The Complexity of Scientific Theories

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"I suspect that the fate of all complex adapting systems in the biosphere - from single cells to economies - is to evolve to a natural state between order and chaos, a grand compromise between structure and surprise."

Stuart Kauffman

Abstract

This paper contains shortly expressed ideas for starting a discussion about the complexity of scientific theories. The uselessness of scientific theory in many contemporary approaches is done by the discrepancy between the complexity of the reality and the complexity of associated scientific theory. In research we use too simple procedures and more, we reduce the knowledge to research, misunderstanding the place of teaching in developing new (or deserted, maybe ignored, most likely prohibited) skills for man's unity and his coherent interaction with reality. Man's unity is done by a well balanced interaction between **rationality, imaginary** and **spirituality**. A pure formal theory has a small complexity. We can increase the complexity of our scientific approach only by renouncing to the simplicity and the elegance of our scientific theory. A complex approach must imply the imaginary and the spirituality as strong synchronous processes added to the formal-structural rationality, instead of a weak and diachronic tolerance of them in a process dominated only by formal-structural mechanisms.

1. Introduction

"What we need is imagination. We have to find a new view of the world."

Richard P. Feynmann

1.1 Between Simple and Complex

Man hopes that using a simple and elegant theory makes possible to understand or to build complex things. The main problem, he says, is to find an appropriate scientific theory. Unfortunately, such theories do not exist. The complexity of a traditional scientific theory is mainly done by the complexity of its foundation not by the complexity of its development. We will use Chaitin's Information Algorithmic Theory to prove it.

Are our scientific theories damned to remain simple and useless for complex realities? I believe no. The scientific theories must change so as to get the ability to manage real complexities. A quantitative complexification is not enough. Our theories must become new ways in which the rational methods intimately interact with *imagined things* and *spiritual feelings*.

Only a new alliance between the *simplicity* of the formal-structural skills, the *spectacular* of the imaginary and *depth* of the spirituality allows us to manage the real complexity.

1.2 Against Dyadic Models

The current approaches in the history of sciences, and not only, use dyadic models in which the rationality is against spirituality, the formal is against the non-formal, the structural is against the phenomenological, civilization is against cultures, Protestantism is against Catholicism and so on. A reconciliation by an equilibrium is impossible without a *new term*, as a new support, that offers a more stable triadic approach. Binary models are truncated and offer distorted images of reality.

Starting with the Gnostic thought and ending with the binary approach in contemporary computers, dyadic models can be sometimes efficient but frequently overlook most of or even the essence of the reality.

1.3 A Triadic Approach

Man's new model that has the chance to overpass the main problems of our times tends to synchronize in the same approach the three basic components: *spirit, imaginary* and *reason*. Let us name this triad the *fundamental triad* (FT). Concerning this FT there are many derived triads. Between FT and the derived triads there is an *approximate* dependence that allows an important openness toward more subtle explanations. We list some of these derived triads:

Intuition - Imaginary - Intellect
Unity - Uniqueness - Uniformity
Sense - Signification - Syntax
Present - Past - Future
Existence - Being - World
Sense - Truth - Form
Education - Training - Instruction
Revelation - Imagination - Explanation
Mystery - Expressiveness - Clarity
Human Being - Communion - Community
Spirituality - Cultures - Civilization
Orthodoxy - Catholicism - Protestantism
Elitism - Centralism - Democracy

In this paper we don't use all these triads, but it is maybe suggestive to present them for helping a better understanding of the basic idea in the triadic approach.

2 Hypostases of Research

"It has been established at the beginning that we can know nothing through demonstration if we do not know the first direct principles"

Aristotel

Research, as one of the ways of knowledge, has become so important that it is often mistaken for the ampler process of knowledge itself. When the ways of knowledge are reduced to the ways of research it is the latter which has to loose the most. Research imposed its own action criteria by which essential characteristics of knowledge were left behind, on a secondary plane. The Aristotelian approach essentially drove forward scientific research but it also generated the premises of the crisis that knowledge is undergoing these days in the Western cultures.

