

# Organizations and Autopoiesis: a Biological Perspective

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## Abstract

Organization studies have recently had plentiful new approaches and paradigms, such as the autopoiesis theory. Maturana and Varela developed the theory of autopoiesis – a biological theory of autopoietic systems – in order to explain the particular nature of living in the physical domain. Their main contribution has been to provide a concise specification of the defining characteristics of living systems, including humans. Several authors, especially the sociologist Luhmann, have tried to extend such theory to social systems, including organizations. Social systems are systems that are based on the interactions of living systems. The question therefore arises if organizations are also autopoietic systems. In this paper, this question and the relevance of the autopoiesis theory are discussed for understanding organizational changes and self-maintenance, from a biological point of view. Supported by the autopoiesis theory, organizations can be interpreted as networks of interactions, processes and rules of coordination.

**Keywords:** Organizations, Organizational Engineering, Autopoiesis, Autopoietic System, Self-maintenance.

## 1. INTRODUCTION

In recent years, new paradigms and approaches for organization studies have been developed. The general understanding of organizations (or enterprises) has been studied from a biological perspective, based specially on the theory of autopoiesis. However, the application of this theory, which was originated in biology, has been controversial. Hence, there is no clear agreement among organization scholars regarding the role or the place of autopoiesis in organization science.

Autopoiesis is a concept developed by two Chilean biologists, Humberto Maturana and Francisco Varela [1980], to denote a form of system organization where the system as a whole produces and replaces its own components, and differentiates itself from its environment. Their concern was not the explanation of the social systems or organizations, but rather to explain what is a living being. The main contribution of Maturana and Varela's [1980] work about autopoiesis was to present an understanding of the defining characteristics of living systems [Kay 2001].

Autopoiesis has been an extensive subject of debate and has been applied in several areas, such as sociology [Luhmann 1990], management [Hall 2003] and law [Teubner 1993; Teubner and Febbrajo 1992], among others. The application of this perspective to social systems is really an ongoing topic of debate [Kay 2001].

In recent years, several papers regarding autopoiesis in organizations studies have been published. Many authors have adopted such perspective to study organizations applying Maturana and Varela's work, as Luhmann, for example [cf. Luhmann, 1995]. Although, several authors have taken autopoiesis straight from the area of the biological sciences to organization studies, others have applied it to the qualified approach of Luhmann, who developed the social systems theory, or have even combined autopoiesis with other approaches [Magalhães and Sanchez 2009]. Some authors are reluctant in applying autopoiesis to social systems, since Maturana and Varela wrote that autopoiesis is not a social theory. In the literature, Luhmann's social systems theory is identified as the predominant adopted approach of autopoiesis to social systems [Fuchs and Hofkirchner 2009].

Aveiro [2010] considers there is a lack of concepts and methods in Organizational Engineering (OE) for a continuous real-time management of organizational changes, through a continuous update of organizational models. In organizations, a large amount of time is wasted in dealing with unexpected exceptions, essentially because organizational models are not current or coherent with reality [Aveiro 2010]. The knowledge of organizational performance in real-time makes possible to empower all the human actors to strategically deal with organizational changes. Organizations are referred to as socio-technical systems. The active resources of an organization are: carbon-based actors (humans) and silicon-based actors (computers). In order to survive, organizations must adapt continuously to a changing environment. Emergence and unexpected exceptions are controversial when applied to organizations, due to the presence of cognitive agents. The mechanisms of emergence within organizations, which are social systems, can be expected to be different from those present in other natural systems. The application of the autopoiesis theory could explain this difference. There is also the need for a better understanding of the Organization as well as the Organizational Self-Awareness [Magalhães et al. 2008].

This paper discusses a new understanding of organizations from a biological perspective and contributes to answering the question: Are organizations autopoietic systems?

The rest of this paper is organized as follows. Section 2 is devoted to the autopoiesis theory, which outlines the basic concepts and main developments of autopoiesis, while section 3 applies them to organizations. Finally, the last section presents some concluding remarks and suggestions for future research.

