which is an arbitrary sign (chemically localized in the nucleic DNA and in the cerebral neuron) and, on the other hand, the integral resurrection of an existential form, either on the mode of genetic reproduction or on the mode of mental memorization. As neither the new being is already preformed nor memory put into a box like a photo, the resurrection and the regeneration of forms remain incomprehensible to us. We are missing an unknown dimension, an unknown order of reality. We are missing that "thermodynamics of forms," necessary, according to Thom, to a true information theory. (Thom, 1974, p.179) More broadly, we are missing that science of forms, for which once again we feel the need, already diversely singled out by d'Arcy Thomson (1917), Gestaltism, Spencer Brown (1972), Thom himself (1972).

Nevertheless, despite its difficulties and deficiencies, complex information already allows us to perceive the importance of two categories of problems fundamental to every biological organization, and which will be aggravated and amplified again in the anthropo-social sphere.

The first problem is that of error. All the pre-informational conceptions of living organization and of anthropo-social organization underestimates the radicality of error which seems to be only a simple epiphenomenon in a universe in which everything self-organizes and acts only in function of "needs" and "interests." Now, needs and interests can be mistaken, when organization is founded on the communication of signals and the archiving of information.

Error is the key problem for everything which is informational/communicational, that is to say for an organization and an action whose primary nourishment is information. Error in the strategy of antibodies as in the strategy of war is what loses and what kills, except when one redeems another. And already the first visage of the idea of truth begins to take shape, and that is counter-error (cf. v.III). Thus understood, the idea of truth, although and because it is bio-degradable, becomes vital.

The second key problem is that of the Apparatus. The generative apparatus is inconceivable so long as we do not conceive informational/communicational organization. Now, we suspect that a theory of apparatuses can help us to illuminate a key politico-social problem. Here, the ultimate opposition with informationism bursts forth: informationism not only hides the Apparatus but contributes to every domination by the apparatus, and it can secrete as sociological ideal only an "informational" society, in which information, under the guise of rationality and functionality, commands communication. On the other hand, the complex vision of information leads us to hope for a communicational society, where information works *for* communication.⁷

Let us conclude: like the ideas of active organization, machine-being, production-of-self, recursive loop, negentropy, in which, once born, meta-Brillouinian information participates undissociably, this meta-Brillouinian information is part of the new generation of concepts, complex concepts with multiple entries, with two foci, which allow us perhaps to articulate what otherwise is disjointed, repulsive, hermetic. I am persuaded that the combat with different weapons which is now going to oppose this type of truth which is complex articulation to this type of error which is simplifying disjunction is situated on the paradigmatic level where the future of humanity is *also* going to be played out.

CONCLUSION

From the Complexity of Nature to the Nature of Complexity

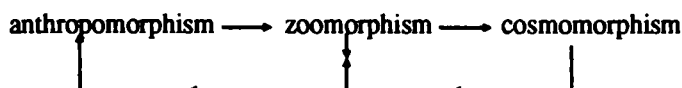
This world, our vast and terrible universe, behold for the first time we are part of it. Carl Sagan.

The simple is always the simplified. Bachelard.

I. The Nature of Nature

From the Enchanted Universe to the Atomized Universe

The universe called “animist” was heavily populated by genies and spirits conceived of anthropo-zoomorphically, and human beings were conceived of cosmomorphically, that is to say made up of the very stuff of the universe. This “enchanted” vision recognized—mythologically—the presence of generativity, of animated and animating beings, of existents at the heart of the universe, and it supposed a loop communication between the sphere of *physis*, the sphere of life, the anthropo-social sphere:



Western physics not only disenchanting the universe, it devastated it. No more genies, no more spirits, no more souls, no more soul; no more gods; one God, if need be, but *elsewhere* no more beings, no more existents, with the exception of living beings, which certainly inhabit the physical universe, but belong to another sphere. Physics in fact can privately be defined as: that which has no life. Nature is returned to the poets. *Physis* is returned, with the cosmos, to the Greeks.

The adventure of classical physics can and must be seen in the light of its admirable ambition: isolate the phenomena, their causes, their effects; tear

from Nature her secrets; experiment so as to substitute proof and verification for affirmation and rationalization. But en route, slantings and permutations of finalities came about: the means—manipulation—became so fine and, by manipulating so as to experiment, we experimented so as to manipulate; the by-products of scientific development—techniques—became socially the principal products. In tearing her secrets from Nature, physics denatured the universe. Reduction and simplification, necessary to analysis, became the fundamental generators of research and explanation, hiding all that was not simplifiable, that is to say all that is disorder and organization.

The principle of simplification reigned over the universe. Things were totally and on principle isolated from their environment and from their observer, both deprived of all existence, if not disturbing. The concordance of observations eliminated the observer, experimental isolation eliminated the disturbing environment. Things became objective: inert, fixed, unorganized objects, *bodies* always moved by exterior laws. Such objects, deprived of form, organization, singularity are, at that degree of abstraction, terribly unreal; but one has hold of them, by measurement and experiment, and that action is terribly real.

Simplification progressed by multiple and successive reductions; the idea of body was reduced to the idea of matter, which became the substance of the physical world, whereas it is an aspect, a reified moment of *physis*, always linked to organization (isolated particles being barely material). Matter was finally reduced to a unity reputed elementary, ultimate, indivisible: the atom. At the end of the 19th century, the physical universe is homogenized, atomized, anonymized.

That universe lost its reality, but that physics is realistic in its measurements, operations, manipulations. *Poiesis* has been sent back to poetry, but physics can do without generativity since it has finally, in every material element, isolated, highlighted, and manipulated its generativity: energy. Since then the new generativity of the physical universe has become anthropo-social manipulation. Science and technique generate and administrate, like gods, a world of objects.

The concepts of physics no longer describe forms, beings, existences, but they have become totally prehensible, beak-claws [Fr. *becs-griffes*; Germ. *Begriff*], allowing us precisely to manipulate everything as objects. They are not anthropomorphous, but they are anthropocentric, since they allow man's domination over the universe. Science is totally unconscious of the praxic, metaphysical, anthropocentric character of its vision of the physical sphere. Doctor Jekyll does not know he is Mr. Hyde.

Now, today this fragmented universe is in crisis. This objective universe

has lost its primary objects, diluted in micro-physical chaos; this homogeneous universe has lost its unity, it drifts apart into three continents, without the slightest conceptual communication: the mega-physical universe on one hand, the micro-physical universe on the other, and between the two, as if on a flying carpet, deprived henceforth of all bases, the "middle band" scaled to our perceptions and observations. This material universe has lost its foundation. Thus, the queen science has not only disintegrated both Nature and *physis*; it has disintegrated its own ground, it knows only mathematical formulas. But it continues to make progress in manipulation. Hence the enormous crisis in the vision of the world is hidden by the enormous success of scientific praxis.

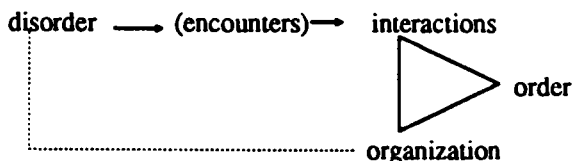
Yet, it is from the crisis of this science that new data and notions emerge which allow us to reconstruct a new universe. As we shall see, the notions which place the simplifying vision of the universe in crisis are the very ones which allow us to conceive a complex universe. The notions which annihilate physics enable us to regenerate a generative *physis*.

Physis Regenerated

It is from the crisis of classical physics, but with a conceptual framework finally regenerated (and I explain this in the second part of this conclusion) that we can generate a universe which is not, however, the former "enchanted" universe. It is a reunified universe, whose unity is more profound than the old homogenization of classical physics, since it is the unity of cosmos, *physis*, and chaos, unity of singularity, of genesis, of generativity, of phenomenality. This universe remains *One*, though shattered, multiple, polycentric, and diverse; it produces by itself disorder, order, organization, dispersion, and diversity. The unity of the universe is, therefore, a complex unity. This universe does not exclude the particular by the general, does not exclude the general by the particular: on the contrary, the one includes the other; the universe produces its general laws from its own particularity. It is an enriched universe: matter is not the ultimate essence of this universe, it is an aspect, which takes on consistency with organization. It is a reanimated universe, moving, acting, transforming, becoming. There is nothing in the universe which is not temporal; there is no element whatsoever, from the particle to the most stable component of a stable system, which cannot be conceived of as event, that is to say as something which happens, is transformed, disappears. The cosmos itself is an Event, which continues its course in cascades of events in which particles arose, atoms were formed, in which suns light up, stars die, life is born. All active organization is an interlacing of events which disorganize and reorganize. Communicational/

informational organization is made up of only of events which it produces, captures, utilizes, resurrects... *Event*, as Whitehead says, is the *unity of real things*. It is the concrete unity which nature gives, not the abstract unity which measurement gives. The universe of old physics could not cope with time, or rather, time could bring it nothing but degradation. The new universe is consubstantial with a rich and complex time: it is neither the simple time of degradation, nor the simple time of progress, nor the simple time of sequence, nor the simple time of perpetual cycle. It is, in a way simultaneously complementary, concurrent, and antagonistic, all of these diverse times, while still remaining the Same. History reenters the universe: the universe has *one* history and *some* histories, which by the billions are made and unmade in stars and galaxies.

Finally, this universe is endowed with generativity; that is to say that the encounters and interactions between its events/elements, in our time-space, allow us to conceive, together with the necessary ingredient of disorder, the constitution of order, the organizing morphogeneses of beings and existences, the diversifying and complexifying developments. Whence the "tetralogue" or "tetragram" formulated in chapter 1:



This tetralogue is not the law of the universe in four articles; it is not the translation of an unpronounceable name, of an inconceivable chaos; it is the assemblage of recursively linked notions, *which we cannot do without* if we want to conceive not only the idea of being, of existence, of matter, but the very emergence of the real. This means, at the same time, that everything needs to be generated, even the real, even the cosmos, even order; that everything which acts, that is to say expends, needs to be regenerated. Ancient mythologies knew that the universe needs to be regenerated, and their rites tried to contribute to this regeneration. The majestic order of Newton and of Laplace is, as we know now, endlessly generated and regenerated by the formidable solar boilers. This means finally that everything which is genestic, generative, creative cannot do without disorder. Disorder is unavoidable, irreducible. Just as we cannot dissociate in man his *homo demens* aspect from his *homo sapiens* aspect, likewise—and it is not by chance—we cannot dissociate in the cosmos its "mad" character (chaos, hemorrhage, waste, loss,

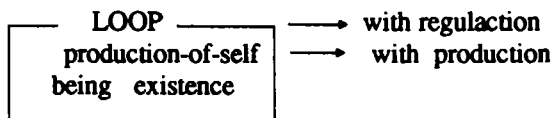
turbulence, cataclysm) from its "wise" character (order, law, organization). The former perhaps has no need of the latter, but the latter always needs the former. Everything which creates and organizes itself expends, dissipates. The universe is more Shakespearean than Newtonian; what is playing therein is simultaneously a nameless buffoonery, a fairy tale, a painful tragedy, and nobody knows which is the principal scenario...

Physis Generalized

We have henceforth an immanent principle of organization, properly physical. Thereby *physis* recovers the generic plenitude which the pre-Socratics had attributed to it. It is this reanimated and regenerated *physis* that can be *generalized*, that is to say reintroduced into everything living, everything human.

This generalization, we have seen, takes place with the evolutive developments of organization. We have followed the genesic logic, one thread of which leads to life:

In the beginning was Action
 then came interaction
 then came retroaction
 then came organization



Then came information and
 communication
 that is to say geno-phenomenal
 organization
 in which the Self becomes *Autos*
 in which being and existence
 become *Life*

From the very beginning a principle of meandering evolution takes shape, by schismo-morphogenesis, where branches are constituted, deviant with respect to the branch from which they spring, which become new norms and from which new deviances will arise. From the very beginning there develops

a dialectic of the improbable and the probable, and life will appear somewhere in this meandering, the fruit of an organizational chain constructing its landings of probability from as many improbabilities, its rules of normality from as many deviances, its central bases from as many marginalities.