Condensing the expression into natural languages, then into formal languages allow an efficient but truncated dissemination of individual experiences. As long as there was no technical support of the representation and manipulation of knowledge or this was rudimentary, notable evolutions in the "technology of research" were not possible. Computer science accelerated explosively the evolution of the style of scientific research. The impact of computer science has given a chance for a sound relationship between knowledge and research. We point out the following significant moments of the evolution of the "technologies of research" in the Western world as steps toward a new form of the knowledge.

2.1 The Aristotelian Cut between *Theoria* and *Episteme*

The ancient Greeks were the first to speak consistently about knowledge as a process governed by coherent modalities for manifestation in community. The Aristotelian *Organon* imposed the first fundamental distinctions still valid for the usual Western approach. In the *Second Analytica* (ll,19) the disjunction between the two essential forms of knowledge, which are the *direct* one and the *intermediate* knowledge, was explicitly discussed.

"As regards the knowledge of the direct principles it may be discussed whether it is or is not of the same kind as knowledge through demonstration, whether both kinds of knowledge deserve the name of science or only one is science while the other is another kind of knowledge, finally whether this faculty of knowing the principles was born at the same time as ourselves but without our knowing it or, if it did not exist before, it was acquired."

For the ancient Greeks knowledge had two quite distinct forms:

- *theoria (qewria)* - the direct knowledge which enables us to acquire the principles, and
- *episteme (episthmh)* - the knowledge intermediated by demonstration, which originates in the principles.

While the distinction is real and constructive in order to understand what knowledge is, it was not as productive to consider it diachronically, i.e., in the sense that every research begins with a strictly *theoretical* approach and evolves through an approach exclusively *epistemic*. This distinct cut proved very productive for the evolution of a superficial knowledge with the view of immediate action. Limiting the *theoretic* only to the start of the knowledge process leaves for the *epistemic* tasks that shall prove to be impossible to solve.

2.5 The Arbitrary in Segregating Axioms from Theorems

In a scientific theory the truth is provided in equal measure by the axioms directly established and by the theorems deduced through the axioms. The development of theoretical (in the contemporary sense of the word) constructions has shown the possibility to build identical aggregates of true propositions starting from different sets of axioms. A theorem in one elaboration may become an axiom in another one, and vice-versa. Thus the privileged position of principles in the body of a theory is demystified. This flexibility in presenting a scientific theory shall be used to increase the flexibility of the formal tools.

The principles and their results do not belong to two segregated worlds. The too distinct Aristotelian Cut between the forms of knowledge is thus attenuated.

2.5 Choosing the Principles - from Obviousness to Utility

If several true propositions in a theory aspire to the dignity of axiom, which is the criterion for choosing the best axioms? Two limit situations can be imagined:

- the minimization of the principles with an increased effort to develop the theory
- the minimization of the effort to develop the formal system starting from an ampler set of principles.

How can one justify the set of principles from which one starts building a theory? Two extreme positions can be pointed out:

- the *obviousness* of the principles, because of their simplicity, a typical option for the first axiomatic systems developed in the antiquity
- the *utility* of the principles, proved by the consistency of their implications in the reality under survey, a feature cherished most particularly by contemporary science which develops theories starting from not so obvious principles, but extremely fruitful in consequences; the best example in this respect is that of modern Physics.

While choosing the principles it was always taken into account that a scientific theory should correspond to a human "dimension". The complexity of the forms perceived and efficiently manipulated is limited to a value belonging to man's nature. An optimal relationship between the principles and the theorems is always reached. The efficiency of the knowledge process regulates the process by which a theory is developed in such a way as to offer a most "friendly" tool to the

human user. Additional problems, but also additional freedoms appear when the user is not human exclusively or when the user is only a computer or an artificial system.

2.5 Mastering Complexity through a Multitude of Rules

The need for theoretical models for reality that are even more complex has pushed into a secondary plane the problems of the human user. Man's limited formal performance was not given priority consideration anymore. Thus, one witnesses the automatic constructions of theories that shall be used also automatically only by a computing system. In addition, the distinction between the axioms and the theorems of the theory is lessened. Reality is described by ample sets of *rules* extracted from a finite portion of it, considered as significant.

