

The Lab's Quarterly
Il Trimestrale del Laboratorio

2009 / n. 1 / gennaio-marzo

Laboratorio di Ricerca Sociale
Dipartimento di Scienze Politiche e Sociali,
Università di Pisa

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COMPLEXITY, VAGUENESS, FRACTALS AND FUZZY LOGIC: NEW PATHS FOR THE SOCIAL SEARCH

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Si è tenuta a Napoli dal 1 al 5 Settembre 2008 la *VII International Conference on Social Scienze Methodology* nell'ambito di RC33 - *Logic and Methodology in Sociology*.

Pubblichiamo le relazioni tenute da studiosi impegnati nel Laboratorio di Ricerca Sociale del Dipartimento di Scienze Sociali, ora, confluito nel Dipartimento di Scienze Politiche e Sociali.

Section

*“Complexity, vagueness, fractals and fuzzy logic:
new paths for the social search”*

*SOME ASPECT OF THE QUALITY IN A LIVING COMPLEX SYSTEM.
A PRELIMINARY APPROACH: "THE LICHEN SYMBIOSIS"*

Paolo Pasquinelli

Abstract

This paper aims at explaining what perspectives could arise by a qualitative evaluation of some biological organisms in symbiosis which represents a complex living system. The aspect of the quality was not much studied by the academic world until 1980. Recently a group of multidisciplinary advanced scientists have used this qualitative concept to apply it to the environment. We propose an example of cooperation in the vegetal kingdom, as the "Lichen symbiosis", which is considered as a high stable association useful to measure that quality effect through the energy point of view. We attempt at encouraging studies and the applications in the new analysis of the quality using the incipient derivation. Then we introduce an interesting fractal view applied to a specific lichen.

Keywords: lichen symbiosis, photosynthesis, quality evaluation, fractals.

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Introduction

Since 1983 the studies of the Energy Fluxes were used to improve the applications in scientific, economic and social fields according to the qualitative theoretical approach. (1).

The necessity to introduce new economic qualitative parameters, which could have importance over the complicated industrial systems, created interest in many other disciplinary fields, one of which more interesting is the Ecology.

A Conference "Advances in Energy Studies: Energy Flows in Ecology and Economy" (2), was held in November 1998 in Portovenere (Italy). This event signed, maybe for the first time, the start of an important phase of comparing theories without any preconceived opinion, useful to give information of the studies produced from Thermodynamics to Environmental Dynamics, from Engineering to Social Sciences and more. This fact encouraged the developments of more correct industrial growth models. The presence of H.T. Odum, one of the most important scientists of that conference (without mentioning him as the "father" of those sciences) stimulated us to promote more advanced studies in environmental applications. After that Odum opened in 1994 the field of the Emergy (3), many scientists produced interesting works concerning their applications in Biology, Economy, Mathematics, Thermodynamics and Philosophy. It is our opinion that we have never observed, from that period, a similar great progression and diffusion of that matter.

In the recent history (even if "in itinere") of living complex systems, we can appreciate very important developments concerning the Quality concept, often "neglected" or, even worse, "overpowering" so far, in spite of the Quantitative evaluation regulated by very consolidated principles and formula easy to sustain in the Academic world. Recently an Italian researcher, C. Giannantoni proposed several papers to Biologists, the last two of which are "The Introduction to the Mathematics of the Generative Processes" (4) and "The Principle of the Maximum Power Emergy, as the base for Thermodynamics' Quality" (5).

Well nowadays, the arguments concerning Emergy, already introduced by Odum, show to be ready to receive improvements moving to the rational approach or better to stimulate attempts at generating a new type of Maths: "The Incipient Differential Calculus". This fact invites us to reconsider the assessment of the Quality (6). At this point it is important to consider that, without an accurate description of any model of "complex living system", even if perfectible in run time, all of that could be wrong. Over all the incipient differential calculus

take in account of some aspects like the Co-production, the Interaction and the Feed-back on the dynamic evolution of the generative processes. In conclusion, the Qualitative question leads us to think that the more the pathways of the living systems are known, the more there is a major approximation for that qualitative plus-value useful to better represent the calculation applied in the measurements of the Emergy.

The definition of Emergy: *Emergy = Available energy of one kind previously required directly and indirectly to make a product or service (H.T.Odum) (7).*

If we want to adapt this definition to the lichen symbiosis we can consider that “one kind” must be change into “solar energy”.