As we have seen, active organization feeds a physical improbability which it transforms into a local and temporary probability. Thus are created and perpetuated regional and temporary quasi-laws: we can speak, biologically, of genetic, demographic, ecological, organismic, and behavioral "laws;" they are, in their statistical character, of unequal probability compared to each other, but in numerous domains they allow prevision and prediction. Likewise, as we shall see, human society has its laws, some implicit, flowing from its very organization, others explicitly emanating from the apparatus which makes and sanctions laws—the State. Now, as we have seen, biological repetition, sociological regularity spring, not from one same universal physical law like the law of falling bodies, but from their own generativity and their own regeneration, *in which the repetition of the improbable becomes hic et nunc* probabilary regularity.

Life is not only a development of physical organization. It is a physically integrated phenomenon. The physical enrooting of life, in the framework of the old physics, was trivial and insignificant: it was its obedience to the laws concerning motion and bodies. Here we see that it is a matter of an integration, fed by the tetralogue disorder/interaction/order/organization within the logic of organization and production-of-self. Life, before being conceived of in biological terms, must be conceived of in physical and thermodynamic terms (Prigogine, 1947; Trinchler, 1965; Morowitz, 1968; Katchalsky, 1965) as a polymachine. The complex polymachine called life appears, from one angle, as a machine-being (individual), from another angle, as a machine cycle in time (reproduction), from still another angle, as a polymachine complex in space (society, eco-systems, biosphere). The organization of life is eco-dependent in character, whence the extreme fragility of its conditions of existence, the extreme quality of its organization which allows it to be informed and to communicate, and its extreme solidarity with all the physical phenomena on which it depends.

The biosphere is a fabulous totality of phenomena and beings simultaneously complementary, concurrent, antagonistic. This biosphere is not only under the geo-climatic dependence of the earth's crust. It is under the dependence and in the citizenship of the Great-Being Motor-Machine, and it integrates in itself, by machining them, myriads of atomic organizations.

It is totally insufficient to consider the solar universe as only an ecological matrix where life feeds on photonic radiation which feeds plants, which feed

herbivores, which feed carnivores, whose corpses feed the soil, which feeds plants that the sun feeds... Life is still more profoundly solarian. It is solarian first of all because all its components have been forged in the sun, and have been assembled, on a planet spit out by the sun, by the effect of ultraviolet rays and electromagnetic storms of solar origin. It is solarian especially because it is the transformation of a photonic streaming, issued from formidable solar swirlings and whirlwinds, in an electronic whirl looping into machines producers-of-self billions and billions of exchanges between atoms issued from the sun. Thereby, life in general and the living being in particular are not only lost in a nook of the cosmic outskirts, between micro- and mega-physics; they are part of an active continuum in which the mega-physical solar Being and a countless micro-physical people, themselves descendants of the sun, are bonded in swirls. We are a small appendant bit of the sun which, after marine soaking, chemical stewing, electrical discharges, *came to life*.

Thus, life can and must appear to us under two physical aspects, according to the angle of view of the observer/conceiver. On the one hand, it is an advanced point in the evolution of active organization which, by becoming informational-communicational, crosses a frontier and becomes life, in the shape of self-organizing beings-individuals. On the other hand, it appears to us as a potentially autonomous emergence, on the surface of the earth's crust, of a formidable solarian solidarity, in which myriads of loops link up with each other, from solar loops to inter-atomic loops, in a formidable micro-meso-mega-physical polymachinery. The two visions, which exclude each other when one follows the principle of simplification, necessitate each other in the complex vision. They conjointly witness to the physical enrooting and integration of life. Consequently, even before broaching complexity *sui generis* biological (v.II), it was necessary to bring to the basket of nascent life what vitalists and reductionists always steal from it: an extraordinary *physical complexity*, not only that of an informational/communicational machine-being, but also that of cosmic connection and micro-physical connection, where life then, and only then, takes existence both autonomous and solarian.

We can, thus, tie together the organizational prehistory of life, the physical dimension of life, the solarian enrooting of life. All of this was completely hidden at the time of closed biology (vitalism), and remains such still today when we consider life only under the angle of classical physical processes and according to the one chemico-molecular umbilical cord. The true umbilical cord swirls from eddy to eddy, returns towards the sun. Born in a marine placenta, life ceases to be orphaned. It has a Hermaphrodite father/mother who nourishes it with honey flowing from its entrails; it is the cousin of countless physical beings, some of them ephemeral, like Aeolian whirlwinds, liquid eddies, flames, others very long-lasting like the stars...

We have penetrated to the physical interior and the physical matrix of life. But true life is still absent. From the first living being, the becoming of organization changes orbit, the quality of existence changes nature. It is not a question only of generalizing the physical concepts proposed here; a generation of new concepts is necessary. Life is not the growth or the multiplication of physical qualities, it is their passage to a new stage. If we are going to recover our actors disorder/organization/order, a new game begins, in which new actors intervene. We will need, therefore, a meta-theory, a meta-physics, not in the extra-physical sense in which this term is conceived, but in the sense of *meta* which signifies both going beyond and integrating.

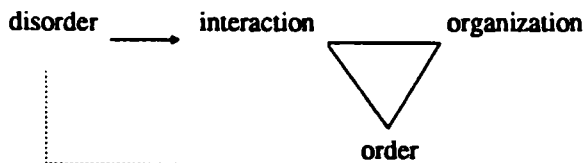
The Physical Nature of Man

The human being is not physical by his body. It is physical by its being. Its biological being is a physical system. We are super-systems, that is to say we unceasingly produce emergences. We are open super-systems, that is to say no living being has more needs, desires, and hopes than we do. We are extremely shut-in systems; none is as closed in its incommunicable singularity. We are physical machines. Our biological being is a thermal machine. This machine-being is itself a moment within a mega-machine that we call society, and an instant within a machine cycle that we call the human race. In our society there is posed in a human, that is to say inhuman, fashion the crucial problem of every machine-being: the organization of work. We are engaged in an uninterrupted productive praxis, producing our lives, our tools, our villages, our monuments, our myths, our ideas, our dreams... We are beings organized in a communicational/informational fashion, and it is in our society that the problem of the Apparatus, the problem of enslavement is posed in a human/inhuman, central and tragic fashion. Like every living being, we are a bit of solarian existence, and from the first lighting of our consciousness, our cults adored the sun. We are children of the sun, this chaos become machine which, spitting out its flames, crackling fire, vowed to deflagration, re-begins its regulating cycle without interruption, institutes its order, the planetary order which surrounds it with its wise and impeccable rotation. The sun feeds our order, feeds the mechanical repetition of our reproductions and regenerations, feeds the order of society. At the same time, it feeds our deliriums, our avatars, the disorders of *sapiens/demens* man, the disorders of society and of history. The irreversible hemorrhage of its radiation feeds our becoming.

I have said that the cosmos is like man, *sapiens/demens*. That was to say that *sapiens/demens* man was close to what is genesic and generic in the cosmos. *Sapiens* man is the organizing being who transforms chance into organization, disorder into order, noise into information. Man is *demens* in the

sense that he is existentially interlaced with pulsions, desires, deliriums, extasies, fevers, adorations, spasms, ambitions, hopes tending to infinity. The term *sapiens/demens* signifies, not only an unstable, complementary, concurrent, and antagonistic relation between "wisdom" (regulation) and "folly" (deregulation): it signifies that there is wisdom in folly and folly in wisdom.

Much more. It is at the moment when humanity has apparently become unstuck from nature, that is to say the time of historical societies which, born some thousands of years ago in Asia, spread over the globe in the form of nations and empires, it is in this departure towards what seems to be the most human in the human, the most social in the social, the most intellectual in the intellect that suddenly a thermodynamic unleashing is triggered. The tetralogue:



once again resumes its full volcanic activity.

After tens of thousands of years of regulation (archaic society), history is like the irruption of physical disorder in biological repetition. Human history appears like a great cosmogonic turbulence, a Niagara of events, a tumultuous torrent of destruction and production, a mad praxis, an unheard-of expenditure of energy, with unbelievable transmutations, from imaginary negentropy to praxic negentropy. Conquests, invasions, constructions, sackings, burnings, enslavements, massacres, great works, mad desires, hates and furies, existential and pestilential excesses, and, in this delirium, while always, everywhere, desirous and delirious machines continue to produce and reproduce, it is ideas, proliferating informational beings, that are the most mad, the most barbarian, myths, beliefs, ideologies, religions.

Now, this unleashing could only be realized in and by the existence and the action of what should be the regulator and the stabilizer, the State apparatus. The irruption of the *Raison d'Etat* is not only that of Hegelian and Weberian rationality; it is that of the *hubris* of power and of enslavement.

Human history has something barbarian, horrible, astonishing, atrocious about it which evokes cosmogenesis. As with cosmogenesis, we can meditate infinitely on the ambiguity of a process in which death, rupture, disintegration, wastes, irreparable destruction have a common trunk, and at the same time an inexpiable antagonism, with births, developments, metamorphoses. The reference to cosmogenesis probably indicates to us that human history is genetic. Chaos and *hubris* woke up in it: everything happens as if, since the

emergence of historical megamachines, a new, monstrous, Ouranian genesis had begun... We are still in anthropogenesis, we are in an uncertain sociogenesis, the planetary age of iron, and not yet at the doors of the golden age. Now, we already know, after having plunged into physical organizationism, that our tragedy is performed centrally at the communicational/informational level of society, the level of the organization of work and that of enslavement, the level of the power and the nature of geno-phenomenal apparatuses, foremost among them the State apparatus. We know moreover, after exploring the problem of information, that error and ignorance weigh and are going to weigh more heavily than force in the destiny of humanity.

Thus, the apparently senseless voyage to the geneses of geneses, to the horizons of horizons, to the organization of organizations, brings us back, like a boomerang, to the very point of departure of our inquiry and of our passion for the being and the becoming of humanity.

We must, therefore, conceive the anthropo-sociological sphere, not only in its irreducible specificity, not only in its biological dimension, *but also in its physical and cosmic dimension*. Thenceforth, nature remembers and returns to life. Nature is not only *physis*, chaos, and cosmos together. Nature is what binds, articulates, makes the anthropological communicate in depth with the biological and the physical. We must therefore rediscover Nature in order to rediscover our Nature, as the Romantics had sensed it, genuine guardians of complexity during the century of the great Simplification. Thenceforth, we see that the nature of what distances us from Nature constitutes a development of nature, and brings us nearer to what is most intimate in the Nature of Nature. *The Nature of Nature is in our nature. Our very deviance, with respect to Nature, is animated by the Nature of Nature.*

But the Nature of Nature cannot close in on us and engulf us.

Open Physis

At the moment when complex, reanimated, regenerated, generative *physis* becoming generalized by that very fact, envelops and embraces all things, including anthropo-social becoming, including the human spirit, and, precisely because it is complex, an unclosable breach is opened in it. In fact, from the very start of our voyage in *physis*, from the very uprise of disorder, the observer uprose and has remained present. This observer, in his vision, language, concepts, knowledge [Fr. *savoir*], culture, society, embraces in his turn the *physis* which embraces him.

We have seen at multiple levels that no physical concept can be totally isolated from the anthropo-social sphere:

a) The fundamental concepts of organization, system, machine actualize a

good number of their potentialities at biological and anthropo-social levels; thus, a retroactive lighting from the bio-anthropo-sociological to the physical is needed to clearly expose these physical concepts.

b) A physical concept like information cannot be conceived outside of the biological being in which it takes shape and outside of the anthropo-social being in which it develops its potentialities.

c) No physical concept can be radically abstracted from its conceiver, just as no physical phenomenon can be radically abstracted from its observer.

The classic and fundamental problem, posed by the fact that there are no "un-thought bodies" (Berkeley), is present here. It is still too early to consider it head-on. But we can no longer escape its modern resurgence at the heart of science. The return of the observer is a capital scientific discovery of the 20th century. Not only is there no longer any privileged observer in the universe of Einstein, Bohr, Heisenberg, Hubble, but we have seen that, in systemics, in organizationism, in *physis*, the position of the observer, the angle of his takes, his framing, determine the nature of the observation and modify the phenomenon observed. We have seen that an inextinguishable uncertainty remains with regard to the real nature of a basic concept like disorder. We have seen that every observer is limited by his situation *hic et nunc* in an uncertain and ambiguous universe.