A good example could be the set of rules describing a natural language starting from a finite selection, rich enough in significant texts, i.e., the *corpus* of that language established by a competent body. Such an approach leads to a description through tens of thousands of rules which can only be used by a machine comparable to the one that found them. What are these rules? Are they axioms or theorems? We believe the distinction is no longer productive.

Most obviously, we are faced with an essential mutation with big chances to become fixed. The Aristotelian aspiration toward simplicity and obviousness of the principles, reiterated by Descartes "on entering the last straight line", is undermined by a spectacular evolution which was made possible thanks exactly to the initial viability of such aspirations. The cut between *theoria* and *episteme* sought to offer a human scale model for a much extended reality. In the context, man reached the conclusion that:

- traditional scientific theories can only describe very simple realities (the simpler the theory, the more restricted field it can describe[1], according to G. Chaitin's algorithmic information theory)
- according to the complexity to be described, a complex theory must be built, i.e., only a theory having a large number of principles, axioms or rules are useful for describing complex realities
- scientific theories could describe more complex realities but only at the price of a complexity than can only be controlled with the help of computer systems.

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[1] "The setup is as follows: The axioms are finite string, the rules of inference are an algorithm for enumerating the theorems given the axioms, and we fix the rules of inference and vary the axioms. Within such a formal theory a specific string cannot be proven to be of entropy more than $O(1)$ greater than the entropy of the axioms of the theory... .

Proof Consider the enumeration of the theorems of the formal axiomatic theory in order of the size of their proofs. For each natural number k, let s^* be the string in the theorem of the form "H(s) ≥ n" with n greater than $H(axioms) + k$ which appears first in this enumeration. On the one hand, if all theorems are true, then $H(s^*) > H(axioms) + k$. On the other hand, the above prescription for calculating s^* shows that $H(s^*) \leq H(axioms) + H(k) + O(1)$. It follows that $k < H(k) + O(1)$. However, this inequality is false for all $k \geq k^*$, where k^* depends only on the rules of inference. The apparent contradiction is avoided only if s^* does not exist for $k = k^*$, i.e., only if it is impossible to prove in the formal theory that a specific string has H greater $H(axioms) + k^*$." [Chaitin '77, p. 356]

So, shall we start building theories for the exclusive use of computers? Maybe yes. If not, we shall have to seek also other new modalities for practicing knowledge at a human scale.

2.5 Synchronizing Direct Knowledge and the Imaginary with Intermediate Knowledge

What have we learned when we came across the limits imposed by the complexity of theories?

- We first learned that intermediate knowledge, as part of the common knowledge currently called science, does not provide us with things clearly distinct from those provided us by direct knowledge.
- An adequate choice of principles may increase the utility of a scientific theory.
- In the case of large complexities, the distinction between axiomatic truth and the truths deduced from the principles ceases to be productive.

The complexity cherished by the scientific approach has evolved much more rapidly than the technology of elaboration of scientific theories. The step which I do hope we are ready to take should

- *conjugate synchronously direct with intermediate knowledge*.
- *replace a dyadic model (of theoretic/epistemic alternative) with a triadic approach in which the* ***imaginary*** *plays an important role.*

The last half millenary of scientific development has excessively stimulated only the epistemic skills of the individual through a teaching process which has too much neglected the **educational** aspects and **training** activities in favor of **instruction** activities. We hoped to manage the complexity through *epistemic*, formal procedures which are inadequate to this end. Re-orientation only toward the *theoretic*, toward the non-formal is not a solution. A consistent way would be remaking the lost pre-Aristotelian unity between *theoria* and *episteme* and to gain new skills by the *freedom (or spontaneity) of imaginary*.

Computer science is the main tool that allows this new and unavoidable tremendous target.

