

L e c t u r e

Complexity seems to open a way towards a new Aristotelian-thomistic ontology

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Abstract. Today's sciences seem to converge all towards very similar foundational questions. Such claims, both of epistemological and ontological nature, seem to rediscover, in a new fashion some of the most relevant topics of ancient Greek and Mediaeval philosophy of nature, logic and metaphysics, such as the problem of the relationship between the whole and its parts (*non redictionism*), the problems of the paradoxes arising from the attempt to conceive the *entity* like an univocal concept (*analogy* and *analogia entis*), the problem of the mind-body relationship and that of an adequate cognitive theory (*abstraction* and immaterial nature of the *mind*), the *complexity* of some physical, chemical and biological systems and global properties arising from *information* (*matter-form* theory), etc. Medicine too is involved in some of such relevant questions and cannot avoid to take them into a special account. (www.actabiomedica.it)

Key words: Complexity, life, mind- body problem, formal ontology, analogy, information, fractals

Introduction

Until some decades ago any sustainable epistemological model for whatever science, according to the proper meaning of that word, should possess at least two leading characters: *reductionism* (1) and a sufficient amount of *formalism* (possibly mathematical or chemical, etc.) endowed with considerable computational and previsional power. Scientific disciplines could be either *experimental* (sciences of observation) or purely *logical-mathematical* (sciences of deductive demonstration), but both should proceed according to some reductionism and symbolic formalism (2)

The lack of one or both properties (reductionism and formalism) would have weakened, if not strongly compromised, the right for any discipline to be included into the catalog of genuine and respectable sciences. Therefore, if mathematics and physics could exhibit their own *pedigree* attesting their uncontaminated scientific descent, more troubles were encountered by chemistry (3) (originated as alchemy, see ref. 4) as long as it was unable to ground itself on experimental and theoretical physics and to invent a suitable symbolic formalism. Many more problems arose for sciences dealing with life and man, such as biology and especially medicine, sometimes considered as proper to an art than a science. The realm of humanistic and social disciplines (psychology, sociology, economy, ethics and politics, etc.) was left in great part to philosophy or even to theology, unless a mathematical approach (at least of statistical nature) could be set up inside them. Medicine has being living, in some sense, in an intermediate land (5). On one side, it received stimulations to develop its theoretical framework according to a physical-chemical reductionism (splitting the human body-man into single isolated organs, cells, genes, proteins, macro-molecules, etc.). On another side it was fascinated by the so called *non conventional* approaches (especially the ones referring to the Oriental traditions, or to the Western Mediaeval ones, perceived sometimes more as mystery carriers than actual doctrines) and tried, in some cases, to investigate their tested results in order to understand them starting from our usual scientific stand point. Skeptical observers would consider as scientifically acceptable only the former way (reduction to biology, chemistry and physics) and substantially as "magic" the latter one (attempt to catch something irreducible to *hard* sciences), even if, in some circumstances could prove itself as effective (?) or at least worth of increasing attention. How to distinguish true science from magic illusion, sometimes dressed even with a pseudo-religious habit? How to distinguish between irrational attitude, *New Age* vogue (6) and serious epistemological and methodological new instances, rationally grounded?

In the last decades the situation has been deeply modified respect to past times. Some issues appearing for the first time in biology and medicine, and in human disciplines (sciences of living or thinking beings), e.g. the problem of a teleonomic behavior and a finalistic orientation of evolution (7), the matter of information (8) and organization of incoherent matter into an organized or a living system endowed with a unifying informational principle, the question of intelligent cognition and mind-body relationship (9) have shown their *irreducible* roots as present also into the *hard sciences,* like chemistry, physics and mathematics, and not only in biology, medicine and human sciences. The criticism of reductionism (the *whole* is not reducible to the sum of its *parts* and vice-versa) has appeared, for the first time, as a matter which is not necessary related to a philosophy inspired to *vitalism* or *spiritualism* (10)

Complexity, whole and *parts, dynamics, attractors, chaos, order, information, self-organization, teleonomy, finality, project, intelligence, mind, concept, self-similarity, analogy,* etc., are the new words arising today, practically, inside *any science*. They sound similar, even if not identical, to some (Latin) terms of ancient (Greek and Mediaeval) philosophy of nature, metaphysics and logic: *complexio, totum et partes, motus, quies, ordo, forma, finis, intellectus, anima, intentio, similitudo, analogia (entis),* etc (11-13).