The Units of Emergy are: sejoule (Joule of solar energy)

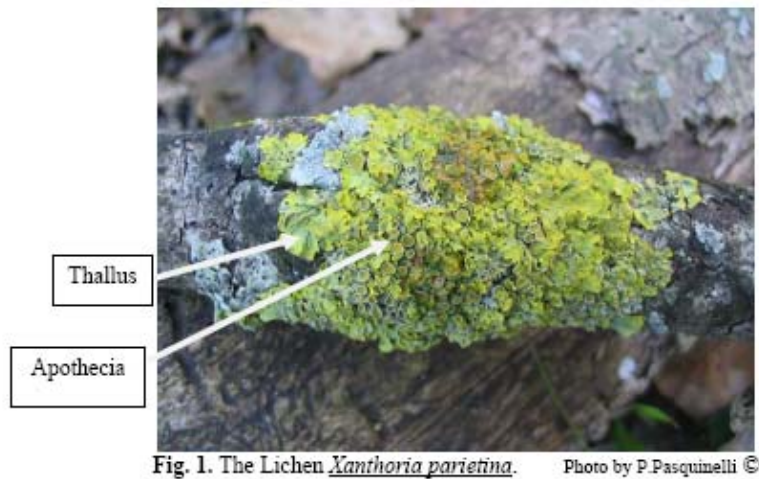
Consequently, the adoption of Giannantoni's new mathematics for the analysis of the complex systems allows us to insert the qualitative evaluation into the quantitative calculation with the purpose to appreciate it in the presence of some dynamic aspects typical of living systems. That analysis contains the concept of the *incipient derivation* or (a-priori derivation) to substitute the “a-posteriori derivation”. This fact consents us to carry, into a dynamic state, some rules of Emergetic Algebra to which Math's complexity texts refer.

To get a feel to those previous considerations we remember what G. Monastra wrote in 2000 on the book “The Origin of the Life”: “Probably we need new innovative analysis methods and especially a new type of mathematics will be necessary to explain more living structures” (8).

1. A Type of Symbiosis

Among the examples considered as fundamental to knowledge and to validate the content of the previous considerations we chosen two keywords which can well respond at the need opportunity: “Symbiosis” and “Photosynthesis”.

For a Biologist who reads these words is easy to find a correspondence from the keys and Lichens. In fact the Lichen Symbiosis is a representation of the good co-operation of two organisms fungus and alga (mycobiont and phycobiont) forming a complex dynamic system where the photosynthesis is the best condition indispensable to the growth and survival of these two partners (9).



The lichen and its structures are represented in Fig.1 where we can distinguish a vegetative tissue also called "Thallus" (vegetative growth) and many spherical structures (Apothecia) useful for the sexual reproduction. Apothecia contain the spores for the diffusion of the Species around the environmental substrates (land or barks). The yellow-green color is due to the photo-symbiotic alga *Trebouxia*.

2. Graphical Representation of the Symbiosis

The lichen symbiosis, already described in its naturalist definition, can be represented like a graphical image of a social system where two partners collaborate in obliged way to live utilizing the external solar energy and other appropriate input as reported in Fig.2.

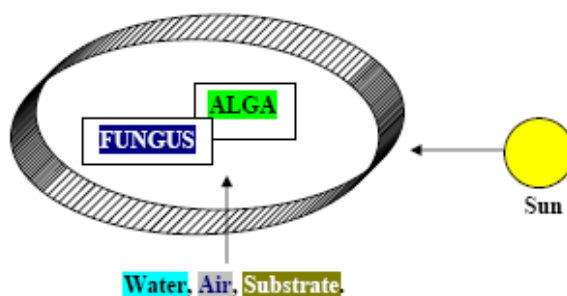


Fig. 2. A possible graphic of lichen symbiosis © Paolo Pasquinelli

The representation in Fig.2, very schematic, shows how the life conditions of two organisms (fungus and alga) depend on the following physic elements: sunlight, water, air and substrate. To well understand this living system we must

consider that each of these components is measurable alike by physics units and by complicated thermodynamic input-output fluxes of energy. What remains undeterminable and difficult to knowledge are the "living state" and the "behavioural adaptation" that represent the achievement, the maintenance and the preservation of the biodiversities. Therefore, using an expression adaptable to the Social Sciences, we courageously can represent the symbiosis as an example of "natural welfare" developed since the first appearance "pioneer community" of vegetal life in the Heart Planet.

It is very complicated to explain how the collaboration between two organisms, unicellular alga and ascomycetes fungus, both set at the lower levels of the evolution pyramid, reach the success when, on the contrary, human systems at a major level, do not co-operate or sometimes they have the tendency to eliminate themselves (i.e. the tribal ethnic struggles inside the same group of population).