Through its immense epistemic availability, computer science can provide us with the liberty to stimulate, through *education* and *training*, the vast *theoretical* reserves and the unforeseeable power of *imaginary*, so that knowledge could be practiced **continuously** by direct knowledge and imaginary, constructively tempered by reason assisted by a "technological" support outside the mind. Man's intuitive and creative skills should be able to interact in "real time" with his analysis skills well supported by the external informational structures. The **theoretic - imaginative - epistemic** synchronism should thus permit to *master the complexity* and to access the *deep knowledge*.

3 Hypostases of Knowledge

"Bacon, you were brilliant, but the world is more complex than your philisophy"

Stuart Kauffman

The hypostases of research show that the discussion should be extended from the level of research to the level of knowledge. The advantages of the Aristotelian Cut exploited only as efficient tools of research have proved to be knowledge restrictive. Originally, knowledge was an instinct which made man self-conscious of being alive. It further enabled men to live in an unpredictable and diverse world. Lately, action has become possible in a complex and meaningful world thanks to knowledge. And so, following this path, research gradually substituted itself to the knowledge and today research provides compact representations of extensive but poor in significance realities.

3.1 Consciousness of Being in Existence: the Spirituality

The first form of knowledge was an interaction between man and Existence perceived as a non-differentiated totality. The tension between the human being which perceives the whole and this whole we call *spirituality*. The consciousness of existing as a primary manifestation of knowledge triggered the history of man and of this world. But in this effort to build a world, man had had to go rapidly beyond the spiritual attitudes. The environmental diversity and certain initial conditions compelled him to *disperse into cultures*. Over the common background of spirituality appeared the cultural constructions with ample historical developments. The historical evolution of cultures was characterized by a process of hiding the common fundamentals of spirituality. This *hiding* permitted conserving unaltered essential values which otherwise would have been altered by current usage in the whirlpool of the world. Cultural history allowed the world to reach the level where optimum reevaluation of spirituality is possible. Practically, so far the history of mankind can be envisaged as a fruitful wandering along paths that converge toward the moment when what is fundamentally human – the spirituality - can be directly fulfilled without fear of derisory dissipation.

3.2 Research and Invention: Dispelling in Cultures

A question that comes to the mind is how did cultures succeed to hide and thus save essential, but unusable values, because of the precariousness of the world in which man lived? Well, by imposing the *secondary values* of research, action and technological invention.

Dispersion into cultures implies delimitation and pragmatism. The global perception of existence can only then be transformed into a useful tool when it is limited. Then, existence is sliced into domains that are investigated with efficient means. The Aristotelian Cut is imposed by:

- retaining a limited number of truths from the global perception, but which are sufficient for a delimited space of reality
- inventing a series of rules which should have permit reconstructing the delimited space with sufficient accuracy.

Diverse portions of the reality shall thus be sealed into simple representations made of a small number of truths and of rules for their usage. Reality should be investigated only from the perspective of such a symbolic system, currently called scientific theories. Knowledge shall then be reduced to research seen as truncation and invention.

In this context, knowledge is substituted by *search* of the truth. For a long time, this model yielded very good results. As long as the complexity of the problems approached was a reasonable one, the correlation between the complexity of a theory and the complexity of the problems to be approached did not come into question. But, approaching some more difficult problems launched the research of a possible correlation between the complexity of the problem to be solved, the complexity of the theory, and the time allotted for solving it. No wonder that the researchers (not the true knower) were surprised to find that a complex problem requires an equally complex theory or a very long time for its solving by search.

Cultures have substituted knowledge with research, with most favorable effects in solving some rigorously and drastically *outlined* problems. These *initial delimitations* determined present-day fundamental limits of the research. It is not the knowledge that is limited but its too gross approximation through research.

3.3 Knowledge as Creation: Recovering through Civilization Triggered by Imaginary and Based on Spirituality

Can knowledge emancipate itself from the patronage of research which it has accepted because of its initial helplessness in fructifying a purely spiritual attitude? Yes, it can. But not returning to an attitude mostly spiritual. Millenary cultural experiences - exhausted within the restrained space where they dispersed into cultures - represent now a base for a new form of knowledge where creation and research might cooperate with big chances of success.

