Organization and Complexity

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The universe, in its diversity, has atoms; molecules; stars; galaxies; and—at least on one small planet—living organisms, humans, and societies. These different entities, which are different from each other and not reducible to each other, have in common the fact that each is made up of organized elements that form a whole. What we perceive as the world around us are these wholes.

The significance of the general notion of organization is not immediately evident. It is not in a search for a common minimum that we need to concentrate our efforts. It is in the manner of perceiving, conceiving, and thinking about the things of our world in an organized way. To obtain a generic, rather than general, concept, it is the idea of organization that we have to delve into.

What is organization? Organization binds elements (particles, atoms, molecules, cells, individuals, etc.) in relationships that thus become components of a whole. In the first definition, organization is a structure of relations between components to produce a whole with qualities unknown to these components outside the structure.

Hence, organization connects parts to each other and parts to the whole. This gives rise to the complex character of the relation between the parts and the whole. Dilthey[1] had already stated, "A whole cannot be understood except by understanding its constituent parts, which cannot be understood except by understanding the whole." Two centuries earlier, Pascal[2] referred to this circular relation, "I consider it impossible to know the parts without knowing the whole, or to know the whole without knowing the parts."

There is a close relation among the concepts of organization, interrelation, and system.[b] These three terms, although inseparable, can be distinguished from each other. The concept of interrelation refers to the types and forms of links between elements and between the elements and the whole. The concept of *system* refers to the complex unit of an interrelated whole, to its characters and properties. The concept of *organization* refers to the structuring of the parts within, with and through a whole. The two notions, organization and system, are linked by that of interrelation: the whole interrelation, if it has stability or regularity, acquires an organized character and produces a system. There is a circular reciprocity between these three terms. When the notion of system disperses the quality of being and existing (to say "living systems" tends to take the emphasis away from living beings and their existential dimension), the notion of organization refers to to something concrete.

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[b]In some cases, the idea of network seems more pertinent than that of system, in the sense that a system tends to have well-defined borders, whereas a network has limits that vary. Both, however, are interconnections of elements of an organized nature. As well, a network can become a system by closing on itself (Internet) or by acquiring an organizing center (the railways). For me, the primordial and common character is organization.

In any case, we need a concept in three, three concepts in one, a macro-concept, each constituting a definable aspect of the same world, but that we subject to the hegemony of the idea of organization.

Organization is a notion that is dependent and at the same time independent of its constituents. The relative autonomy of the ideal of organization is illustrated by isomers, compounds with the same chemical formula and molecular weight but with different properties only because the atoms are arranged differently in the molecule. We know that differences between atoms are the result of differences in the number and structure of three types of particles and that the diversity of living species depends on differences in the number and structure of four basic elements that form the letters of a "code." We immediately see the importance of organization if it changes the qualities and character of systems or entities consisting of similar, but differently structured elements.

Organization gives the entity autonomy and stability, at least within certain limits. Autonomy is derived from stability, and stability proceeds from autonomy. It is therefore not a mere exercise of the mind to distinguish an organized entity in relation to its environment. Organizational stability is ensured in a fixed way by the chemical bonds in molecules, but in the stars, stability/autonomy is guaranteed by an antagonistic complementarity between implosive and explosive processes. As we shall see, the maintenance of autonomy/stability is a primordial problem for living beings, which preserve it by continuous regulation and reorganization.

UNITAS MULTIPLEX

The relatively autonomous and relatively stable entity that organization produces, maintains, and preserves, is a complex unit, simultaneously one and multiple: unitas multiplex. This holds for the atom, the star, the living being, and the social unit.

The idea of multiple unit embodies two mutually exclusive notions. The concept of unit renders homogeneous and breaks up multiplicity; the concept of multiplicity divides unity into compartments and breaks it up. Hence the organized entity is one and homogeneous from the point of view of the whole, and different and heterogeneous from the point of view of the constituents.

What we have to understand is the complex characteristics of the unitas multiplex: it is a global, nonelementary entity, because it consists of different parts. It is a nonhomogeneous but hegemonic unit because the organized whole dominates the distinct elements and holds them in its power. It is a nonprimitive but original unit: it has its own irreducible properties. It is an individual unit, quite indivisible: it can be decomposed into separate elements, but this changes its existence.