3. The Photosynthesis: An Essential Condition for the Lichen Symbiotic Life

If we consider the Photosynthesis as the evolutionary process, based by the use of solar energy, fundamental for developing and surviving of the Heart Planet, this requires to pay attention to the mechanisms that the vegetal living systems have organized as a consequence of this enormous availability energy. This adaptability shows an excellent capacity to maintain the biodiversity of the Species, to enhance themselves, when compared to what Humans are able to destroy in the environment. The alternance of light and dark is also an opportunity of the development of the photosynthetic organisms. In fact, as is well known, the photosynthetic process consists in two phases -light and dark (also called independent by light) - where Carbohydrates and Oxygen are synthesized from Carbon Dioxide and Water in many complicated enzymatic steps (10).

From the sociological point of view, it is not hazardous to define the lichen symbiosis as mutuality relationship or better altruistic-auto conservation due to the generosity to feed themselves (symbiotic organisms) and other living creatures. The organisms that exercise solidarism to perform a constructive association like the symbiosis also show to have a major resistance to the stress. Of course these two partners, even if each of the two maintains its peculiarity well distinguished, are able to develop a great solidarism. It is our opinion that

this condition seems owed by a great number of information contained in their DNA which suggests a mechanism of adaptability to a social aggregation more useful for two than one single organism.

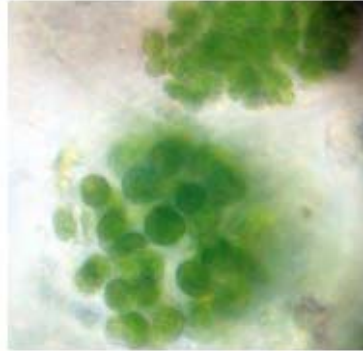


Fig.3. Unicellular alga *Trebouxia*. Photosynthetic activity. Photo by F.Puccini,P.Pasquinelli ©

The cellular components and their structures, especially Tylacoids with Chlorophylls are able to activate the photosynthesis (10) which consents to give carbohydrates to the fungus and to produce Oxygen to add to the atmosphere gases. In different way, the fungus gives mineral salts to the alga by hyphae absorption from the substrate. All of that is completed when the conditions of light and humidity are fitting to maintain their activities.

If we consider the case when the two organisms are in activity, and if we admit that the air (gaseous components) and the substrate are constants which do not interfere in the process analysis, we can conclude that variables of the system are the light and the water represented in different value. In last synthesis it is evident that the fungus can live also in absence of light, on the contrary the alga needs both light and water to have a good activation.

4. Performances Useful to Develop a Natural Lichen Symbiosis

Giving a value to the environmental needs of the partners of the symbiosis and simplifying the analysis of this state, we can decide to discriminate the importance and the dependence of the lichen viability in function of the two parameters light and water.

Environment	Lichen partners
Light	Alga
Water	Alga & Fungus

Tab. 1. Environmental dependence of the lichen partners © Paolo Pasquinelli

If we consider the parameters (light and water) in Tab.1, we can deduct that the alga is the predominant organism in the symbiosis. Similarly the water is the chemical-physical the most important component of which alga and fungus need. In fact in microclimate scenarios of potential high-dryness and elevated temperature of the air, the symbiotic functions have a great decreasing on the metabolism. Then they reach a steady state of growth, even if the global radiation on the upper lichen surface was excellent to activate the photosynthesis. As soon as the humidity condition will come suitable, the photosynthesis restarts immediately. This fact opens, so we think, an interesting chapter: the intermittence functions on the living organisms (in this case we call "intermittence" the restart of the activities dependent by photoperiod and relative humidity). All of that gives us the confirmation, in addition to what already known, that the water is "Mater vitae". At this point, coming back to the main topic of this paper "The value of the Quality", it is necessary to put a question and to give a suggestion for the answer:

Q.: What can we consider as the best aspect, as far as the quality of the symbiosis is concerned, to be dealt with the incipient differential calculus?

A.: The answer is very complicated, so we limit to suggest: "The Photosynthesis"

5. The Qualitative Approach

With reference to the living aspect of the energy transformation by the photosynthetic organisms it is necessary to deconstruct the complex system in more simple pathways useful to choice the way very interesting for a Thermodynamically (11) and Emergetic point of view.

The photosynthetic process presents, at a cellular level, fluxes of charges (electrons and protons). This condition is typical for those irreversible transformations which originate many qualitative and precious levels of growth. To have an evaluation of those energetic fluxes some researchers use the methodology QEM (Quality Equivalent Methodology), considered as being valid

to solve the problem of the quality of the energy (12). This method consists in the application of a very complicated system of linear equations to describe the complexity of the energy fluxes in ecology and economy fluxes. The solution of these equations depends on the determination of the quality factor β (vector) for each type of energy and also by the vector Φ which represents the coefficient of the efficiency fitting for each process of the studied system.

Every process of the lichen symbiosis must necessarily be well known to have acceptable results in energetic balance.