Annihilating the Aristotelian Cut, is being made possible by the present-day context offered by:

- the information technology tools available for validating and moderating rationally the creative "delirium" of *will, intuition* and *fantasy*, the three components of **imaginary**
- the cultural diversity we may count on as a source for creativity stimulating the imaginary
- the revival of spirituality, long time hidden or distorted, as a source of the deep intuitions

For the current complex problems the analytic effort of the rational approach appears too hard, the inventiveness of the imaginary seems uncontrollable and the synthetic skills of intuition are unusable. But the chance that computers offer now, for avoiding these three independent limitations, is terrifying:

- thanks to their *computational* abilities, computers alleviate man from a useless huge amount of analytic work
- thanks to their *representation* facilities the computer stimulate coherently the imagination, facilitating trans-cultural interconnections
- thanks to their *communication* functions, they offer the access to reality as a whole, allowing deep spiritual feelings.

Under these conditions, *knowledge may become a continuous process of creation*, deepened, stimulated and also tempered by the three essential functions of the information systems, i.e., *communication, representation* and *computation*.

Giving up the Aristotelian Cut allows knowledge to manifest itself as a continuous creative process, tempered and validated by the information systems at our disposal. A solution "found" through creative imaginative or intuitive effort, well stimulated through adequate education or training, shall be accepted after systematic checking efficiently achieved by a computing system.

The essential question is: which are the means by which we should be able to go from the systematic search of solutions within spaces that are sometimes exponentially extensive ones, to direct, intuitive or imaginative, "finding" of some solutions that can be easily validated systematically? The difference between the complexity of the systematic *search* and systematic *validation* is the difference between the number *n* (the dimension of the space when we must find the solution) and its logarithm (the number of steps in which we can validate or invalidate a "guessed" solution). It is a difference by no means hard to ignore. What could we do to turn it into good account? Well, change the researchers into true knower for whom *finding by guessing* would be a current exercise. And thus, **education** and **training**, instead of instruction, assume a role it had never played before in the history of knowledge.

4 Hypostases of Teaching

"... we must emphasize that a comparative judgement of observation languages, e.g. materialistic observation languages, phenomenalistic observation languages, objective-idealistic observation languages, theological observation languages, etc., can start only when all of them are spoken equally fluently."

Paul Feyerabend

We must learn from our teachers to *perceive* the wholeness of the Existence, to *generate*, starting from our imagination, a new internal or external world and to *understand* which can be rationally understood. So teachers satisfy the three components of FT used by learners to be manifest into Existence, as against of Being and in the World. Instruction, training and education are hypostases of teaching needed for developing the FT in each human being.

4.1 The Instruction that Offers Formal and Structural Skills

All that is rationally established in formalized descriptions or structural construction can be learned by *instruction*. Mathematics, engineering, management are mainly domains having the same content everywhere in the world. Almost all the content of these disciplines can be taught by instruction, using formal methods with structural examples and suggestions. The theorem of Pythagoras has the same content and is taught in the same manner everywhere. It belongs to the Civilization, beyond of cultures on the surface of Existence.

By instruction the knowledge is transmitted mediated only by formal and structural procedures. The process is easy to design, to disseminate and to verify.

The image of the reality taught by instructions is a truncated one because only structural-formal models are used. Therefore, skills got by instructions are limited and usefulness for mastering the complexity, the depth and diversity of the world.

4.2 The Training that Stimulates the Imaginary

In order to make a person efficient in some activity we can use repeated practice, i.e., we must teach her/him by *training*. So we will stimulate the ability to imagine new forms or techniques. Training is applied in a domain taught by instruction (e.g., mathematics) or in a specific domain, such as eurythmics. In both cases there are two kinds of consequences:

- the learner becomes more efficient in that domain
- improves the ability to imagine.

A efficient action is the first step towards breaking out the imagination.