## **2. AUTOPOIESIS**

Maturana and Varela [1980] proposed the concept of autopoiesis (from Greek: *autos* = self, *poiein* = to produce) as a definition of life. This theory was developed in order to provide an understanding of the nature and characteristics of living systems, namely biological cells and metacellular organisms.

The main idea of autopoiesis is that living systems are characterized by their self-production, which means that the components of the system produce the components of the system.

Therefore, the requirements for the maintenance of self-production limit the way in which individuals can interact with their environments. All components and processes of the system produce the same components and processes, which establishes an autonomous and self-producing entity [Mingers 1995]. According to Maturana and Varela [1992], autonomy is the key concept of living beings and is the ability to specify what is proper to them. Moreover, these systems can only be characterized with reference to themselves and whatever takes place in them is necessarily determined in relation to themselves, i.e, self-referentiality. Therefore, the mechanism that makes living systems autonomous is autopoiesis.

An autopoietic system exists as a network of relations and processes, which continuously produces the components that realize such network as a concrete unity. An organization can be viewed as a distributed network of carbon and silicon actors, dynamically evolving in real-time.

A significant implication of autopoiesis is the distinction between organization and structure:

- Organization is the relation between the components of the system and determines the identity of the system;
- Structure is the realization of a system's organization in a specific realization space [Maturana and Varela 1980].

The system constantly reproduces its structure and organization, and the continuous reproduction of the system's structure and organization is fundamental to living systems.

Maturana and Varela [1980] identified this phenomenon, autopoiesis, and defined it as the ability of a system to generate its specific constitution and its components (structure), and their interplay (organization) on its own. For instance, by analogy, an algorithm for solving a certain problem can be viewed as a description of the system's organization. From this viewpoint, the corresponding computer program can be viewed as the realization of this organization, i.e., the structure in a certain space. In this case, such structure is the programming language [Abou-Zeid 2001]. Therefore, all systems of a particular type have the same organization, but they can have different structures, and the structure may change without changing the organization. Hence, all living systems have the same autopoietic organization realized in an infinity of different structures. Zeleny [2005] interprets an organization as a network of interactions and processes, which are identified by its rules of coordination – organization – and differentiated by applying such rules of coordination under different conditions – structure.

The model of autopoiesis presented by Maturana and Varela is presented in Figure 1. The network of operations of a living system is closed, i.e., the system is operationally closed, and in its interaction with its surrounding environment it is structure-determined.

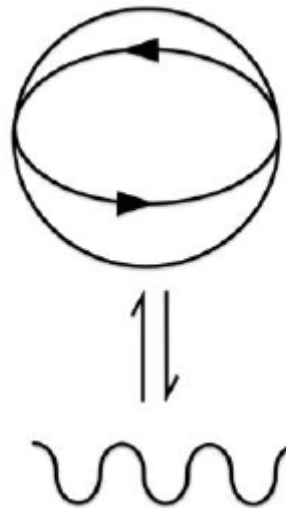


Figure 1 - Model of autopoiesis according to Maturana and Varela

From an autopoietic viewpoint, an individual's behaviour is determined by particular states of nervous system activity, which is defined by the concept of operational closure [Maturana and Varela 1980]. This presupposes that in all cases nervous system activity works in a closed cycle [Maturana and Varela 1980]. An environmental perturbation may act as a trigger for change, but the nervous system's structure always dictates which forces can be a trigger [Mingers 1991].

Autopoiesis generates a structural coupling (see Figure 2) with the environment: the structure of the nervous system of an organism generates patterns of activity, which are triggered by perturbations from the exterior, thereby contributing to the continuing autopoiesis of the organism. In other words, an autopoietic system can be viewed as a network of transformation and destruction processes and its components interact to constantly regenerate such network.

Therefore, autopoiesis is necessary and sufficient to characterize a living system [Maturana and Varela 1980].

Figure 2 shows the metabolic pathways of two autopoietic systems (circles/spheres) in the context of their surrounding environment. The reciprocating arrows between them show an interdependence that has developed over time. The structure of both systems and environment change as a result of mutual non-destructive perturbations.