It seems that the need, for science, to reconsider its logical and metaphysical foundations, emerges as an internal problem (as a matter of self-consistency, as a condition for new progress in explaining experience and systematizing theory in a non contradictory way) and no longer as an exterior appeal coming from outside (e.g, from moral philosophy and theology). I do think that it would be profoundly unscientific to approach the new-ancient problems emerging from sciences as a symptom of irrationality, or a pathology of human reason itself, to be solved following some irrationalistic philosophy, or pseudo-religious vogue. On the contrary the new instances look like evident claims in order to revise some aspects of current scientific methodology (i.e. reductionism, univocism, mechanism, new forms of positivism, etc.) and to search for a *wider* notion of *rationality* (14). A sort of new scientifically claimed ontology could, reasonably, emerge following this way (see, for instance the Web site http://www.formalontology.it). A theory of logical and ontological foundations of sciences, common in its essential aspects, to any science, since it would provide the principles and methods which cannot be renounced to avoid contradiction. Probably a non trivial theory of foundations common, at least in its main principles, to all sciences, would be of significant help also to biology, medicine, human and philosophical disciplines (and even to philosophy and theology!), beside to logic, mathematics, physics, etc.; and it could favor mutual dialog and reciprocal understanding as a establishing a reference language spoken by all scientists (on the foundations of sciences see, e.g, the Web site http://www.pul.it/irafs/irafs.htm) (15).

Some examples

Mathematics and logic

a) Non linearity. It may appear as astonishing but some problems which, in ancient times, where dealt with in the context of philosophical disciplines, like metaphysics and natural philosophy, have a relevant mathematical "interface" in today's sciences. The classical metaphysical principle of the irreducibility between the *whole* and its *parts,* for instance, arises inside mathematics whenever one attempts to approach *non linearity.* One could reasonably say that the mathematical formulation of non reductionsim is represented by the emergence of *non linear* "objects" (e.g. non linear functions, non linear operators, non linear differential systems, etc.). In fact non linearity in mathematics, means, by definition, that some "objects" cannot operate on *something* (interpreted as the *whole*) in order to obtain it as a "sum" (suitably defined) of *some other things* (interpreted as *parts*) and vice-versa. In symbols mathematicians can write down the previous sentence, according to their own mathematical language, by an *inequality* formula like:

$$f(x + y) \neq f(x) + f(y),$$

in which f stands for any *non linear* "object" (a function, a differential operator or other), $f(x)$, $f(y)$ represent the *parts* and $f(x + y)$ the *whole* generated by the action of f on the *things* denoted by x and y. While linearity is defined by the *equality*:

$$f(x + y) = f(x) + f(y).$$

In effect, mathematicians know many things about linearity, since any linear approach and methodology allows to split (*reductionism*) a complicated problem (the *whole*) into simpler and solvable ones (the *parts*). Then one comes back simply by taking the sum of the solutions of the splits, a sum which represents the solution of the original problem (i.e. the *whole*). This one is, for instance, the way of operating of the integral calculus, which is typically reductionistic. Of course some amount of reductionism is unavoidable and legitimate in science, and it proves successful; but in many *complex* situations and systems (the most interesting ones for an higher level approach) it fails. That is because *complex* means *irreducible* to simpler, while *complicated* means *reducible,* even if technically difficult.