This world, which long ago escaped Laplace's deterministic model, forbids us even to dream of an ideal observer (demon), an ideal observation point, an ideal code of interpretation. At last Brillouin has made us renounce the idea of an observation, not only exhaustive, but which does not include its praxis. But the observer of physicists, from Heisenberg to Brillouin, remained an abstract observer, and *not yet a human subject endowed with an understanding mind, immersed in a scientific, intellectual, cultural, social praxis.*

d) Thenceforth, the idea of social praxis emerges, in the hinterland of the observer, at the same time as the idea of subject. All knowledge [Fr. *connaissance*] is a physical praxis which is at the time an anthropo-social praxis. Our physical concepts are not only tied to that vision of the world, they are inscribed in an anthropo-social praxis tied to that vision of the world. There is, therefore, no longer any physical knowledge purely "disinterested" or purely physical.

The Reversal

Consequently, it is at the moment when everything can re-enter generalized *physis*, including social science and the science of the mind, that

this *physis* swings of its own motion over into social science and the science of the mind; not only can it not close up on itself and become self-sufficient, but it knows that it exists and takes shape only in a human mind which conceives it, and is part of an anthropo-social praxis.

In other words, it is at the moment when the science of man becomes a physical science that physical science becomes a science of man. Simplification can exclude one of these propositions only at the expense of the other. On the contrary, it is a matter of rising up to a meta-system of thought in which these two propositions become complementary while remaining concurrent and antagonistic, in which each is relativized and criticized by the other in confrontation, in exchange, and finally in a recursive "loop" since each of these propositions, if followed in depth in the logic of its complexity as I have here followed physics, requires the antagonistic proposition.

We have seen that thermodynamics is inseparable from the industrial revolution, that cybernetics, born in the anti-aircraft salvos of World War II, corresponds to a new generation of artificial machines, that information is born from Bell Labs telecommunications, that these historical and social determinations are not neutral. We have seen that it is not only the idea of the social machine which must refer to the physical idea of machine; it is also the physical idea of machine which must refer to the reality of machinism in the social megamachine. More fully, more fundamentally, the link which we have been able to discover between the conceptual deficiency of physics and its triumph as measurement and manipulation, in revealing to us the hidden face of manipulation, at the very heart of concepts like energy, obliges us to link the idea of science, apparently the most disinterested, the most universal, the most objective of all, to the historical praxis of the Western world.

And that, far from cancelling out the observer/conceiver, obliges him still more to consider himself as *subject*, that is to say to ask himself what game he is playing, where he is situated in and with respect to his society, what means he has to understand it and to understand *himself*. It is certainly here not a matter of transmuting the old physicism into a sociology, of substituting for the old imbecile vulgate of pure science, which blinded the scientific by the social praxis working in it, a new feeble-minded vulgate which dismisses verifiable ideas as ideological products of capitalism. In my perspective we can no longer pass from one simplification to another. We are constrained to complexity, that is to say the hard work of elaborating a science with henceforth double or multiple entries (among them always a physical entry and an anthropo-sociological entry), with two bases (object and subject).

First Spiral

It is in this sense that in the course of the first volume, I have tried hard to

effect productive exchanges between *physis* and anthropo-sociology, through an initial looping, an initial spiral progress. There has resulted, it seems to me, a double and solidary addition of complexity:

1. An addition of complexity from the physical sphere to the biological sphere and to the anthropo-sociological sphere. We have first of all discovered in us, living beings, human, social, an unsuspected dimension and depth and physical amplitude which, in terms henceforth entirely modern, restore to *physis* the place it had in the *De natura rerum*.¹ We have discovered our central (solarian) physical bond [Fr. *lien*] and our peripheral physical bound [Fr. *lieu*].

Much more: enriched *physis* brings to anthropo-social science basic concepts both better founded and more complex than those which it had, and it allows it to complexify its trivial concepts. Thus, the idea of system has become both founding and complex. The ideas of work and of enslavement find their foundation. The concept of Apparatus, unknown (or merely political), emerges in its formidable power. To tell the truth, the central contribution is this: *we discover that in order to begin to conceive the idea of living organization and a fortiori the idea of anthropo-social organization, we need a formidable and unsuspected conceptual underpinning, a very complex infrastructure or theoretical infrastructure concerning the physical idea of organization*. Thus, this voyage which seemed to transport us to the very depths of *physis* was leading us in fact to the foundations of all anthropo-social theory; this apparent excursion to the antipodes of the present concern in fact our most present problems. As in all loop movement, what distances us from the point of departure is at the same time what draws us near.

2. An addition of anthropo-sociological complexity to physical theory:

—by the anthropo-social lighting of the physical concepts of disorder, system, organization, machine, information;

—by the possibility of a critical examination of these concepts other than by solely empirical and logical verifications;

—by the permanent insertion of the observer/conceiver, and by that fact, although still in a blurred and uncertain way, of the subject in every observation/conception of the object.

3. A mutual addition of complexity. As strange and confusing as this might have seemed to many, as superficial as this seems to me, the biological, anthropological, and sociological examples which I have given in the course of my development on the notions of organization, opening, machine, information, etc., had a double function: on the one hand, they allowed me to clarify concepts whose complexity is fully deployed only at the bio-anthropo-social levels; on the other hand, they allowed me to point out that these concepts

concern us and can contribute to the elucidation of our anthropo-social sphere. At the same time, this translated my efforts to give these concepts a double or multiple foundation, a double or multiple entry which they needed, and to sketch out, through trial and error, the circular movements which were to form the loop.

4. The production of complexity by complexity. Finally and especially, it is in these circular movements that there arises an addition of complexity to complexity, that is to say the multi-faceted process in which complexity, perceived, recognized, empirically integrated, *is in the process of being transformed into principle.*

II. The Complexity of Complexity

Complexity asserts itself first of all as an impossibility to simplify; it arises where complex unity produces its emergences, where distinctions and clarities in identities and causalities are lost, where disorder and uncertainty disturb phenomena, where the subject/observer surprises his own face in the object of his observation, where antinomies make the course of the reasoning go astray...

Complexity is not complication. What is complicated can be reduced to a simple principle like a tangled skein or a sailor's knot. Certainly, the world is very complicated, but if it were only complicated, that is to say confused, multidependent, etc., it would suffice to perform well-known reductions: a game between a few types of particles in the atoms, a game between 92 types of atoms in the molecules, a game between four bases in the "genetic code," a game between a few phonemes in the language. I believe I have shown that this type of reduction, absolutely necessary, becomes cretinizing as soon as it becomes sufficient, that is to say claims to explain everything. The real problem, therefore, is not to reduce the complication of developments to rules with a simple base. *Complexity is the base.*

We have seen that there is no longer anywhere, neither in micro-physics nor in macro-physics nor even in our middle mesophysical band, a simple empirical base, a simple logical base. The simple is but an arbitrary moment of abstraction torn from complexity, an effective instrument of manipulation laminating complexity. Genesis is complex. The particle is hypercomplex (and no longer the element finally made simple). Organization is complex. Evolution is complex. *Physis* is unsimplifiable, and its complexity totally defies our understanding of its origin, its infra-atomic texture, its cosmic deployment and becoming.

This is to say that *everything* is complex: the demonstration of physical

complexity is valid *ipso facto* for the biological sphere and the anthropo-social sphere, and dispenses us from proving it here.

Complexity emerges, we have said, as a darkening, as disorder, uncertainty, antinomy. This is to say that the very thing which provoked the ruin of classical physics constructs the complexity of the new *physis*. This is to say, by the same token, that disorder, darkening, uncertainty, antinomy impregnate a new type of comprehension and explanation, that of complex thought.

As we have seen, complex thought is forged and developed in the very movement in which a new knowledge [Fr. *savoir*] of organization and a new organization of knowledge feed each other:



Conceptual Reorganization

The organizational retooling of *physis* entailed a conceptual retooling. Anemic or trivialized terms strengthened and developed themselves: organization, system; notions driven away have been rehabilitated and promoted: disorder, event, being, existence; others, introduced by cybernetics, systems theory, information theory, have been examined, deloused, vitaminized; they have been enriched by detechnocratization, they have taken on their meaning by linking up with the central notion of organization: work, entropy, negentropy, information. Some concepts have constructed themselves: the concept of production-of-self, of recursive/generative loop, of machine-being. Others have shattered the cybernetic chrysalis which imprisoned them: the idea of communicational/informational organization and the idea of generative Apparatus. These concepts have not been constituted as closed entities. They are not simple notions adding onto other simple notions. They are of another order. They are not spatial concepts encircling a domain: they draw lines of force; they do not isolate essences: they activate relations; they interact among themselves. Atomizing concepts have been replaced by macro-concepts binding in themselves notions heretofore distinct, indeed antagonistic (I translate these connections by the sign /). Even inseparable conceptual chains or constellations have been constituted: thus, just the notion of organization or active organization *ipso facto* comprises the following key notions: production/transformation/praxis, machine-being, production-of-self, recursive/generative loop, opening/re-closing, existence... At the base of *physis*, there is no primary, sovereign concept, but a looped conceptual, producer process.

These concepts have at least a double identity. They are always open to an *Umwelt*, an environment which is their *eco* and which echoes them. They are always open onto a beyond, a *meta* from which they are less and less dissociable when they are more and more complex. We will see more and more that the ecological dimension must be present in every observation and every thought, that everything must be ecologized, and that everything must be seen in meta-system and meta-perspective.

These double-identity concepts (ecological identity and internal identity) are also double/triple entry concepts: physical, biological, anthropo-sociological, as we have seen for all the key organizational notions: system, machine, information. Information is particularly remarkable: it is a physical concept which appears (at least in the present state of knowledge [Fr. *savoir*]) only with the living being and which unfolds at the anthropo-social level.

These multiple-entry concepts are also all double-based concepts: they all include the base-object and the base-subject (the observer/conceiver).

Henceforth, objects are no longer merely objects, things are no longer things; every object of observation or of study must henceforth be conceived in function of its organization, its environment, its observer.

Such a junction of notions heretofore disjoined brings us closer to the very principal core of complexity which is not only in the linking of what is separated/isolated, but in the association of what was considered antagonistic. Complexity corresponds, in this sense, to the irruption of antagonisms at the heart of organized phenomena, to the irruption of paradoxes or contradictions at the heart of theory. The problem of complex thought, therefore, is to generate together, without incoherence, two nonetheless contrary ideas. This is possible only if we find: a) the meta-point of view which relativizes the contradiction, b) the inscription within a loop which makes productive the association of antagonistic notions now become complementary.

Thus, we can see taking shape a principle of thought *in the transformation of a disjunction or alternative, irreducible on the ground of simplifying thought, into connection or complex unity.*

At each stage of our way, we have encountered this problem. At each stage, we have had to associate repulsive concepts, articulate disjunctive concepts. It was not a game of wit on ornamental concepts. It was a necessity of intelligibility concerning primary and fundamental concepts. Thus:

* Disorder/Order, Disorder/Organization (and that without discontinuity, for every problem of order and organization, with the necessary mediation of the terms interaction/encounter);

* Chaos/*physis*, Chaos/Cosmos;

* One/Multiple, One/Diverse, One/Complex (the notion of diversity had always been annihilated by the principle of order of classical science; the diverse was always the epiphenomenon which had to be dissolved on behalf of the uniform);

* Singular/General, Individual/Generic (we have seen that the paradigm "the only science is general science," which excluded all individuality and all singularity, must be radically surpassed: the first object of all science, the world, is singular in its origin, in its globality, in its development, and it is that which founds the generality of the Laws of Nature, universal laws of our singular Universe);

* Autonomy/Dependence, Isolation/Relation (thus, we must simultaneously accentuate the autonomous and isolable individuality of an existential being, and the fact that it is a moment/event/element in a system of system of system, in a poly-machine, itself organizationally connected to its environment, the latter organizationally tied to its environment, and so on; whence the necessity, *method-ically*, to simultaneously link and isolate; I will return to this a little further on.)