Because of this paper only represents a preliminary approach, we propose a simplified study which attempts at introducing the arbitrary efficiencies between the partners of the lichen symbiosis. In fact we describe one of the steps of that methodology concerning the efficiency: "Quality-Adjusted Process Efficiencies". In this particular case we consider the solar efficiency to produce the biomass of the lichen equal to 1 as the arbitrary unit of reference (13). It is then possible to propose that subject in the following Table 2.

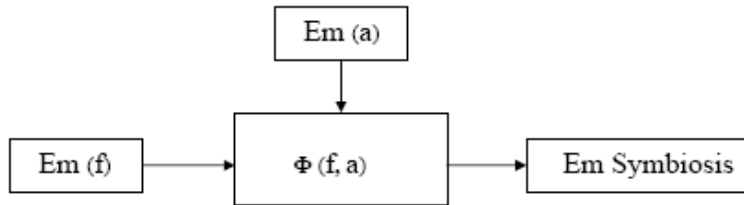
Type of the Energy Feed	Process	Arbitrary Efficiency Φ
Solar	Lichen biomass	1.00
Water (f.alga)	Photosynthesis	0.96
Solar (f.alga)	Photosynthesis	0.93
Water (f.fungus)	Solute transfert	0.89

Tab.2. Arbitrary efficiencies relatively to each process in the lichen symbiosis © Paolo Pasquinelli

It is evident that the irreversible processes of the lichen symbiosis, shown in Tab.2, have different efficiencies from i.e.: (water function of alga for the photosynthesis) and (water function of fungus for solute transfer). Overall this fact is important if we take into account of the fitting of input and output that the energy quality can bring. That quality is represented by the choices derived from the information contained on the DNA of each vegetal cell committed to the photosynthesis.

Again in tab.2, the different value between the arbitrary efficiency of the alga $\Phi=0.96$ and the fungus $\Phi=0.89$ put in evidence the two ways of the use of the energy feed. Consequently the difference of two data of this parameter (Φ) differs of 7% in efficiency. This allows us to think that the major ability of the symbiosis resides in the photosynthesis process. Of course, from the physiological point of view, the photosynthesis contains a much more high complexity than the simple ions transfer (14). Obviously if we must calculate the absorbed energy without consider the qualitative aspect, the alga could be an

advantage in Energy of a rate $(0.96/0.89) = 1.08$. So we like to consider the quality of this living system as an advantage which could increase and favourite so much the developing symbiosis.



Tab.2. A Possible representation of the Energy on the lichen symbiosis pathway

Where $Em (f)$ and $Em (a)$ represent the inter-active fluxes of Energy necessary to the growth of the fungus and the alga respectively. If $\Phi (f, a)$ is the expression of the efficiency of the interaction system, so $Em Symbiosis$ is the final product of the Energy process. Necessarily, in this pathway, the constant equivalence of the input-output of the whole system must be respected.

6. Fractal approach

My experience in Environmental Science and in Visual Arts, allows us to put attention to the macroscopical structures of the lichen *Peltigera polidactila* (Fig. 4) of which growth develops in fractal form. The fractal units are represented as trimarginate border of the small leaf even if unseptate (Fig. 5).



Fig.4 *Peltigera polidactila* Fractal growing. ©
Collection and Photo by Paolo Pasquinelli



Fig.5 *Peltigera polidactila* Fractal unit ©
Collection and Photo by Paolo Pasquinelli

If we have to reduce the lichen to a geometric representation of fractal unit we must use an approximation by several irregular polygons (from triangle to hexagon) useful to rich the repetitive images.



Fig. 6 Geometrical representation of the fractal unit. Artistic elaboration by the author ©

In Fig.6 we used the method of "box counting" which consists to cover the set by geometric elements. If we adapt the equilateral triangle as the geometrical unit to calculate the dimension of the fractal we have a simple situation similar to the "Koch snowflake" where the dimension of the fractal is $d = \log 4 / \log 3$ equal to 1.26. Very complicated and not easy to solve is the case of the lichen growth surface where it is impossible to cover only by a monofractal system. In fact we are in the presence of a multiscaling fractal quantity which imposes to know the boundaries of each part of the set. In a good approximation it could be similar to a little more $d > 1.26$ which will be better assessed soon.

7. Conclusions and Future Work

In this paper we pointed out that the major expression of the intrinsic quality of the living systems consists in the survival processes useful for the diffusion and maintenance of the biodiversities. The Lichen Symbiosis is one of the examples where the quality expressions can emerge through the photosynthesis and the choice of the social aggregation (10). The incipient differential calculus can give a value to the qualitative aspects of the dynamic living systems. Also the comparison of the efficiencies of each process enables us to have an idea of how the solar energy is harmoniously distributed and utilized by the vegetal kingdom.

It is our intention to develop very soon a second step, where we will attempt at representing some examples of symbiotic socialization between human and animal Species.

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