A non linear approach to mathematical objects reveals the presence of some properties of the object itself, considered as a whole, which cannot be deduced starting from the analysis of its parts. Mathematicians call them the *global* properties, in opposition to the *local* ones related to each part.

b) Topology. Some of them are studied following "qualitative" methods, based on geometry (a curve can be approximated to a straight line only locally (i.e. in the neighborhood of any of its points), a manifold approaches its tangent plane only locally, etc.) and *topology,* i.e. the study of the relations between the objects and their parts, and of the properties invariant by continuous deformation without cut, tries to catch some of the global properties of a complex structure (connection, number of holes, number of handles, etc.).

It is significant that *topology* was originally called *analysis situs,* recalling the Aristotelian category of *situs,* involving the reciprocal orientation relations among bodies as parts of a whole (16). In fact mathematics, with the introduction of the *set theory* of Cantor (1845-1918) made a relevant step towards ontology, since it does no longer consider as its proper objects only numbers (*arithmetic*), points, lines, manifolds and solids (*geometry*), or relations like functions (*calculus*), but new other *entities* like *collections* of objects (*set theory*) (17). Topology has also open the way to consider the concept of *quantity* itself, which is typically inherent to mathematics, non longer as limited to numerical quantities, or to geometrical extensions, but also to the relations between the *whole* and its *parts,* and of the *parts* to each other; a new curious point of contact with the Aristotelian metaphysics of the category of *quantity,* defined as *what makes parts distinct from other parts* (18).

c) Paradoxes. Set theory made mathematics significantly more proximate to metaphysics, since *sets* possess more properties of *entity* (Latin *ens*), than the *number* or the *extension*. A symptom of such a *"load" of entity* arose with the emergence of contradictions and paradoxes inside the *theory of sets* (19). In the light of Aristotelian Thomistic logic and metaphysics, such contradictions are clearly related with the attempt of considering sets as *univocally* defined by the *univocal* relation of *belonging* (denoted by the symbol Œ). Mathematicians, thanks to set theory, have encountered in a new form, the ancient problem of the inconsistency of the attempt to *reduce* notions like *entity* (Lat., *ens*) to a logical *genre,* i.e. to a concept associated to a unique definition. The ancient logical-metaphysical theory of *analogy* seems to claim to be newly discovered and formulated by the language of our mathematical symbolic logic. Logic and mathematics have become very near to ancient metaphysics today. What must be avoided is an irrational escape towards a "fantastic" metaphysics conceived as an alternative to rationality, while logic and mathematics are now very near to a rational approach to ontology, suggested by a necessity of internal consistency. It seems to be a reversal of the Cartesian attempt to *reduce* the wider categories of Aristotelian-Thomistic metaphysics into the narrower ones of numerical and extensional quantity and relation of mathematics. On the contrary, today's logic and mathematics seem to claim a *widening* of the notion of *set* towards that of *entity,* non univocally defined (Lat., *analogia entis*) (20-21).

All the previously referred problems, together with many other, are a manifestation, in the context of mathematics, of what is called in all disciplines "the emergence of *complexity*". Of course complexity does not reduce to non linearity, since it is non only a mathematical question, but non linearity represents a fundamental mathematical aspect of it (22). Other aspects involve physical dynamics, structure, organization, information, oriented evolution, etc (23).

d) Fractals. One of the most elegant examples of complexity in the framework of mathematics (geometry) is provided by *fractals,* which are structures generated by the *feed-back* iteration of the same operation for a great number of times (in principle infinite). The results, when plotted on a computer screen reveal a self-similar structure which reflects visually such iteration process: the same figure seems to replicate itself on different scales inside the original one, as a *part* repeating itself inside a *whole,* and such behavior generates also infinitely indented boundaries (Figure 1). Beside exhibition of elegant shapes like those of Mandelbrot and Julia sets (generated by iteration of complex valued functions) or the ones obtained by the application of Newton's interpolation method (Figures 2-6), many other fractals seem to provide geometrical models of real physical things (like leafs, clouds, coasts, mountains and snow crystals, and even breaking curves of materials, etc.) (24, 25). Regarding anatomy a fractal like shape seems to appear in neuron cells, in pulmonary alveolus, in intestine tissues, and in a number of other structures.