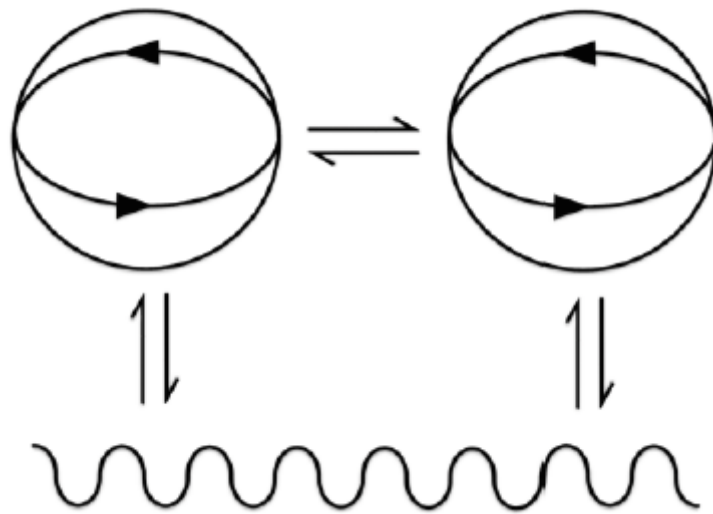


Figure 2 - Structural Coupling

Systems theory identifies that processing is the life function of all living systems, which is the act of sequentially selecting actions. Moreover, the selection can be considered as the fundamental operation enabling dynamic processing, and the potential actions are the basic building blocks dynamically chained to a process, as presented in Figure 3 [Thannhuber 2001].

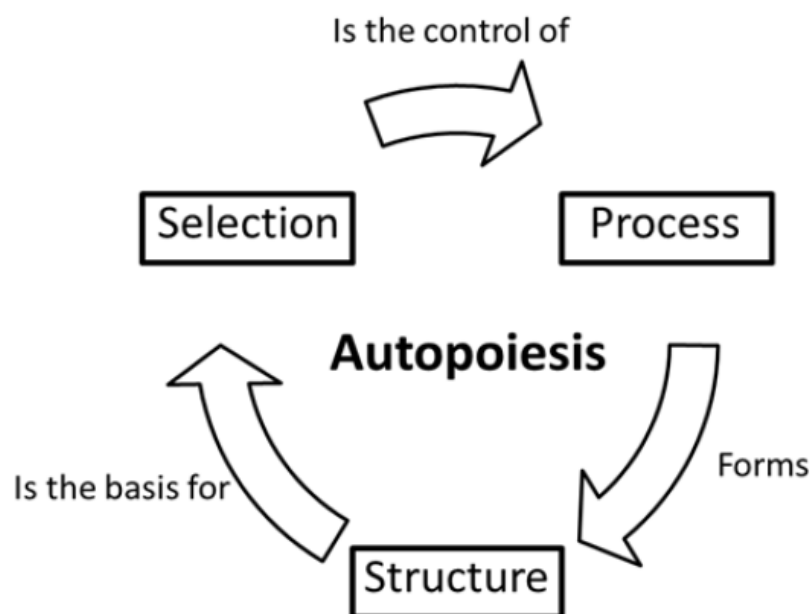


Figure 3 - Autopoiesis (adapted from Thannhuber et al. [2001])

Varela et al. [1974] enumerated six criteria, which have been discussed by other researchers (e.g. Hall et al. 2005) considered necessary and sufficient to recognize when a system could be considered to be autopoietic, as follows:

1. Bounded: the unity has identifiable boundaries;
2. Complex: the system is comprised of a set of components;
3. Mechanistic: the unity is a mechanistic system, which proprieties are generated by components' interrelations and not by components' individual proprieties;
4. Self-differentiated: the components forming the system's boundaries are intrinsically determined by their properties in the space of their interactions;
5. Self-producing: the unity generates the components of this boundary, either from existing components or by coupling of non-component elements from its environment;
6. Autonomous: all the unity's components participate in the production of its components.

If all these criteria are fulfilled, then the system is considered as being autopoietic.