Organization contains the seeds of its own disorganization. Maintenance of the complex unit presupposes the existence of dissociative forces. Binding forces contain or presuppose forces of repulsion. The parts that undergo organizational constraints carry the virtuality of their acquisition of autonomy in relation to the whole; this happens when the constraints relax or break down, destroying the organization, as occurs in cells that evade the constraints of the organism and proliferate in a disordered manner as a malignant cancer. Finally, the whole organized entity tends to a condition of disorder, according to the second principle of thermodynamics. Every-

thing that is composed tends to decompose. However, in the more complex organizations, self-organization maintains homeostasis with negative feedback (elimination of deviations that threaten the stability of internal complexity) and uses the mortal effect of the forces of disintegration to regenerate itself. A living organism ceaselessly degrades its energy; this degradation would be irreversible if its autonomy did not permit it to draw on energy from outside to produce new molecules and young cells to replace those that decompose. Hence anti-organization is not just antagonistic, but necessary to organization.

Moreover, the organizational constraints of the whole cause division in the great living and social polyorganizations, between the universe of the parts and the universe of the whole. None of the cells of Anthony (50–100 billion in number), none of his organs, know that Anthony declared love to Cleopatra, and Anthony knows nothing about the life and functioning of his cells: there is mutual ignorance at the heart of indissoluble unity.

Thus the idea of unitas multiplex acquires density of meaning when we understand that we cannot reduce the whole to its parts or the parts to the whole or the one to the multiple or the multiple to the one, but that we have to try to conceive the notions of whole and parts, one and different, organization and antiorganization, together, in a way that is simultaneously complementary and antagonistic.

EMERGENCES

All organizations produce something beyond their components, considered in an isolated or juxtaposed way: (a) the organization itself; (b) the global unit constituting the whole; (c) the new qualities and properties emerging from the organization and global unit. These can be called "emergences."

As indicated by von Foerster, the rule of composition of elements that interact in organization is superadditive (superadditive composition rule, see von Foerster,[3] pp. 866–867).

It is now important to extrapolate the qualities or new properties that emerge with organization and globality. They are qualities or properties of an innovative character with respect to the qualities or properties of the components taken separately or structured differently in another type of system. Thus the atom has original properties, such as stability with respect to the particles that compose it, and it imparts this quality of stability by feedback to the labile particles that it unites. With regard to molecules, "the new species bears no relation to the primitive constituents: its properties are not the sum of theirs, and it behaves differently in all circumstances. Though the mass (the total quantity of matter) remains the same, its quality or essence is completely new" (see Auger,[4] pp. 130–131).

The mixture of two gases, ammonia and hydrochloric acid, produces solid ammonium chloride. The apparently banal but in fact complex example of water shows that its liquid character (at normal temperatures) is not due to the properties of the atoms but to the molecules of water, bound together in a flexible way.

The association of an atom of carbon in a molecular chain brings about stability, an essential quality for life. As far as life is concerned, "clearly the properties of an organism are more than the sum of the properties of its constituents"[5] and clearly the

living cell has emerging properties unknown to macromolecules outside biological orgnization: it feeds, metabolizes, and reproduces. These emerging properties, the group of which is what we call life, affect the whole because it is a whole and affects the parts by feedback because they are parts. From the cell to the organism, from the genome to the gene pool, complex organizing units with emerging qualities constitute themselves.

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

It is quite extraordinary that apparently elementary notions, such as matter, life, sense, and humanity, are really emerging qualities of complex organizations. Matter only has consistency at the level of the atomic system. Physical materiality is not the first quality but emerges in and through organization. Life emerges from living organization: living organization does not emerge from a vital principle. The sense that linguists look for in the depths of language is the emergence of discourse, which appears in the unfolding of global units and has feedback on the basic units that made them emerge. The human being is an emergence of a hypercomplex brain system in an evolved primate. To define man in opposition to nature means defining him exclusively for his emerging qualities.

The surprise is that the emerging qualities of a basic system, the atom, become the basic elements of the molecules, the emerging qualities of which become the primary elements for cell organization, which become the basic elements of multicellular organisms, and so forth.