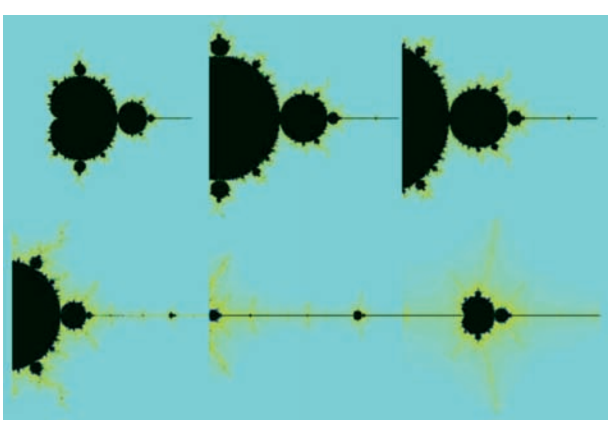

Figure 1. Self-similarity of Mandelbrot set

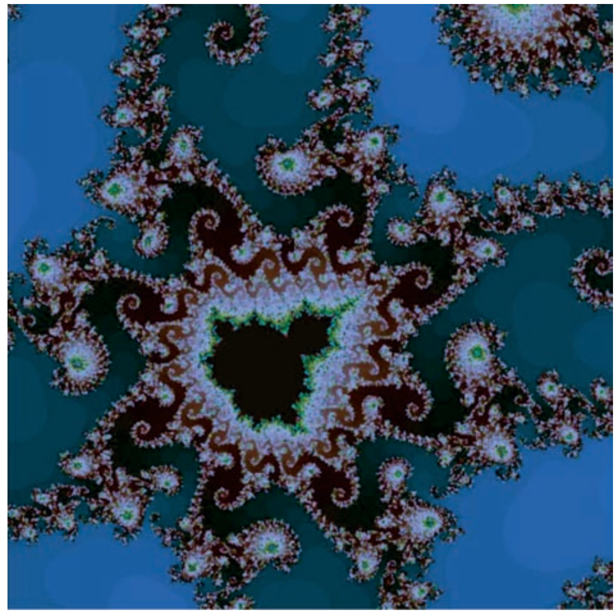

Figure 2. A secondary Mandelbrot set inside the main Mandelbrot set

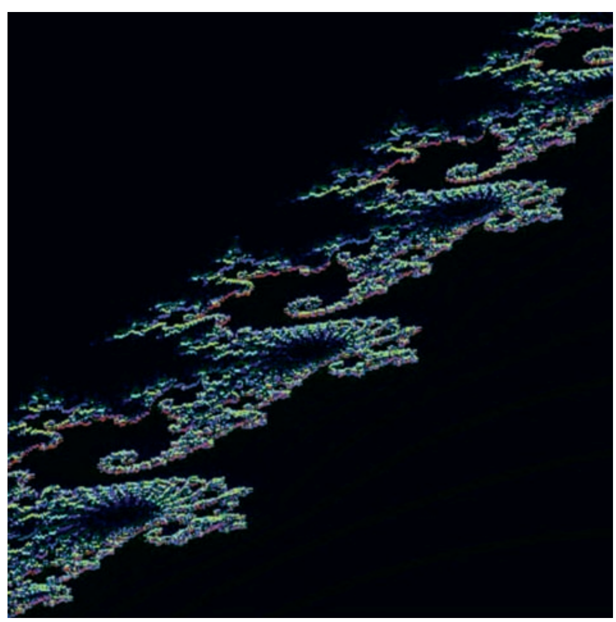

Figure 3. The so called "seahorses" inside Mandelbrot set

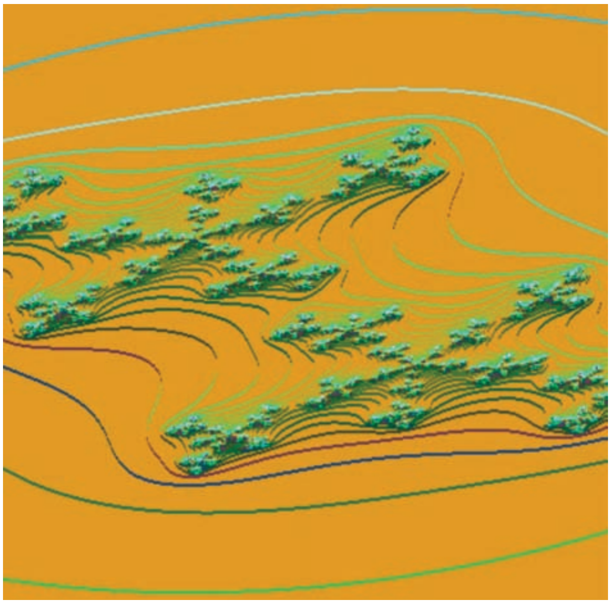

Figure 4. The so called "dendrite" Julia sets

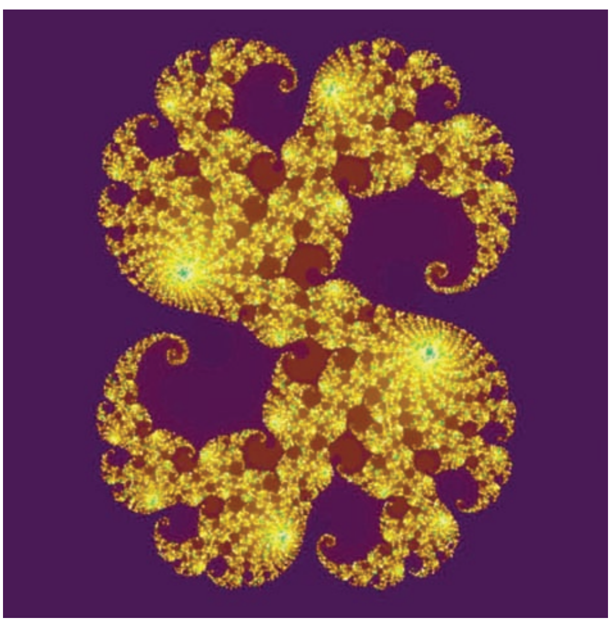

Figure 5. Self-similarities inside a Julia set

Physics, chemistry and biology

All what we have seen about mathematics is passed also to physics and all the sciences which make use of the mathematical language. Therefore we do not need to repeat it now. We add that in physics *complexity* involves, beside the shape and *structure* of matter, also the *time evolution* of the systems (*dynamics*), which is described by non linear mathematical