### **3. ORGANIZATIONS AND AUTOPOIESIS**

There has been considerable debate regarding the application of the autopoiesis theory to social systems, including organizations. Indeed, the theory of autopoiesis provides ways of thinking about mechanisms of organizations.

In the literature, few authors incorporate the theory of autopoiesis directly on Maturana and Varela's original work, even as others have adopted Luhmann's social system theory [Goldspink and Kay 2009]. Additionally, other approaches have also been combined with the autopoiesis theory. For instance, the autopoiesis theory combined with the complexity theory has demonstrated profound implications about organizations [Kay and Goldspink 2009].

Nicklas Luhmann, a German sociologist, extended this concept of autopoiesis to establish a theory of social systems, which is based on the idea that human social systems were formed by recursive networks of communications. Luhmann's work of the theory of autopoiesis in social systems is a thorough and ambitious reworking of the autopoiesis theory. According to Luhmann [1995], the basic elements of social systems are not people but communications. This perspective has the advantage of describing the system in terms of its operational characteristics, independent from the specific participants in such system as well as from time. We consider the exclusion of humans from social systems as the main problem of such theory.

The autopoiesis theory gives a comprehensive of living beings from the simplest unicellular organisms (first-order unities) to the most complex multi-cellular organisms (second-order unities), and it extends beyond organisms toward “social systems” of animals or people (third-order unities). Social or business organizations are examples of third-order unities [Beeson 2009]. When applying the autopoiesis theory to organizations, we are considering the organization itself as a unit system to which autopoiesis might be ascribed.

Morgan [1997] identifies three main features of Maturana and Varela's theory of living systems – autonomy, circularity, and self-reference – and suggests that organizations can be seen as attempting to turn their environments into extensions of their own identity, which implies a focus on establishing the organization's identity.

Fuchs and Hofkirchner [2009] argue that social systems (including organizations) are autopoietic. However, they suggest an understanding that is human-centred and that humans permanently create the unity of human actors and social structures (human sociality). This means that their interpretation of social systems and autopoiesis departs from Luhmann's social system theory.

Organizations must to be able to produce their specific organizational dynamics, as a process of the adjustment of internal chaotic dynamics to the chaotic dynamics of the environment. This crucial survival process as a self-organizing ability is essential to a sustainable organization. An organization must guarantee that it has regulation capabilities to deal with exceptions, in order to have control and self-maintenance, and to be a self-sustainable system. When dealing with organizational complexity, managers need to understand what kind of strange attractors are naturally propelling the autopoiesis in their organizations as well as to find out what kind of activity can attract and concentrate the energy of their employees.

External perturbations from the system allow for its structure changes as long as these do not affect its operations, and guarantee the system's identity and closure. Biggiero [2001] argues that inputs cannot be distinguished from perturbations, and organizations' boundaries are not stable and independent, thereby such a perspective is not applicable to organizations.

If all the criteria presented in Section 3 are fulfilled, then the system could be considered to be autopoietic. However, an organization as a complex socio-technical system does not fulfil all of such criteria. The boundary of an organization is its unique language, which allows to distinguish an organization itself from its environment through a linguistic space. An organization is a complex and dynamic network of two kinds of active components: carbon-based actors (humans), and silicon-based actors (computers). These components communicate through the interactions among them. Therefore, we can consider that an organization is bounded, complex and mechanistic. System boundaries are internally determined in interaction with their surrounding environment. Nevertheless, organizations do not evidently produce their own components and

boundaries through the actions of its own components. Most organizations import ready-made components from its environment. From this viewpoint, organizations are not autopoietic systems.

We consider acceptable to apply autopoiesis in a metaphorical way to other systems, and in particular, to organizations. Many concepts of the autopoiesis paradigm may be useful and applicable to study social systems and organizations, such as self-organization, self-maintenance, self-reference, autonomy, operational closure and structural coupling.