4.3 The Education: a Spiritual Way

The unity of the Existence cannot be deconstructed in a formal or a structural way in order to be taught by instruction. Also, the constructions of the imaginary, however much trained, are helpless to regain the wholeness of the Existence. To the unity, the deep and the wholeness of Existence the access is conditioned only by an appropriate education. Teaching by education is beyond the limits of the structural - formal rationality or the phantasms of the imaginary. Education makes sense for the wholeness of the Existence related with the human being. Direct, theoretical, knowledge can be practiced only having a good "connection" with the deep Existence.

5 Instead of Conclusions: Man's Hypostases

"... l'exotérisme a jetée le
désordre au sein de l'humanité."

Fulcanelli

Man must learn in a teaching process done without distinctions between instruction, training and education. The first Christian millennium followed mainly a spiritual way, teaching being dominated by education. The next half millennium was dominated by the blow-up of the imaginary stimulated by teaching through training. The last few centuries where characterized by reason imposed by the instruction as the main form of teaching. Thus man was diachronically implied in teaching forms that must be exercised synchronically. Therefore, man must regain the lost unity of the *fundamental triad*. The way from truncated and limited research to exhaustive knowledge is difficult and roundabout, but the minimal requirement is to make a good balance between man's hypostases.

5.1 Rationality: Support of Civilization

The most evident hypostasis of man is its **rationality** because it manifests in *community*. The main role of reason is to allow the unity of the man's created world: the civilization. Civilization is based on universal accepted facts. Local and individual differences do not matter. The way towards the civilization is apparently a rational one and is based only on the instruction process. But the civilization is only an external and formal context in which the human being performs superficial simple attitudes. Deepness and spectacular (complex) acts start beyond the simplicity of the formal and structural approaches. The reason grounds only simple and evident truths of the formal theories. To overpass this level we need imagination and spirituality.

5.2 The Collective Imaginary

The **imaginary** is not the usual hypostasis of a common man and is manifest by the rule in *communions*. It makes differences between men and communities, generating the cultural diversity. In the same time imaginary, *by an additional imagined "construction"*, shortcuts many times the way toward solutions "hidden" in too large (exponentially dimensioned) spaces, where a systematical search is evidently inefficient. But, if a candidate for a solution is found, then it is very easy to validate or invalidate it using rational (formal, computational) methods.

Also, each cultural space is characterized by its **collective imaginary**. This collective imaginary is reflected in most of the cases in the common language or other customary attitudes. Therefore, particular ways of knowledge can be emphasized. These ways use "local" values of a culture but must be validated by the rational, universal methods. The imaginary has no independence in the scientific space. (It has autonomy only in arts and related domains where the imagination can be self-consistent.) Also, the access to the deep Existence is limited in the context of the imaginary. We must do the next step.

5.3 The Spirituality Based on the Collective Unconscious

Spirituality is the most hidden hypostasis of the *human being* but, in the same time, it is the most important and deep connection between man and Existence or between men. Man's uniqueness is related with Existence's unity by the spiritual way. Reason's superficial values can aspire to universality only grounded on the deep spirituality of men, manifested as the *collective unconscious* emphasized by C. G. Jung. Also, the spectacular values of the imagination have chances to be rationally validated based on the spiritual tension between the uniqueness of man's attitude and the unity of the Existence.

In the same time, the spiritual attitude of the human being is stimulated and sometimes validated in the rational grounded communities and in the cultural communions based on collective imaginary. Therefore, the fundamental triad of *spirit, imaginary* and *reason* and its diverse forms can not be substituted by dual approaches as oppositions between spirit and reason, cultures and civilization, non-formal and formal, spirit and mater, and so on.

Universal reason, collective imaginary and collective unconscious forms the unity that allows man to have access to knowledge by "new scientific theories" in which *clarity, expressiveness* and *mystery* opens towards simple (if it exists) *syntax*, diverse (maybe spectacular) *significations* and deep *senses* of Existence.

References

[Aristotel] Aristotel : *Second Analytica*.

[Chaitin '77] Gregory Chaitin: "Algorithmic Information Theory" in *IBM J. Res. Develop.*, July 1977, p. 350-359.