evolution laws. One can see fractal structures in the basins of attraction and the Poincaré maps related to phase trajectories toward which the dynamics tends to stabilize itself (*attractors*), or from which it escapes (*repellers*), while they are built up in time, and no longer as static purely geometrical shapes. Here the non linearity of the mathematical systems involved may lead to a non predictable behavior of unstable systems which are highly sensitive to small perturbations of initial conditions (26).

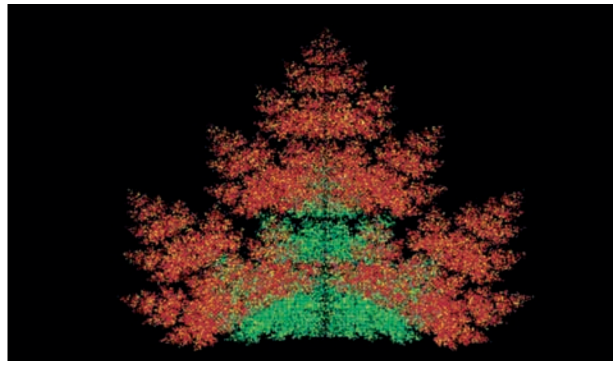

Figure 6. A fractal leaf

Complexity affects also the distribution of matter and energy in space, or its *structure*. The structure of *non local* and *not separable* physical, chemical and biological systems and that of molecules presents some holisitc properties which are not reducible to those of their component parts.