* Event/Element;

* Organization/Anti-organization, Organization/Disorganization (*via* Reorganization);

* Constancy (or Invariance)/Change (stationary states, homeostases) and, afterwards:

* Equilibrium/Disequilibrium (Meta-disequilibrium), Stability/Instability (Meta-instability);

* Cause/Effect, Causality/Finality;

* Opening/Closing;

* Information/Noise, Information/Redundance;

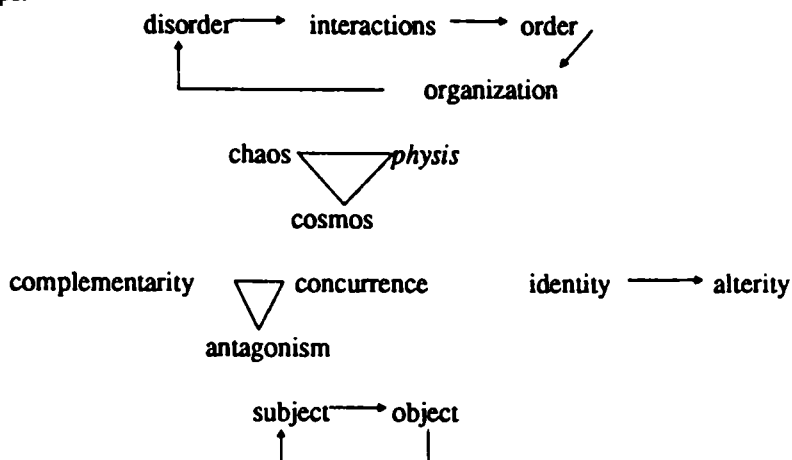
* Normal/Deviant;

* Central/Marginal;

* Improbable/Probable (everything organizational, from the formation of stars to the birth of life, from the birth of life to the apparition of *homo sapiens*, and what follows, can be considered as both deviance becoming central, marginality becoming normal, general improbability transforming itself into local and temporal probability).

It is not sufficient, in order to conceive the principle of complexity, to associate antagonistic notions in a concurrent and complementary way. We must also consider the very character of the association. It is not only a relativization of these terms in reference to each another; it is their integration in the heart of a meta-system *which transforms each of these terms in the process of a retroactive and recursive loop.*

The loop, here, is in fact a poly-loop made by the looping of fundamental loops:



We will have to conceive the nature of the looping of those loops; I will attempt this at the properly epistemic stage of this work (v.III).

As of now, the idea of loop carries in itself the principle of a knowledge [Fr. *connaissance*] neither atomistic nor holistic (totality which simplifies). It signifies that we can think only starting from a cognitive praxis (active loop) which productively makes sterile notions interact, sterile when they are disjoined or simply antagonistic. It signifies that every explanation, instead of being reductionist/simplifying, must pass through a retroactive/recursive game which becomes the generator of knowledge [Fr. *savoir*]. The loop substitutes for a hollow, sovereign, primary, terminal master-word; it is not a master-word

(unless we reify the loop into formula, that is to say pour it into simplification): *it is a necessary mediation, it is an invitation to generative thinking.*

The loop generates itself at the same time as it generates; it is producer-of-self at the same time as it produces. It is not a vicious circle, since it draws its nourishment (information) from the observation of phenomena, that is to say from a phenomenal eco-system (its ecotheque) and since it is animated by the cognitive activity of the thinking subject (its "genotheque"). It is an open loop which recloses, and in that way can develop spirally, that is to say produce knowledge [Fr. *savoir*]...

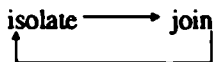
On this side of the loop, nothing: not nothingness, but the inconceivable and the unknowable. On this side of the loop, no essence, no substance, not even the real: the real is produced through the loop of interactions which produce organization, through the loop of the relations between object and subject.

Here a great shift of base takes place. There is no longer at departure an entity for knowledge [Fr. *connaissance*]: the real, matter, mind, object, order, etc. There is a circular game which generates these entities, which appear as so many moments of production. By the same token, there are no more inexorable alternatives between antinomic entities which fought for ontological supremacy: the great classical alternatives, Mind/Matter. Liberty/Determinism, fall asleep, become residues, seem obsolete to us. We even discover that materialism and determinism, which lived by excluding the observer/subject and disorder, are as metaphysical as spiritualism and idealism. *The real debate, the true alternative are henceforth between complexity and simplification.*

Now, just as simplification constitutes a fundamental principle which grounds knowledge [Fr. *connaissance*] in disjunction and opposition between the primary concepts of order/disorder, subject/object, self/environment, so complexity constitutes a fundamental principle which associates nuclearly these primary concepts into a loop. *Now, the fundamental relations of exclusion and/or association between primary concepts, that is to say the preliminary alternatives and associations, precisely constitute paradigms which control and orientate all knowledge savoir, all thought, and thereby all action (since knowledge savoir is transforming and transformable.)* It is at the level of the paradigm that the vision of reality, the reality of vision, the face of action change, that reality in short changes. We discover, therefore, that complexity is situated, not only at the level of the observation of phenomena and of the elaboration of theory, but at the level of principle or paradigm.

The original character of the paradigm of complexity is that it differs, by its intrinsic nature, from the paradigm of simplification/disjunction, and that

this extreme difference allows it to comprehend and integrate simplification. In fact, it is absolutely opposed to the absolute principle of simplification, but it integrates simplification/disjunction now become relative principle. It does not ask us to reject distinction, analysis, isolation; it does ask us to include them, not only in a meta-system, but in an active and generating process. In fact, to join and to isolate must be inscribed in a recursive circuit of knowledge [Fr. *connaissance*] which never stops nor is ever reduced to one of these two terms:



The paradigm of complexity is not anti-analytical, it is not anti-disjunctive: analysis is a moment which endlessly returns, that is to say which is not drowned in totality/ synthesis, but which does not dissolve it. Analysis calls for synthesis which calls for analysis, and this *ad infinitum* in a process productive of knowledge [Fr. *connaissance*].

We see then that the paradigm of complexity is structurally different from all paradigms of simplification conceived or conceivable, physical or meta-physical. It does not merely create new alternatives and new junctions. It creates a new type of junction, which is the loop. It creates a new type of unity, which is not the unity of reduction, but of circuit.

It is difficult to understand complexity, not because it is complicated (complexity is not complication), but because everything dealing with a new paradigm is very difficult to understand. It is not the refinements of thought which are difficult to understand when one sets out from an evident principle; it is the evident base of a different principle. Every new paradigm, *a fortiori* a paradigm of complexity, always appears confusional in the eyes of the former paradigm, since it embraces what was evidently repulsive, mixes what was essentially separate, and breaks what was logically unbreakable. Complexity perplexes and baffles because the reigning paradigm blinds us to evidence that it cannot make intelligible. Thus, the evidence that we are simultaneously physical, biological, and human beings is hidden by the paradigm of simplification which commands us, either to reduce the human to the biological and the biological to the physical, or to disjoin these three characters as incommunicable entities. Now, the principle of complexity allows us to perceive this suppressed evidence, to be astonished by it, and to seek a non-reducing intelligibility.

Complexity, in this sense, exhumes and reanimates the innocent questions that we have been trained to forget and despise. This is to say that there are

more affinities between complexity and innocence than between innocence and simplification. Simplification is a brutal rationalization, not an innocent idea (as far back as we go in archaic mythology, we never find a simple idea, always a complex myth). The force of The Sermon on the Mount, of the innocent Rousseauist, of the Dostoevskian idiot, of the Pouchkinian simpleton who cries in *Boris Godounov*, is to be outside the reign of the abstract idea, which, weak negentropically, is beneath the water line of the least living reality: these innocent people express the richest communicational complexity that life has been able to give rise to, that of love. Contrarily to imbecile abstract thought which disqualifies love: love is complexity emergent and lived, and the most vertiginous computation is less complex than the slightest tenderness...

Complexity makes us sensible to dormant evidence: the impossibility of expelling the uncertainty of knowledge [Fr. *connaissance*]. The joint irruption of disorder and of the observer, at the heart of knowledge, brings uncertainty, not only in description and prevision, but with regard to the very nature of disorder and the very nature of the observer. The problem of complexity is neither to enclose uncertainty between parentheses, nor to enclose itself in a generalized skepticism; it is to profoundly integrate uncertainty in knowledge and knowledge in uncertainty, in order to understand the very nature of the knowledge of nature. Already, we are discovering the horizons, namely that infinite mystery whence there emerges what we call the real. Just as incompleteness and imperfection are necessary in order to conceive the very existence of the world,² so it is unfulfillment, incompleteness, flaw, and imperfection at the heart of our knowledge [Fr. *savoir*] which make its existence and progress conceivable. Only the insufficient is productive, to repeat Kayserling's phrase.

Complexity is a progress of knowledge [Fr. *connaissance*] which brings the unknown and the mysterious. Mystery is not only privative; it liberates us of all delirious rationalization which claims to reduce the real to the idea, and it brings us, in the form of poetry, the message of the inconceivable.

The Way

We are only at the beginning of complex knowledge [Fr. *connaissance*] and the recognition of complexity. At the end of this first volume, we have envisaged essentially the physical entry of the knowledge [Fr. *savoir*] of organization and of the organization of knowledge [Fr. *savoir*]; we have only been able to propose a first universal affirmation of complexity and a first detection of the fountainhead or "paradigmatic" core of complexity. We have

simply executed a double looping:



We have simply executed a first spiral. We see henceforth that key questions are posed, which have not even been touched upon here yet. Thus, we are not yet armed to examine the very concept of subject; we will first of all have to recognize what the *autos* signifies in and for a living being; but already we suspect that subjectivity no longer necessarily nor principally signifies contingency, sentimentality, error, and that the concept of subject includes a logical and organizational core. Neither are we armed to envisage the bio-anthropological structures of knowledge [Fr. *connaissance*]. We know nothing yet of noological organization itself. We know nothing yet of this paradigmatic tuff where organization of ideas and the organization of society first take shape. Finally and especially, anthro-po-sociological knowledge [Fr. *connaissance*], whose role here becomes capital, since it becomes the reference necessary to all physical knowledge, the second entry necessary to all scientific concepts, is still non-existent. How can we discover the social unconscious in the scientific conscious? How are we to decipher society in the observer? The necessary critical consciousness with regard to society can be critical only if it is itself open to critique and includes this critique itself. And we arrive at the personal problem, from which no one can escape, including and above all the author of these lines: how to self-analyze?³

Once again the plurality, the immensity and the difficulty of the problems tell me that I have taken on an impossible mission. But I see ever more clearly that it is not a question of resolving them cumulatively. I see ever more clearly that one must not aim at building a Tower of Babel of knowledge [Fr. *savoir*], but a productive principle of knowledge [Fr. *connaissance*] or *method*.

From Anti-method towards Method

Where are we? Method, in the beginning, was anti-method: it was only to dare to start, despite the sneers, not only external, but also, the worst ones, internal. It was to have as sole viaticum what is impossible to prove, even to oneself: curiosity, passion, openness and at least the *feeling* of complexity. Method took shape only negatively, in a void, in resistance to master-words, to closed thought, to idealist reification where the idea replaces the real to rationalization, to all reduction, including certainly the spiritual reduction of

the "Gnosis of Princeton." (Ruyer, 1974) Method took shape by discovering and circumscribing the paradigmatic shape and depth of the enemy: simplification.

Other proofs came along, which do not appear in this volume, rewritten three times, during which a decisive combat (of Sisyphus?) took place. In fact, the systemic, cybernetic, informational notions, which allowed me to go beyond an old way of thought, themselves included a new simplification whose depth at the outset I didn't measure. It was not a question, as I believed it to be at the outset, only of dissociating two systemisms, two cybernetics, two informationisms, the first "open" and "fertile," the second "engeeneral" and "technocratic." I had to not let myself be enclosed in the notions which, liberating in a first deconstruction stage, became imprisoning in the reconstruction stage. I had to understand that the danger is precisely in what brings a provisional liberation. I had to understand that it was the very notions of system, cybernetics, information which I had to go beyond by the very movement which had brought them. That I could not do it alone; I needed the on-going criticism of Stewart, the ultimate maieutic of Victorri, and it is this maieu-criticism which made me fully assume my principle of complexity. In this spiral progress which is not yet method, but where method if secreted, I have understood more and more strongly that everything which does not bear the mark of disorder and of subject is insignificant and mutilating, and this also concerns cybernetics, systemism, informationism, in their rationalizing functionalism, their machines, their program, their information, that noise always deregulates and degenerates. I have radically understood that everything which does not carry the mark of disorder eliminates existence, being, creation, life, liberty, and I have understood that all elimination of being, existence, self, creation is rationalizing madness. I have understood that order alone is nothing but bulldozing, that organization without disorder is absolute enslavement. I have understood that we must fear, not disorder, but the fear of disorder, not the subject but feeble-minded subjectivity which takes itself for objectivity. I have understood that the richest and most audacious theories, those that bear the most complexity, have turned into their opposite because they had fallen back into the gravitational orbit of the paradigm of simplification.