Emerging qualities have feedback on the parts and give them qualities that they could not have if they were isolated from the organizing whole. Thus, the neutron acquires the qualities of duration in the nucleus, electrons acquire the quality of individuality in the atom under the organizational effect of Pauli's exclusion principle. The cell creates the conditions for the full development of molecular qualities not seen in the isolated state. In human society, culture enables individuals to develop their aptitudes for language, crafts, and art: their richest individual qualities emerge within the social system. Thus we see systems in which macro-emergences have feedback on their parts, creating micro-emergences. The whole is not only more than the sum of the parts, but the part of the whole is more than the part by virtue of the whole.

The idea of emergence contains the closely linked ideas of quality, product (the emergence is produced by the organization of the system), globality (because it is indissoluble from the global unit), and innovation (because it is a new quality with respect to previous qualities of the elements). Quality, product, globality, and innovation are therefore the notions that need to be connected to understand emergences.

An emergence has something relative (with respect to the organization that produced it and on which it depends) and something absolute (in its innovation); it must be considered from these two apparently antagonistic points of view.

The emergence is a new quality that arises once the system is constituted and therefore has the property of event. The emergence presents as irrefutable phenomenon. It is empirically irreducible because it cannot be reduced to the qualities of the organized elements. It is not logically deducible because it cannot be deduced from the sum of the qualities of the organized elements. The new properties that arise at

cell level are not deducible from their molecules. Hydrogen is irreducible and nondeducible to its constituents, crystals to their constituents, living organisms to their constituents, intelligence to its constituents, awareness to the constituents of the brain. Even when it can be predicted from the conditions in which it arises, the emergence consititutes a logical jump and opens the gap in our minds through which the irreducible can penetrate. The emergence forces us to revise the notion of qualitative leap.

How do we classify emergence? Sometimes it seems to be an epiphenomenon, product or resultant, at other times the main phenomenon constituting the originality of the organized entity. For example, if we consider our awareness, it is the global product of brain interactions and interferences, inseparable from the interactions and interferences of a culture on an individual. It is possible to conceive it as an epiphenomenon, a flash like a will-o'-the-wisp, incapable of modifying programmed behavior (genes, urges, society, etc.). Awareness can also rightly be viewed as a superstructure, resulting from deep organization that manifests in a superficial and fragile way, like all that is secondary and dependent. Such a description, however, does not consider that this fragile epiphenomenon is at the same time the most extraordinary global quality arising from the brain, self-reflection through which "the I emerges from the brain." This description also ignores the feedback of awareness on ideas, behavior, and being, and the revolution it causes (awareness of death). Finally, this description ignores the completely new and sometimes decisive dimension that the self-critical attitude of awareness can bring to personality. The feedback of awareness may be variably uncertain and cause modifications of variable degree. Awareness manifests as a pure epiphenomenon, a superstructure, a global quality, capable or incapable of feedback, depending on the moment, conditions, individuals, the problems faced, and the urges aroused. However, more than anything it is the supreme and richest product of the human intellect, and its value is related to its fragility, like all that is best and most precious to us: love, understanding, the primary virtues, the soul, and the spirit are complex virtues, phenomena of wholeness, emergences; and this is why they cannot survive death, which is the disintegration of the whole and dispersal of the parts.

Thus the concept of emergence is not reduced by those of superstructure, epiphenomenon, or globality, but entertains necessary relations, oscillating and uncertain, with them. Its very irreducibility and this undefined and dialectic relationship make it a complex notion.

THE COMPLEXITY OF THE NOTION OF ORGANIZATION

With the idea of system and organization, things are no longer things, and objects, enriched by complexity, are no longer merely objects.

Organized objects not only obey an external universal order, they produce, in their structure and specific configurations in space and time, their own organizational order. They often arise with the collaboration of disorder and have to struggle not only against external, but also against internal disorder.

Organization binds, forms, transforms, produces, maintains, orders, and renders autonomous. It cannot be reduced to structure. Structure only means rules of invari-

ance and transformation in a system. Organization means structure, relation to wholeness, specific characters, relations between the whole and the parts, unity–multiplicity, and emergences. The idea of structure mutilates the idea of organization, strips the idea of system, enucleates the idea of complexity. The more the organization is complicated, the more the idea of structure becomes inadequate. Hence, it is in anthropo-social hypercomplexity that this small region of organizational truth presumes to erect itself a throne. In biology, the current dominant concept makes genes govern organization, whereas genes are an institution in self-organization.