Complexity of structures is also related to *self-organization* of thermodynamic dissipative systems which exchange *energy* and *information* with their surrounding environment (27). Living organism represents a higher level of a self-organized system, even if it may not be reducible to it, since it may exhibit some specific irreducible properties, characterizing it as a *living whole.* The theory of *information* seem to be able to open a way to understand the characteristic of a similar immaterial principle unifying a living system. It is relevant to point out that even if information is always carried by a material support, its message is independent of the matter of the carrier. In this sense it proves to be immaterial. The concept of *information* as a principle unifying a system as a whole, irreducible to its parts, and governing its teleonomic growing and evolution according to some project, reminds in a modern fashion the Aristotelian concept of *form* (28). Again today's science becomes close to ontology. The notion of causality itself, begins to overcome reductionism, when it is conceived no longer as a locally mechanical action of a part on another part, but it is invoked as a structural information organizing globally the inseparable whole (*formal causality*). The idea of a project, in today's science, appears non longer as a philosophical or theological intrusion, but it arises from the concept of a global information shaping some self-organizing system, may it be a micro-organism or the entire universe (29). Certainly if a similar revision of the epistemology has become indispensable for the *hard* sciences, how much a similar revision should be relevant for a science of man life and health like medicine, provided it is carried out starting from the internal claims of the medical discipline itself, and not on the basis of some irrationalistic attitude or vogue (30).

Mind-body problem and artificial intelligence

Another problem of great interest which seems to involve several disciplines interested to *complex phenomena* (cognitive sciences, medicine, biology, informatics, logic, mathematics, etc.) is that of mind-body relationship and that of intelligence, human and artificial. I will non enter that subject which is treated profoundly in other important contributions in the present special issue. I want only emphasize that it would be interesting to compare the most recent studies with the ancient Aristotelian-Thomistic cognitive theory of *abstraction,* which is related to the formation of universal concepts in the human mind, starting from the singular signals revealed by our corporeal five senses. In such theory the immateriality of information seems to play a fundamental role when it is detached from the singular carrier of chemical and electrical nature traveling and acting on the body, to be raised to the universal and immaterial level according which it is present in the mind (31, 32). A similar view is very different from the reductionistic one, like that of David Hume (1711-1776) which considers the universal concept as a (quantitatively) rarefied material sensation, and is much closer to the approach of complexity, distinguishing between (qualitatively) irreducible levels. Investigations both in the field of human cognition, psychology, cerebral physiology and also artificial simulation of human intelligence will presumably prove of great interest for a deeper understanding of the role of immateriality of information and mind in relation with material carriers and physiological functions. If the notion of an immaterial human mind may be taken into consideration it must not be postulated dualistically or irrationally, but it should arise as reasonably simple and almost unavoidable principle to explain observation and experience in a more satisfactory way.

Perspectives and conclusions

In the present contribution we have attempted to show, through a brief sketch, how today's sciences, even if starting form different point of view and employing different methods, seem to converge all towards very similar, if not identical, foundational questions. Such claims, both of epistemological and ontological nature, seem to rediscover, in a new fashion some of the most relevant topics of ancient Greek and Mediaeval philosophy of nature, logic and metaphysics, such as the problem of the relationship between the whole and its parts (*non redictionism*), the problems of the paradoxes arising from the attempt to conceive the *entity* like an univocal concept (*analogy* and *analogia entis*), the problem of the mind-body relation and that of an adequate cognitive theory (*abstraction* and immaterial nature of the *mind*), the *complexity* of some physical, chemical and biological systems and global properties arising from *information* (*matter-form* theory), etc. Therefore medicine itself seems to require to take into account such new epistemological and foundational context, in order to avoid both the excess of a strong reductionism and the illusion of an irrationalism which might lead it out of a genuine scientific approach.

Even the heavy ethical questions (which have not been examined in the present contribution) need to be grounded on some objective metaphysical and anthropological frame of reference and could not be solved starting from an arbitrarily conventional attempt of agreement.

Then we may conclude that present days open a very interesting time for future investigations which may contribute to the unity of knowledge and a more human science.

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