The first positive base of method is in the first universal affirmation of complexity. *The problem is henceforth to transform the discovery of complexity into a method of complexity.*

Now, we are only at the preliminaries. What we have acquired are a few guiding ideas. The idea that every concept, every theory, all knowledge [Fr. *connaissance*], all science must henceforth include double or multiple entries (physical, biological, anthro-po-sociological), a double base (object/subject), and must constitute a loop. The idea that looping is not mooring but

transformation. The constitution of a new field of knowledge [Fr. *savoir*] is not constituted by opening up frontiers, as naive persons believe; it is constituted by transforming what generates frontiers, namely the principles of the organization of knowledge [Fr. *savoir*]. And it is at the level of exploration, recognition, reconstruction, at this fountainhead or paradigmatic level that my effort is truly replaced.

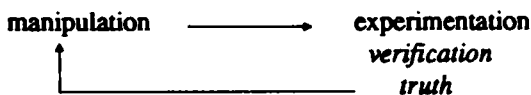
We glimpse as of now that it is a question of imitating thinking which includes its own reflexivity, which conceives its objects, whatever they may be, by including itself. Classical science was incapable of conceiving itself as object of science, and that because the scientist was incapable of conceiving himself as subject of science. Henceforth, we cannot conceive science in which science does not become object of science, that is to say does not reflect itself: science — and thereby reflect on its own limits, its environment, its praxis.



Henceforth we must state in scientific terms this principle which one could believe to be simply “philosophical:” *it is never in setting the knower [Fr. le connaissant] aside that one goes towards complex knowledge [Fr. connaissance]*. Knowledge thus becomes necessarily communication, a loop, between knowledge (of a phenomenon, of an object) and knowledge of that knowledge. It is from the idea of loop and of meta-system that we would have to conceive a knowledge which would produce concurrently its self-knowledge.

This mode of knowing, of thinking, which perhaps will be highlighted by the nascent principle of complexity, will necessarily be a new mode of acting. We have already seen this, but let us never forget it: *Knowledge [Fr. savoir] transforms, and it transforms us*; it is always an informational/negentropic praxis, *ergo* an anthropo-social praxis. Whence the principle which will be fully developed in v.III: *it is not outside of praxis that a new knowledge [Fr. savoir] will be constituted, but by a meta-praxis which will still be a praxis*.

Complex knowledge [Fr. *connaissance*] cannot be operational like classical science. But the operability of classical science is in fact an operability of manipulation. From the seventeenth century to our day, a praxic loop has been constituted in which experimental verification is as much at the service of manipulation as manipulation is at the service of verification:



Manipulation, now become technique, becomes more and more autonom-

ous in regard to science, more and more dependent in regard to social Apparatuses. Thus, a veritable suction of finality takes place on behalf of manipulation. Now, and I would like the reader to begin to suspect this, the paradigm of simplification opens the door to all manipulations. I am henceforth convinced that all knowledge [Fr. *connaissance*] which simplifies is mutilated and mutilates, and is expressed by a manipulation, repression, devastation of the real as soon as it is transformed into action, and singularly into political action. *Thought which simplifies has become the barbarity of science. It is the specific barbarity of our civilization. It is the barbarity which today joins forces with all the historical and mythological forms of barbarity.*

Let us say forthwith that a complex science will never have to validate itself by the power of manipulation that it procures; on the contrary. But if it does not lead to manipulative actions, it does lead necessarily to action. Now, in enriching and changing the meaning of the word to know [Fr. *connaître*], complexity calls upon us to enrich and change the meaning of the word action, which in science as in politics, and tragically when it wants to be liberation, always becomes ultimately manipulation and enslavement. We can foresee that a science which brings about possibilities of self-knowledge, which opens up on cosmic solidarity, which does not disintegrate the face of beings and of existents, which recognizes the mystery in all things, could propose a principle of action which does not order but organizes, does not manipulate but communicates, does not direct but animates.

END OF VOLUME 1

NOTES

Notes to pp.xiii- xlv

1. The Science of Man can be briefly defined as the study of what it means to be human. Eric Xavier Ryan, founder of the Science of Man Honors Program at Marist College (1973-1990), saw four basic modes of human consciousness: the philosophical, the scientific, the religious, and the mythopoeic.

2. J.B. Fages, *Comprendre Edgar Morin* (Toulouse: Privat, 1980. 241pp.), gave a thorough study of Morin's life and thought up to 1979. We will concentrate herein on Morin's masterwork, *La Méthode*, of which three out of five projected volumes have been published. *La Méthode* was first sketched out in *Le Paradigme perdu: la nature humaine*. There has also just appeared (May 1990) *Arguments pour une méthode (Autour d'Edgar Morin)*, (Paris: Editions du Seuil, 272pp.), a collection of papers presented at the 1989 Colloque de Cérisy, a week-long assesment of Morin's thought by scholars from a variety of disciplines.

3. Edgar Morin, *Le Cinéma ou l'Homme imaginaire: Essai d'anthropologie sociologique*. Paris: Les Editions de Minuit, 1956. n.ed. 1978. 250pp. *Les Stars*, Paris: Le Seuil, 1957. n.ed. 1972, 1984. 243pp.

4. Edgar Morin and Massimo Piatelli-Palmarini (eds.), *L'Unité de l'homme*, Paris: Editions du Seuil, 3v., 1974. n.ed. 1978.

5. Morin's original family name was Nahoum, and he recently published a biography of his father entitled *Vidal et les Siens*, Paris: Editions du Seuil, 1989. 372pp.

6. Edgar Morin, *L'An zéro de l'Allemagne*, Paris: La Cité Universelle, 1946. 260pp.

7. Edgar Morin, *L'Homme et la Mort*, Paris: Editions du Seuil, 1951. n.ed. 1977. 376pp.

8. Edgar Morin, *Commune en France: la métamorphose de Plodemet* (actually Plozevet in Sud-Finistère), Paris: Fayard, 1967. n.ed. 1984. 288pp.

9. Edgar Morin, *Sociologie*, Paris: Fayard, 1984. 466pp.

10. Pierre Teilhard de Chardin, SJ, *Le Phénomène humain*, p.44. Paris: Editions du Seuil, 1955. Collection Points No.6. 318pp. Cf. also *The Phenomenon of Man*, p.56. New York: The Philosophical Press, 1957. 320pp. All further references are to this English edition.

11. Edgar Morin, *Introduction à une politique de l'homme*, Paris: Editions du Seuil, 1973. n.ed. 1979. 125pp.

12. Edgar Morin (with the collaboration of Claude Lefort and Cornélius Castoriadis), *Mai 68: la brèche*, Paris: Fayard, 1968.

13. Edgar Morin, *Le Paradigme perdu: la nature humaine*. Paris: Editions du

Seuil, 1973. 249pp. This essay is herein referenced simply as PP. Quotations are my own translations. It was the discovery of this essay that first attracted my attention to Morin, since a colleague, Eric Xavier Ryan, had founded at Marist College an Honors Program called the Science of Man, whose goal it was to recover the essence of what it meant to be human; Ryan also believed that the paradigm of human nature has been lost.

14. Edgar Morin, *La Nature de la Nature*, p.10. See Note 30.

15. His books are profusely annotated, and he has also recently published an essay entitled, "Les Livres essentiels d'Edgar Morin le Sociologue, Première Partie: Voyez les ruses de la raison." *Le Temps stratégique*, Automne 1988, pp.113-122. Deuxième partie: "J'ai été très peu adulte." Hiver 88-89, pp.105-116.

16. In this Introduction whatever is in Morin is clearly referenced as such; what is not referenced is my own added commentary and critique.

17. Norbert Wiener, *Cybernetics: Control and Communication in the Animal and the Machine*. New York: John Wiley, 1948. This was followed by *The Human Use of Human Beings: Cybernetics and Society*. New York: Avon Books, 1950. 288pp.

18. Claude E. Shannon and Warren Weaver, *The Mathematical Theory of Communication*, Urbana: University of Illinois Press, 1949. 125pp.

19. Actually, the goal—or *telos*—of life for Morin is Love, which alone, in ever-increasing complexity, namely, ever-increasing interdependence, can maintain the social system. See VV 393. This view links up with Teilhard's for those who, like John the Apostle, believe that God is Love. (1Jn 4:8,16)

20. No doubt Morin has been strongly influenced by his biological studies. François Jacob (b.1920), in his magisterial study of heredity, *La Logique du vivant*, also stresses this major tenet of general systems: the more complex the system, the looser the constraints must be (pp.207,343). (Paris: Gallimard, 1970. 354pp.)

21. The title of one of his books borrows from the well-known statement of Rabelais, "Science sans conscience n'est que ruine de l'âme:" *Science avec conscience*, Paris: Fayard, 1982. 328pp. In a few obvious cases I have translated the French conscience as consciousness/conscience.

22. This is one of the constants in Teilhard's thought as well: proliferation and complexification are the necessary prerequisites for advancement in hominization. (Teilhard de Chardin, pp.48, 49, 61, 72, 87, 106, 107...) François Jacob affirms the same: "Evolution is seen first of all in an increase of complexity." (Jacob, p.332)

23. Here Morin may be echoing Jacob, who wrote: "It is possible, in one sense, to see in the transmission of a culture across generations a sort of second genetic system superimposed on heredity" (p.342). And further: "Now, it is no longer natural selection which plays the first role in the transformations of man, at least in certain societies. It is culture..." (p.343). Before Jacob, the Japanese scholar Magoroh Maruyama had suggested "that 'cultural selection,' rather than natural selection is the mechanism of human evolution since much of man's environment is man-made." ("The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes," p.169. In *American Scientist*, 51:164-179) I am grateful to my colleague Peter Amato for this last reference.

24. I would add, still further, that there is also spiritual energy, namely love, and that this is the only truly inexhaustible source of energy, the only energy which is everlasting, as says St. Paul (1Cor 13:8). Since Love is God (cf. 1Jn 4:8,16), we're back to Teilhard's cosmogony. (See Note 19.) Unfortunately but understandably, many contemporary atheistic scientists and thinkers like Edgar Morin, François Jacob, Jean Rostand, Jacques Monod, work off the outdated but tenacious theological concept of God as Law rather than God as Love, a warped and flawed concept still propounded by some hierarchies. Simone Weil's incisive critique of Judeo-Christianity is still too little known! (*Lettre à un religieux*, Paris: Gallimard, 1951. 96pp.) Weil insists on the primacy of Love over Truth. (Cf. especially pp.42-47, 65) Love leads to harmony, Truth leads to killing. Morin affirms that Love, not Truth, is the core, the *telos*, of Life.

25. Teilhard de Chardin, pp.180-184, 225f, 270-278, 286-290. According to the *Oxford English Dictionary*, the word "noological" was first used by Jeremy Bentham (1748-1832) in 1816 to mean the opposite of physical. Le Robert informs us that the first use in French was by Ampère in 1834 to mean the opposite of cosmological.

26. Cf. especially Hans Georg Gadamer, *Truth and Method*, New York: Crossroad, 1982. 551pp. Tr. from the second (1965) German edition. Gadamer's thesis is the subjective character of all truth.

27. Bernard Lonergan, *Method in Theology*, p.4. Minneapolis: The Winston Press, Inc., 1979. 405pp.

28. Lonergan, *Method*, p.6.

29. Lonergan, *Method*, p.6.

30. Edgar Morin, *La Nature de la Nature*, Paris: Le Seuil, 1977. Collection Points, No. 123. 410pp. Herein noted as NN, with page references to the original French. Translations are my own.