Another relevant application of the Maturana and Varela's work, in the context of organizational studies, is the humans' capacity for reflexive self-awareness. Organizational Self-Awareness is of utmost relevance on OE. An organization is self-aware when all of its actors maintain a real-time synchronization of their individual organizational models and share the view of the "whole", which supports the organizational knowledge, allowing the actors to make better decisions and increase their autonomy [Magalhães and Tribolet 2006].

Integrating autopoiesis with systems theory through the principles of dynamic systems is another approach to study of organizations as systems. Regarding the dynamic aspects of an organization, we can consider three feedback loops: (1) Feedback loop 1: stable model; (2) Feedback loop 2: model configuration change owing to a changing environment; and (3) Feedback loop 3: need for a new and suitable model due to a radical change [Tribolet et al. 2014]. In organizations, the constant change and continuous adaptation require a representation that allows to capture the overall picture of the system as an unit in all its dimensions and complexity. In this sense, an organization maintains its capability to govern itself, static and dynamically, through an informed and intelligent action of the actors, based on the Enterprise Cartography [Tribolet et al. 2014].

#### **4. CONCLUSIONS**

The theory of autopoiesis has been demonstrated to have philosophical implications for our thinking about organizations. Despite its popularity, autopoiesis theory has not achieved the expected profile in the field of organization studies.

The main contribution of this work is theoretical and it helps to answer a long standing controversial question among researchers: Are organizations autopoietic? Concisely, our position is that, applying directly the autopoiesis theory, organizations themselves cannot be considered autopoietic systems. However, we consider that many concepts of the autopoiesis theory are useful to explain the operating system of organizations, and the autopoiesis can be metaphorically applied.

This work suggests that autopoiesis may be used as a backdrop for a new organizational and management paradigm. Hence, autopoiesis also appears to introduce a multidisciplinary approach to management by



introducing biological thinking. The theory of autopoiesis can really guide managers and provide a better understanding about operations of their organizations, in order to avoid wasting time and resources.

Further work is necessary regarding autopoiesis and organizations. Besides more theoretical research is needed in this direction, autopoietic concepts can contribute in a practical way to organization management. Moreover, we consider that autopoiesis and OE have several concepts that can answer to organizational challenges. Applying the autopoiesis metaphor and the concepts of OE it is possible to develop an adequate organizational self-maintenance's framework that can make adjustments to quickly adapt to organizational perturbations, in order to maintain the control of the organization when such changes occur. We consider that the conception, implementation and maintenance of information systems in organizations should be based in the presented perspective. Additionally, for instance, given its holistic nature, autopoiesis can provide a suitable framework for the integration of IT/IS into organizations.

Future research is also needed to study the underlying dynamics of the change process, to better understand how organizations as a system are or should be developed, and how they grow.

Then, we can explain the successes and failures of organizations, and also define resilience strategies in order to control perturbations in organizational systems.

## REFERENCES

- Abou-Zeid, A.-S., "Toward an Autopoietic Approach for Information Systems Development", in M. Rossi and K. Siau (Eds.), *Information Modelling in the New Millennium*, Idea Group Publishing, Hershey, 2013, pp. 34-52.
- Aveiro, D.S.A., G.O.D. (*Generation, Operationalization & Discontinuation*) and Control (sub) organizations : a DEMO-based approach for continuous real-time management of organizational change caused by exceptions, PhD thesis, Universidade Técnica de Lisboa, 2010.
- Beeson, I., "Information in Organisations: rethinking the autopoietic account", in R. Magalhães and R. Sanchez (Eds.) *Autopoiesis in Organization Theory and Practice*, Emerald Group Publishing, Bingley, 2009, pp. 185-200.
- Biggiero, L., "Are firms autopoietic systems?", in Van Der Zouwen, G. and Geyer, F. (Eds.), *Sociocybernetics: Complexity, Autopoiesis, and Observation of Social Systems*, Greenwood, Westport (Ct), 2001, pp. 125-140.
- Fuchs, C. and W. Hofkirchner, "Autopoiesis and Critical Social Systems Theory", in R. Magalhães and R. Sanchez (Eds.), *Autopoiesis in Organization Theory and Practice*, Emerald Group Publishing, Bingley, 2009, pp. 111-129.
- Goldspink, C. and R. Kay, "Autopoiesis and organizations: A biological view of organizational change and methods for its study", in R. Magalhães and R. Sanchez (Eds.), *Autopoiesis in Organization Theory and Practice*, Emerald Group Publishing, Bingley, 2009, pp. 89-110.
- Hall, W.P., "Organizational autopoiesis and knowledge management", Presented, ISD '03 Twelfth Int. Conf. Info. Syst. Dev., Melbourne, Aust., 25-27 Aug, 2003.
- Hall, W.P. P. Dalmaris and S. Nousala, "A Biological Theory of Knowledge and Applications to Real World Organizations" in *Proceedings, KMAP05, Knowledge Management in Asia Pacific* Wellington, NZ 28-29 November 2005.