There is a primordial epistemological interest in the notion of organization. Organization opposes separability (that breaks up the complex unit) and reducibility (which suffocates the microlevels); hence organization itself cannot be reduced to "holism," which suffocates the microlevels of the constituent parts. In its complex nature, it is a key linking concept: it institutes multiple unity, establishing inseparable complementarity between the idea of unity and the idea of diversity or multiplicity, which originally repelled and excluded each other; it establishes a circular relation between the parts and the whole, the whole and the parts, whence the need for circular understanding from the whole to the parts and vice versa.

The whole is more and less than the sum of the parts: this pseudoarithmetic formula suggests that the whole produces qualities unknown to the isolated parts, namely emergences, and at the same time establishes constraints that suffocate qualities and render virtual certain possibilities of the parts. Hence the whole is not necessarily superior to its parts, if, for example, like a totalitarian empire and the nations it dominates, it inhibits the qualities of the parts that were richer than those of the whole, or if the richer emergences belonged to the parts, as for example awareness, which emerges in individuals but not in society. Extending this idea to the cosmos, it really seems that "some small parts of the universe have a greater reflective power than the whole" (see Gunther,[6] p. 383). We have also noted the importance of the idea of emergence from the logical point of view.

The idea of organization invokes the concrete quality, not only of an object, but in the case of organizations perennially self-producing and self-organizing, of a being. As we have said, only things that are organized can be known as beings, and the idea of organization is therefore of ontological importance. The organized being, and especially the self-organizer, is a "*dasein*," "to be there," *hic et nunc*, depending on an aleatory environment and subject to time the transformer; thus we come to the idea of existence, which is the condition of living beings in a universe where there is risk, danger, and probability.

Hence the organization is rooted in *physis* (the physical world), but at the same time it draws from the observer-inventor who isolates it relatively in a tangle of organizing–disorganizing feedback mechanisms and a web of systems one within the other (see Méthode 1,[7] pp. 139–141). The idea of organization, like that of system, is physical for the feet and mental for the head.

It is understandable that science, based on the reducible, the simple and the elementary, reacted against complexity of organization. It is understandable why the concept of organization was ignored and that of system avoided and neglected. Very few systemists have introduced complexity into the definition of system.

The main thing is that the notion of organization induces us to use a number of "connection keys," which will be increasingly necessary as we load organization with complexity. On the one hand we can predict a break with linear thought and a need to use feedback and self-production cycles, like the need for circular understanding to establish the relation between the whole and the parts. On the other hand, we are induced to tackle logical complexities in the identity of the multiple unit, the product–producer, and the nondeducibility of the emergence. All this leads us towards dialogic, a principle of knowledge that conceives the complementarity of antagonisms, such as in the relation organization–disorganization.

The complex notion of organization allows a great advance in understanding, but this advance opens onto a great cosmic mystery; why does organization, and not just disorder or order, appear in our universe?

BASIC COMPLEXITY

Organization is a complex basic concept of universal importance. The increase in organizational complexity manifests through an increase in the number and internal variety of the constituents and through a process of complication of internal structures. Beyond a certain threshold, when the physico-chemical organization of a complex of macromolecules, for example, can no longer take on more variety, then a more complex organization that becomes self-organizing emerges and makes new qualities emerge: the qualities of life.

We will be able to consider the specific characters of the different types of self-organization when we have clarified the connection keys, especially recurring cycles and dialogic.[c]

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[c]Some passages have been modified from the section entitled "Organisation" of Méthode 1 (pp. 94–151: pp. 104, 105 multiple unity; pp. 106–108 emergence). To complete the examination of the notion of organization, the reader is referred to the following passages, not used here: particularly pp. 112–114: "the whole is less than the sum of the parts," pp. 115–123; "organization of the difference, complementarity and antagonism," pp. 123–144. The concept of system, particularly pp. 126–129: "All is not all," pp. 129–136; organization in organization, pp. 138–144; beyond formalism and realism, pp. 150–151.