31. James Gleick, *Chaos: Making a New Science*, New York: Penguin Books, 1987. 352pp.

32. Michel LeGuern (ed.), *Pensées*, Paris: Gallimard, 2v., 1977. Collection Folio Nos.936 and 937.

33. Ludwig von Bertalanffy, *General System Theory*, New York: George Braziller, rev.ed. 1968. 295pp.

34. Teilhard de Chardin, pp.108, 110, 141, 225.

35. John Henry Newman, *The Idea of a University*, pp.162f. San Francisco: Rinehart Press, 1960. Introduction and Notes by Martin J. Svaglic. 428pp.

36. Georg Lukacs, *History and Class Consciousness*, p.83. Tr. Rodney Livingstone. Cambridge, MA: The MIT Press, 1971. 356pp.

37. Cf. note 24.

38. Cf. Teilhard de Chardin, especially the great page 263; also pp.172f, 257-264, 265f, 284.

39. The word "event" means a happening at a given time and place which sets off a process of thinking, acting, and understanding. Note that acting precedes understanding. In discussing application, Gadamer writes, "Understanding proves to be a kind of effect and knows itself as such." (p.305) Interestingly, Erwin Schrödinger

suggests the synonymy of process, event, and happening. (P.72. *What Is Life? The Physical Aspect of the Living Cell*. New York: The Macmillan Company, 1945. 91pp.) The Gadamer Index as well melds event and process. (p.544)

40. Both works relate a murder from the points of view of several characters, each differing widely, of course, from the other in describing the "exact" events.

41. See Walter Sullivan, "Physicists Now Confront Possibility That Natural Action Is Ever Complex," *New York Times*, 4/28/76, p.44, c.3.

42. Gadamer, p.274.

43. Paul Claudel, *Cinq Grandes Odes*, p.233, in *Oeuvre poétique*, Paris: Gallimard (Editions de la Pléiade), 1957. Translation my own.

44. Edgar Morin, *La Vie de la Vie*. Paris: Editions du Seuil, 1980. Collection Points, No.175. 482pp. Noted herein as VV. Translations are my own.

45. Erwin Schrödinger, *What Is Life? The Physical Aspect of the Living Cell*. New York: The Macmillan Company, 1945. 91pp. He writes: "Thus the device by which an organism maintains itself stationary at a fairly high level of orderliness (=fairly low level of entropy) really consists in continually sucking orderliness from its environment." (p.75)

46. Schrödinger, p.75.

47. Claudel, *Art poétique*, p.143, in *Oeuvre poétique*. Translation my own.

48. In his insistence on the physical and biological essence of Self and Subject, his *computo* v. Descartes' *cogito*, Morin appears to be breaking new ground in modern philosophy. Actually, such a belief, viz., the unity of the material and the spiritual, has been the focus of much thinking. In a 1948 essay entitled "Materialism and Spiritualism," ("Matérialisme et Spiritualisme," pp.25-30, in *La Théologie de la matière*. Paris: Editions du Cerf, 1968. 152pp. Collection Foi Vivante, No.59. Translations are my own), the eminent Dominican theologian Marie-Dominique Chenu (1895-1990) had written that "spirit comes to existence only in matter" (p.26). He talks of "two stages, then, that of the spirit as such, free and pure, the *noûs*, that of the spirit tied to matter and its psychic determinisms, the *psuche*, and beyond, for the Christian, the spirit united to the Spirit of God, the *pneuma*" (p.27). This stance against the duality of matter and spirit, Chenu maintains, has us return to "the full sense and unity of Creation, first economy in which matter does not form a schism with spirit, but enters into its destiny, precisely through man, in whom matter and spirit form one being" (p.27). Chenu concludes with the notion of "evolution of matter towards spirit, involution of spirit towards matter" (p.28).

In a subsequent essay, "The Spirituality of Matter," ("Spiritualité de la matière," pp.15-23, in *La Théologie de la matière*. Translations are my own), published fourteen years later in 1962, Chenu reflects on the doctoral work of Claude Tresmontant on the problem of the *individuation of man through matter* (p.16). Such a thesis, "that man is individualized through matter" (p.17), Chenu informs us, is found already in Aquinas: "For Saint Thomas, in fact, matter *enters into* the internal composition of the human being, to the point of being consubstantial with it, in its very personality, although the spirit is, as such, subject of being, and therefore subsistent, beyond its

relation to matter. The body is clearly at the source of the individuation of the soul, but it does not command its completion" (p.19). (Morin, of course, would not accept "substantiated beyond its relation to matter.") Like Morin, Chenu even says that such thinking leads us to "an exact—and how necessary, today—intelligence of the solidarity which man as corporal being contracts with the cosmos" (p.22), thereby embracing Morin's concept of the *oikos* in its fullest sense. Chenu concludes: "Thus reintegrated in *human nature*, and even into the very *person* of human beings, matter takes on a dignity which we have dared to call a 'spirituality.' The presence of the Christian in the new scientific and technic civilization will come about only in this contemplation of Creation and in this Christian sense of human being" (p.23). Note Chenu's inclusion of the impact of modern science and technology, inescapable today in any serious study of philosophy and theology. This Morin subscribes to fully.

We know, also, that Teilhard de Chardin's entire thesis rests squarely on the belief of matter hypostatized to spirit. The latter he calls in French *conscience*, that is to say, the "within, consciousness and then spontaneity—three expressions for the same thing." (Teilhard, p.57)

Finally, there is a group today called spiritualist or neo-Gnostic physicists and astronomers who also hold the belief that matter and spirit are integrally bonded. Raymond Ruyer names Gustav Stromberg, W.F. Weiskopf, E.T. Whittaker, C.F. von Weizsäcker, G.J. Whitrow, D.W. Sciama, David Bohm, I.J. Good, Fred Hoyle, V.A. Firsoff, and Nobelist R.P. Feynmann. (Raymond Ruyer, *La Gnose de Princeton*, pp. 417f. Ed. revue et augmentée. Paris: Fayard, 1977. 447pp.) The most prominent French representative is Jean Charon, who has expressed his views especially in *L'Esprit, cet inconnu*. Charon locates Life precisely in the electron. (Jean E. Charon, *L'Esprit, cet inconnu*, pp.79-95, esp. p.86. Paris: Marabout, 1977. 255pp. The title is evidently inspired by Alexis Carrel's famous *L'Homme, cet inconnu*. Charon quotes Carrel and Teilhard de Chardin in exordium.) Though this 'spiritualist' movement began among physicists and astronomers, psychologists and especially biologists have today taken the lead. After the classic works of J.C. Eccles and J.B.S. Haldane, we have, among others, J. Marquand, W.M. Elsasser, W.S. Beck, B.L. Whorf, and Eric Berne. (Ruyer, pp.419f.) The French biologist Joël de Rosnay of the Paris Pasteur Institute focuses in on the ATP (adenosine triphosphate) molecule, "the universal combustible of life." (Joël de Rosnay, *Les Origines de la vie*, p.51. Paris: Editions du Seuil, 1966. Collection Sciences No.510. 190pp.)

In his *Chance and Necessity* Jacques Monod rails vehemently against such spiritualist or vitalist thought in science, labelling it unacceptable poetry and dreams. (Monod, *Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology*. Cf. entire Chapter 2, esp. pp.23-44. Tr. from the French by Austryn Wainhouse. New York: Alfred A. Knopf, 1971. 199pp.) He even chides the great Niels Bohr, though compelled to admit that it was vitalism that led to breakthroughs in relativity and quantum physics. The French Nobelist ascribes vitalism to an "anthropocentric attitude" (pp.40f) which calls for Man to be the crowning achievement of evolution and thus escape contingency (p.44). Another great scientist

has also grappled with this "anthropic" attitude. Theoretical physicist Stephen W. Hawking (*A Brief History of Time*, New York: Bantam Books, 1988. 198pp.) defines this attitude thus: "We see the universe the way it is because we exist." (p.124) What is needed, I believe, is a dose of DeGaulle realism: What is, is. Man is evidently the center of our universe, whether this was intended or not. No need for any "what if." Monod notes that this anthropocentric attitude is inherent to Marxism. (pp.34f) Morin does admit to a strong Marxist influence in his thinking ("Les Livres essentielles d'Edgar Morin le Sociologue, Première Partie: Voyez les Ruses de la Raison," p.121) and on these two points differs from his Nobel prize friend. Monod notwithstanding, dozens of very reputable scientists today flirt with or fully embrace spiritualist theory, as we noted just above.

All this circumambient or precursive thought does not detract, I believe, from Edgar Morin's own status. For he alone in our day has framed and expressed his worldview in a brilliant synthesis boldly and poetically couched. We recall what we said at the outset, that Morin's greatness resides in his vision of the Whole, rather than in the originality of any one part.

49. This statement intuitively sees the same source of knowledge as Paul Claudel did in 1904. In the second part of his seminal *Art poétique*, "Traité de la Co-naissance au monde et à soi-même," Claudel wrote, "Nous faisons partie d'un ensemble homogène, et comme nous co-naissons à toute la nature c'est ainsi que nous la connaissons." (*Art poétique*, p.153, in *Oeuvre poétique*.) Roughly translated, which is all anybody can ever do with Claudel's etymological plays on language: "We are part of a homogeneous whole, and since we are co-born with all of nature it is thus that we know it." Gilbert Durand also plays on this "co-naissance" theme. (*L'Imagination symbolique*, p.22. Paris: Presses Universitaires de France, 3e éd., 1976. 133pp.)

50. In natural selection Matter determines action; in intentional selection Spirit chooses action. We should now add "cultural selection" (cf. Note 23), in which culture would determine action. The shift from Darwinian natural selection to Lamarckian intentional selection takes place, Teilhard de Chardin notes, "in very big complexes (above all, man)." Before Man, chance dominates; with Man, "anti-chance can be seen to dominate.... It is only through strokes of chance that life proceeds, but strokes of chance which are recognized —and grasped that is to say, psychically selected." (Teilhard, p.149n1)

51. Maurice Blondel, p.423 (468 original). *L'Action: Essay on a Critique of Life and a Science of Practice*. Tr. Oliva Blanchette. Notre Dame, IN: U. of Notre Dame Press, 1984. 446pp. For another pertinent passage I prefer the translation in Jean Lacroix, pp.115f: "After we have acted, we are different, we know differently, we will differently from the way we did before." (*Maurice Blondel: An Introduction to the Man and His Philosophy*. Tr. John C. Guinness. New York: Sheed and Ward, 1968/1963. 158pp.)

52. Bernard J.F. Lonergan, SJ, *Insight: A Study of Human Understanding*, p.613. Cf. also p.615. New York: Harper & Row, Publishers, 1958. 785pp.

53. Lonergan, *Insight*, p.667.

54. Alfred Jarry (1873-1907), *Ubu Roi*. Pp.29-131 in *Tout Ubu*. Ed. Maurice Saillet. Paris: Librairie Générale Française, 1962. 502pp. Livre de Poche Nos.838/839.

55. Karel Capek (1890-1938), R.U.R. pp.419-447, in *Twentieth Century Plays: British, American, Continental*, ed. Richard A. Cordell, 3rd edition, New York: The Ronald Press Company, 1947. 447pp.

56. Charles Chaplin (1889-1978), *Modern Times*, 1936.

57. Teilhard uses the term "groping" and defines it as "directed chance," (p.110) and Lonergan writes that "Knowledge comes by the apparently random process of discovery." (*Insight*, p.689)

58. Edgar Morin, *La Méthode*, v.3: *La Connaissance de la Connaissance*, Livre Premier, *L'Anthropologie de la Connaissance*, Paris: Editions du Seuil, 1986. 251pp. Herein referred to as AC. Translations are my own.

59. Morris Kline, *Mathematics: The Loss of Certainty*, pp.263f. New York: Oxford University Press, 1980. 366pp.

60. In *Chance and Necessity*, published back in 1970, Jacques Monod was ambivalent about cellular "cognitive" ability. He put the word in quotation marks several times (pp.46,59,88), and at other times he used the expression "discriminative" ability (pp.46,51,52,59,88), with or without "cognitive," but he does once write unambiguously about "a protein's cognitive function" (p.91). As we have seen, Morin holds that all cells compute and must compute to live.