- Kay, R., "Are organizations autopoietic: A call for new debate?", *Systems Research and Behavioral Science*, 18, 6, (2001), 461-477.
- Kay, R. and C. Goldspink, "Autopoiesis: Building a Bridge between Knowledge Management and Complexity", in R. Magalhães and R. Sanchez (Eds.), *Autopoiesis in Organization Theory and Practice*, Emerald Group Publishing, Bingley, 2009, pp. 233-242.
- Luhmann, N., *Essays on Self-reference*, Columbia University Press, New York, 1990.
- Luhmann, N., *Social systems*, Stanford University Press, Palo Alto, CA, 1995.
- Magalhães, R. and J. Tribolet, "Engenharia Organizacional: das partes ao todo e do todo às partes na dialéctica entre pessoas e sistemas", in S.G. Costa, L.M. Vieira and J.N. Rodrigues (Eds.), *Ventos de Mudança*, Editora Fundo de Cultura, Rio de Janeiro, Brasil, 2006.
- Magalhães, R. P. Sousa and J. Tribolet, "The Role of Business Processes and Enterprise Architectures in the Development of Organizational", *Revista de Estudos Politécnicos, Polytechnical Studies Review*, Vol. VI, 9, 2008.
- Magalhães, R. and R. Sanchez, "Autopoiesis Theory and Organization: An Overview", in R. Magalhães and R. Sanchez (Eds.), *Autopoiesis in Organization Theory and Practice*, Emerald Group Publishing, Bingley, 2009, pp. 3-25.
- Maturana, H.R. and F.J. Varela, *Autopoiesis and Cognition: the Realization of the Living*, vol. 42, BSPS, Reidel, Dordrecht, 1980.
- Maturana, H.R. and F.J. Varela, *The tree of knowledge. The biological roots of human Understanding*, Shambhala Publications Inc, Boston, MA, 1992.
- Mingers, J., *Self-producing systems. Implications and applications of autopoiesis*. Plenum Press, NewYork, 1995.
- Mingers, J., "The Cognitive Theories of Maturana and Varela", *Systems Practise*, 4, 4, (1991), 319-338.
- Morgan, G., *Images of organization*, Sage Publication, Thousand Oaks, CA, 1997.
- Teubner, G., *Law as an Autopoietic System*, Blackwell, Oxford, 1993.
- Teubner, G. and A. Febbrajo, *State, Law, and Economy as Autopoietic Systems*, Giuffrè, Milan, 1992.
- Thannhuber, M. M.M. Tseng and H.-J. Bullinger, "An Autopoietic Approach for Building Knowledge Management Systems in Manufacturing Enterprises", *Annals of the CIRP*, 50, 1, (2001), 313-318.
- Tribolet, J. P. Sousa and A. Caetano, "The Role of Enterprise Governance and Cartography in Enterprise Engineering", *Enterprise Modelling and Information Systems Architectures*, 9, 1, (2014), 38-49.
- Varela F.H. Maturana and R. Uribe, "Autopoiesis: the organization of living systems, its characterisation and a model", *Biosystems*, 5, 4, (1974), 187-196.
- Zeleny, M., *Human systems management: Integrating knowledge, management and systems*, Singapore: World Scientific Publishing, 2005.