61. Morin agrees here with Monod who recorded that the biological maturing of the brain stops with puberty. (Monod, p.135)

62. Monod, p.135.

63. Jacob Bronowski, "Knowledge or Certainty?", pp.353-374, in *The Ascent of Man*, Boston: Little, Brown and Company, 1973. 448pp. Bronowski underscores Heisenberg's principle of uncertainty.

64. By language Morin seems to mean only "verbal" and not "non-verbal;" however, he does not broach this distinction. His habitual linking of consciousness to cogitation, with implied neglect of the non-verbal, should be frontally broached in the future.

65. "Comprehension...apprehends...by analogy." In fact, the best United States test of human intelligence is precisely the Miller Analogies Test, an inexpensive half-hour test of one's ability to recognize patterns. (No.1436, p.241, in *Tests in Print III*, ed. James V. Mitchell, Jr. Lincoln, NE: U. of Nebraska Press, 1983. 714pp.) But Morin does not develop his conception of analogy to any extent; he merely notes that the poetic sphere is "where analogies live in liberty." [AC 143] The litterateur thinks immediately of Baudelaire's "correspondences," ("Correspondances," p.87, in *Baudelaire: Oeuvres complètes*, ed. Y.-G. Le Dantec. Paris: Gallimard, Bibliothèque de la Pléiade, 1954. 1575pp.) The idea of universal analogies is very old. Hippocrates (466-377 B.C.) in his *De Alimento* talks about "sympatheia ton holon." Philo the Jew (c.20 B.C.-54 A.D.) synthesizes theism and pantheism. Plotinus (204-270 A.D.) considers the world as a manifestation of God; it is said that his last words were, "What is divine in me is leaving to be united with what is divine in the universe." The

natural philosophers of the Middle Ages believed in hylomorphism, and Pico della Mirandola (1463-1494) also believed in universal analogies. The doctrine is clearly anti-dualist, is clearly "animist."

66. David Tracy, *The Analogical Imagination*, p.408. New York: Crossroad, 1981. 467pp.

67. Lonergan, *Insight*, pp.613,615.

68. Like Camus twice at the door of early death, Morin knows that the greatest consciousness is the consciousness of death. "To philosophize is to learn to die." (Michel Eyquem de Montaigne, p.127, in *Essais: Livre 1*, ed. Alexandre Micha, Paris:

Notes to pp.3 - 22

1. I have already stated them (Morin, 1973, pp.11-14).

2. All indication between parentheses of an author's name, followed by a date, refers to the work listed in the bibliography at the end of this volume, in alphabetical order, with mention of the date of the edition to which the note refers. The original edition is indicated only when it is necessary to underline the innovative or historical character of the ideas included in the work cited.

3. "The mind, not attentive to itself, imagines and thinks that it can conceive effectively existing bodies non-thought or out of mind, although at the same time they are grasped and exist in him." (Berkeley, *Principles of Human Knowledge*, Section 23).

4. I go further. Can one so easily disjoint one's science from one's life? Can one consider himself at one time (scientifically) as a determined object and at another time (existentially, ethically) as a sovereign subject? Can one skip several times per day from the objective religion founded on determinism to a humanistic religion of the Self, of conscience, of responsibility, then, if necessary, to official Religion where the World finds a creator and man, a father and savior? Can one be satisfied with passing from "serious" science to some miserable philosophical rationalizations, then to political hysteria, and from there to a private pulsional life?

5. In so far as the method of Descartes is disjunctive, thus far the irrefutable evidence of the cogito constitutes the transformation of the apparently vicious circle into productive circularity. The "vicious" circle is the I think that where thought turns

in circles by reflecting itself *ad infinitum*. Now, in fact, reclosing the circle, instead of locking thought up in a vacuum, causes the self-reference to rise up clearly, that is to say, the being-subject or *Ego*: I. And by that very fact the *cogito* is

transformed into irrefutable affirmation of existence: I

am

Notes to pp.23 - 90

1. Here are concentrated, under the aegis and the control of the concept of order, the notions of determinism, law, necessity, which are its derivatives or applications. The rest of my work will allow me to justify this primary assertion.

2. Carnot had shown that, in order to obtain work from heat, two sources of heat were needed, different in temperature, so that a fraction of the heat drawn from the hot source could be transformed into work. As soon as there is no more calorific heterogeneity and thermic disequilibrium, there are no more exchanges or transformations conceivable.

3. Boltzmann defines the entropy of a system (macroscopic variable) by the number of microscopic complexions or configurations which the atoms or molecules can take therein, according to the formula:

$$\begin{array}{ccccc} S & = & K & & \log P \\ \text{Total entropy} & & \text{Boltzmann's} & & \text{Thermodynamic} \\ \text{of the system} & & \text{constant} & & \text{probability} \end{array}$$

4. Maxwell introduces a little demon, gifted with very fine senses, into a gas container separated into two parts, A and B, which can communicate by the opening of a valve, and where there is thermic equilibrium, that is to say, maximum entropy. The demon surveys the movement of the molecules haphazardly agitating. As soon as a fast molecule from A heads towards B, the demon opens the valve and the molecule passes into B. As soon as a slow molecule in B heads towards A, the demon again opens the valve. Thus, in time, part B, filled with the fastest molecules, became hot, part A became cold. There is disequilibrium and heterogeneity; work is possible. Thus, the second law has turned around, without the system's acquiring or spending energy, without its physical nature being modified. Evidently we can escape the probability of the second law only with a very improbable being: a demon.

5. In *Creative Evolution*, 1907.

6. As Victorri wrote me (manuscript notes): "The idea of non-eternal physical laws permits returning to the problem of the origins of the universe: we cannot perhaps explain it because any present explanation appeals to the present laws of physics which were not then yet born."

7. Which it would be anthropomorphic and logocratic to call God.

8. Nuclear physics can conceive the synthesis of the first nuclei and light chemical elements (helium, hydrogen) only in states of very hot and dense formation, therefore in the first moments of the cloud.

9. The physicists' notion of *self-field* and renormalization.

10. Manuscript note of Victorri: "...in the field analysis, it matters little if we have History launched by the hypothetical ball of fire or take off from already constituted galaxies; what is important is to show the *replicating* character of the tetralogue: the first constraints associated with the first disorders create the first organizations by the

first interactions, which in turn create new disorders and new constraints which in their turn, etc. This process of replication in the tetralogue, to function, requires, like the process of replication in living beings, death as well as life..."

11. Let us note finally that physicists (d'Espagnat, 1972) have envisaged the particle as a peduncular, penisular (or rather, insular in the same sense that the island communicates sub-marinely with the continental base) aspect of an inseparable reality. In this hypothesis, the universe remains a unique entity all of whose parts communicate immediately with each other, that is to say that "effects are proposed therein at an infinite speed and without being lessened by the distance." (d'Espagnat, 1972, p.118) This hypothesis would give us a new face of the relation chaos/*physis*/cosmos: on the one hand we would have a physical infra-temporal and infra-spatial unit-trunk, on the other hand a cosmos all of whose elements are burst into particles and dispersed in space and time, and these two contradictory universes would be the *same*.

12. For the definition and discussion of this notion of machine, cf. the second part of this volume.

13. The idea of cosmic death triggers the refusal of death, which, inventive, surmounts it in various ways. Lupasco supposes that we must couple our universe of increasing entropy to an anti-universe of decreasing entropy (Lupasco. 1962); Charon (Charon, 1974) supposes a law of conservation of entropy: we could also dream that a metabolic evolution should give birth to some Maxwellian archangels, who would fell the demon of entropy by their art of sorting molecules.

14. Will we find ruses to plumb the pre-origin? Is there one anti-universe or are there several? Is our universe only one bunch among bunches of universes? Is there a retroaction of the whole as whole upon the crumbled parts of the diaspora? Is there an immediate link in the One beyond time and space? Are there unknown interactions and communications? Is energy the first material reality or the ultimate substantial concept?

15. Thus, forms, with time, lose their contours, become corroded, spongy; they separate, come apart, but new forms are born, develop, spread. Living beings fall back finally into dust, but life continues its ascending march. Perfumes evaporate and do not regain their vapors (law of dispersion and displacement), but perfume-makers invent new perfumes, which (etc). Scrambled eggs unscramble themselves no more, but hens lay new eggs which (etc.). Thus, dispersion goes on at the same time as the wheel reconstructs, concentrates, organizes...

16. This hypothesis will be examined later (v.2).

17. I have introduced, for this second edition, the two neo-notions of *chaosmos* and *Pluriverse*, which simultaneously crystallize and complete the idea of complexity in *physis* and in the cosmos. (Olsson, 1977, and T. Schneider, 1976, "Univers et Plurivers," *Ark All*, 2, pp.57-61. In the bibliography of *La Méthode*, v.2)

18. "The universe is the game of a child throwing dice..."

Notes to pp.91 - 150

1. I understand by classical science the science which, founding its principle of explanation on order and simplification, reigned until the beginning of the 20th century, and which finds itself today in crisis.

2. As we saw in the preceding chapter, p.34f.

3. And if it is something other than waves and particle, as Bunge claims (Bunge, 1975), it is still nonreducible to the classical concept of object.

4. The "systemic" tradition in sociology, from Comte and Pareto to Parsons, does attempt to explain what a social system is, but not how it belongs to the family of systems.

5. Galileo, in his *Dialogo dei massimi sistemi*, does not give a word of explanation on what he means by system.

6. The term element, here, does not return to the idea of simple and substantial unity, but is relative to the whole to which it belongs. Thus, the "elements" of systems we are going to speak of (molecules, cells, etc.) are themselves systems (which become thenceforth subsystems), and/or events, and/or individuals (complex beings endowed with a strong organizing autonomy). A complex whole, like the human being, can appear as element/event of a social system and of a system of biological reproduction.

7. An aggregate has a non-relational diversity, and therefore does not constitute a system. It may be that exterior conditions impose a certain unity. Thus, we speak of a closed system for a hermetic receptacle enclosing a gas. But this gas, a population of molecules moving and striking each other by chance without establishing interrelations, does not constitute a system: it is *in* a system: the receptacle. In a system, the interrelations between elements/happenings or individuals are constitutive of totality, and by that, constitute the organization of the system.

8. The apposition, at the same time synonymous and complementary, between the terms organization and system, in the works of François Jacob, indicates that the two terms constitute two faces of the same phenomenon, doubling each other without being redundant.

9. The interrelations or bonds can go from association (union of elements or individuals which strongly preserve their individuality) to combination (which implies a more intimate and more transformable relation between elements and determines a more unified set). The unions can be assured:

- by fixed and rigid dependences,
- by active interrelations or organizational interactions,
- by regulatory retroactions,
- by informational communications.

10. Ashby brought to our attention that as soon as a relation, between for example A and B, becomes conditional to a value or a state C, an organizational component is present. (Ashby, 1962)

11. It seems established that the sequences of the DNA of the chimpanzee and those of *homo sapiens* differ much more by the arrangement of large units than by the

alignment of details.

12. *Gestalt* has insisted on the action of *field* which commands the formation of non-additive totalities: the whole is different from the sum of the parts, it constitutes its own form, which imposes itself in each state or modification of the parts. *Gestalt*, notably with Kohler, has clearly seen the physical character of the globalitary phenomenon—whereas many systematists create a purely formal concept of the system; but it has not developed the organizational/systemic character of the global form or *Gestalt*.

13. The properties of hydrogen and oxygen (atomic weight, position in Mendeleev's table) seemed to have to make H_2O a gaseous compound (in H_2S , which stays gaseous at ordinary temperatures, the atom S is heavier than the atom O.)

14. As Lupasco excellently puts it: "For a system to be formed and exist, it is necessary that the components of every group, by their nature or by the laws which govern them, be susceptible of coming together as well as of excluding each other, attracting as well as repelling each other, associating and dissociating, integrating and disintegrating." (S. Lupasco, 1962, p.32)

15. On the notion of crisis, cf. Béjin (1976), Morin (1976).

16. We owe to Bertalanffy in particular and to General Systems Theory in general for having given pertinence and universality to the notion of system as a whole not reducible to the parts, for having broached in fact certain organizational problems by means of the notions of hierarchy, for having formulated the notion of open system. I will come soon to the idea in my opinion extraordinarily fruitful of opening (on condition that it not block out the idea of closing) and I will examine in volume II the organizational problem of hierarchy. Yet, *General System Theory* has not explored theoretically the concept of system, beyond a few "holistic" truths schematically opposed to reductionism; it has marked time in a taxonomy barely heuristic. The idea of complex unity and the idea of organization remain embryonic. The interesting idea of *holon* has emerged alongside systems theory. (Koestler, 1968)

17. Pascal, *Pensées*, ed. Brunschvicg, II, 72.

18. Let us recall: linkings can be assured by:

- fixed and rigid dependences,
- reciprocal interactions,
- constitutions of elements common to two associated systems (becoming sub-systems of the constituted system),
- regulating retroactions,
- informational communications.

19. The questions of structure and structuralism will be treated head-on at their theoretical and epistemological level in volume III.

20. "Is system what man-system and engineer-system have decided would be a system." (Barel, 1976)

Notes to pp.151 - 178

1. Whose definition I recall: reciprocal actions modifying the behavior or the nature of the actors.

2. Thus, the production of carbon atoms at the heart of a star is effected in an extremely improbable way, and we could consider it only as the result of chance encounters if there were no organization in the star which ceaselessly provokes collisions between helium nuclei, as I have shown in Chapter I of Part I. (p.49 - 51)

3. We will see further on that it is not without reason that I extrapolate the Chomskyan pair, competence/performance, from linguistics to the theory of productive organization or machine. (cf. p.166 - 168)

4. The only machines which produce exclusively destruction are war machines, themselves produced in and by our historical societies. Whereas in nature death and destruction come in a disorderly and irregular way, death machines organize annihilation on demand and systematically.

5. Therefore, it would be wrong to define the machine (on the model of artifacts) as a mechanical organization devoted to production. It is an active organization whose complexity is productive.

6. Reading the book of D  tienne and Vernant on the *metis* of the Greeks, *Les Ruses de L'Intelligence* (M. D  tienne and J.P. Vernant, 1974), shows that *metis*, the intelligence of the *sistemare* and of the *combinazione* which proceeds by the assemblage and alloy of the diverse and the opposite, was conceived by Hesiodic Theogony and Orphic tradition as "the great primordial Divinity, which, emerging from the cosmic egg, carries in itself the seed of all the gods, the germ of all things, and...brings to light, as first generator, the entire universe in its successive course and the diversity of its forms." (p.128) We have seen here that, from the union and combination between the two inimical retroactions, a primordial Metis is born, the praxic organization of the sun.

7. The earth itself can be considered a complex machine/motor which transforms itself by transforming its components, works itself by working on several concentric levels, from its core in fusion to the surface where the conjunction of the movements of the substratum, the oceans, the winds, variations in temperatures, etc., determines transforming/producing activities of every order; and, in this sense, the constitution of macro-molecules of nucleic acids and proteins, then the birth of life, then the unfolding diversification, eco-organization of this life are in some way by-products of the praxic activities of the *round machine*.

Notes to pp.179 - 233

1. Eddies are constituted in the current of rivers starting with a solid and fixed element which, playing a circuit-breaker role, provokes by repression a counter-flux of inverse direction, which combines with the flux in such a way as to create and maintain the rotative loop.

2. At the center of the sun, the core, where thermonuclear reactions take place, around which the photosphere is constituted of incandescent vortices equivalent to thousands of hydrogen bombs, then the chromosphere, and finally the crown.

3. Thus, organization, continuously re-equilibrating, re-stabilizing, reacts to the perturbations which arise from the outside (variations in fluxes, forces, pressures) and from the inside (tendencies to dispersion and disintegration), and its reaction is manifested by small fluctuations which both express (deviance) and correct (return to normal) the perturbations undergone.

4. I could limit myself to the thermostat fixed on the boiler itself, which regulates the heating according to the temperature of the water at the start; but including the room, without modifying in the least the nature of the example, makes it more illustrative.

5. We will see amply in Volume II how complex the relation between the generative and the phenomenal is, for, of course, what is phenomenal participates in generativity, what is generative participates in phenomenality. These terms are absolutely confused in the eddy, for instance: according to our perspective, we can see in the spiral circuit either the generative loop itself, or the phenomenal form, or the organizing form, and the three points of view are accurate since they concern three indistinct aspects in the same form.

6. The key problem of Bénard's convection patterns shows that the forms of spontaneous organization which arise in conditions of disequilibrium "are created and maintained thanks to energy exchanges with the exterior world." (Prigogine, 1972, p.553) What Prigogine calls "dissipative structures" can also be named open systems.

7. Pollution and excrement are compensated for by the solar manna, which indefinitely renews the energy necessary to life, and by the extraordinary complexity of the eco-systems, which integrate degradation in regenerative cycles where waste becomes new provision, where the pollutant is transformed into the nutrient. It is only when the enormous anthropo-social machines exceed vital thresholds in exploiting and massacring living beings, in the discharge of industrial residues and non-biodegradable poisons that the disintegrative retroaction of the anthropo-social praxis on the environment will dominate natural reorganizing retroactions.

8. Cf. the symbol  introduced by Varela in the arithmetic of Spencer Brown (Varela, 1975, 1976), and which designates not only the character of self-reference proper to the living, but also (and that is where I radicalize Varela's idea): the *self*.

9. This problem in the logic of identity will be considered biologically in Volume II and logically in Volume III. In any case, it is not yet the place here to examine more fully the relation between identity, that is to say self  $\rightarrow$, generativity (to be

generated by the same), and stationary state (to have constancy in one's being in spite of variations and perturbations.)

10. As indicated by the S curve, all growth, *a fortiori* all growth in positive retroaction, sooner or later finds its moderation and/or correction in energy exhaustion

(its own or that of its environment). Likewise everything which tends to infinity hastens its end, and in its triumph *hubris* knows death.

11. We can dream also of substituting a right angle for a circle, as in the different forms of the cross, including the Nazi swastika. Such a figuration abandons or is unaware of the recursive loop, and privileges the center, post of command, control, power, which radiates across the axes to the four horizons.

12. For there has always been the other current, naturalistic, pantheistic, Romantic.

Note to pp.235 - 256

1. The capitalist enterprise of the industrial era, in enslaving only the work strength and not bothering any longer to appropriate the being of the worker, creates the proletariat. But a number of modern Machine powers are discovering neo-enslaving formulas.

Notes to pp. 257 - 271

1. Living eco-systems furnish us countless examples of productions of quasi-finalities starting with loopings linking independent processes: thus, mutual finalities take shape through the symbioses and parasitisms which bind more and more tightly species becoming interdependent. For example, bees, attracted by the odorous sugars secreted in the hollow of corollas and by the accessibility of anthers, feed on nectar and pollen. The bee does not have as finality the dissemination of pollen, nor the pollen to feed the bee. Besides, countless insects fecundate flowers without seeking pollen, by the simple fact of circulating in the corollas. But, in the course of evolution, the reproduction apparatus of certain floral species with entemophile fecundation has shown itself to be more and more attractive to bees and more and more adequate for their gathering of honey. With much disorder and waste, because the dissemination of pollen is a by-product of the gathering activity of the bee and the stored pollen is lost to dissemination, a mutual finality emerges: bees have become part of the reproduction process of floral species which have become part of the nutritional process of bees. The bee is made for the bee, the flower for the flower, flower and bee are made, henceforth, for each other. Each is the means of the finality of the other, all the while operating for its own end.

Thus, the looping which couples two distinct living processes immediately produces its immanent finality, which is the continuation, reproduction, multiplication of each constituent element of the loop and of the loop itself. Each moment or sequence—the flight of the bee, the gathering, transformation into honey, etc.—becomes both the ends and the means of the global process. But this finality is uncertain, fragile, and in it are combined the uncertainties of circularity, the uncertainties of the "bottom," and the uncertainties of the "top."

2. Equifinality signifies that a system can, according to accidents, difficulties, resistances which it encounters, use different strategies to reach the same goal, and that

several similar systems can reach the same ends by different means.

Notes to pp.273 - 289

1. In the course of a colloquium on the notion of information (*Concept*, 1965) Ferdinand Alquié had challenged Norbet Wiener: "A machine does not feel pain!" Wiener answered: "That is not certain..."

Alquié believes he is opposing an exorbitant pretention of mechanistic philosophy. But his spiritualism expresses the same contempt as scientism for a physical universe made only of matter/energy, and not of existent beings. Wiener in his retort (which one could too easily take for a quip) indicates that if pain is a mysterious emergence unique to an existent endowed with self-reserve [Fr. *quant-à-soi*], then it is not sure that the being of a machine, even an artificial one, cannot feel its own pain in the machines perturbations. It seemed certain to Aristotle that the slave was an animated tool; it was certain to Descartes that animals did not have a soul... Maybe Wiener missed the point, but the sense of his remark is very strong: pain, unlike the soul, is an emergence, unique to machine-beings: we, the living, are among these beings; perhaps there are others, perhaps there will be others born...

2. Production of man by man: man $\longrightarrow$ production
 $\uparrow$ $\longleftarrow$

Notes to pp.295 - 304

1. What we said earlier about artificial machines holds for the problem of negentropy. These machines are negentropic only functionally, if we consider them as isolated physical beings; they are integrally negentropic if we consider them as moments and elements in the anthropro-social production-of-self.

2. Cf. p.33.

3. Terms borrowed here from Boris Ryback, and which I shall return in the next volume. (Ryback, 1973)

4. In French *protéine/entropie*.

Notes to pp.305 - 371

1. This is why we can attempt to understand informational generativity, not so much by assimilation to the execution of a program, but by the processes analogous to those of remembrance, processes wherein, furthermore, a quasi-program with digital aspects is ontogenetically constructed.

2. I do not exclude the possibility of a mnemopraxia for other beings, other lives, as in the beautiful film of Twardowski, *Solaris*.

3. "All modern life rests on the possibility of multiplying information at minimum cost." (Brillouin, 1959, p.154)

4. While information is transformed into "noise" in what we call news, propagandist redundancies eliminate information as noise. They effectively exclude as

parasitical everything which is event, novelty, surprise: nothing ever happens other than the schema foreseen by the doctrine and the confirmation of its own truth.

5. As we shall see in v.II (socio-organization), we must not set up as alternatives the anonymous power of apparatuses (State, party, trust) and the concrete power of individuals or groups occupying posts of power (kings, chiefs, directors). *They are in each other's power*: possessors and masters are the instruments of the anonymous power, which is also their instrument. This recursive relation oscillates between two poles: at one pole, the "caprice" or "the arbitrary" of the one in power manipulating his power; at the other pole, the anonymous power of the Apparatus which "possesses," in a quasi-thaumaturgical sense of the term, the Mandator who incarnates it.

6. And this confirms for us, in consequence, that the best organization is not the perfect organization, purely redundant, if such existed: it is the imperfect organization, which includes its shadows, its deficiencies, its fundamental disorder, but which knows how to live with disorder, how to counter-parasite it, which knows in sum how to be organized in uncertain relation and relativity, far from the absolute.

7. It is in this communicational sense ("self-managing") that the ideas of Laborit are developed, despite their informationist title. (Laborit, 1973)

Notes to pp.373 - 397

1. Lucretius, *On the Nature of the Things of Nature*.

2. The determinist universe was an apparently perfect machine animated by perpetual motion. Now, a perfect machine can be only perfectly imperfect: its poverty is such that it can neither exist nor engender, because, in order to be generated and to generate, chance is needed, always; it can neither transform nor produce, because to transform is to degrade, that is to say to produce imperfection. Perfection is proof of the non-existence of the determinist world and imperfection proof of the existence of a chance world.

3. I can refer the reader who wants to inform himself on my relation to subjectivity to previous essays of self-examination. (*Autocritique*, 1958; *Le Vif du Sujet*, 1969), which does not dispense me from a fresh effort of self-analysis in function of this very work. I do not yet see under what form I will do it, for on the one hand I cannot encumber this work with my subjectivity; on the other hand I insist on not excusing myself personally from the obligation required by its very logic.

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