

# KNOWLEDGE AND SELF-PRODUCTION PROCESSES IN SOCIAL SYSTEMS

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## Short Contents List

1. Introduction
2. Social Systems
  - 2.1. Free Market "Invisibility"
  - 2.2. Social Kinship Networks
  - 2.3. Boundaries of Social Systems
3. Autopoiesis (Self-Production) of Networks
  - 3.1. Organization and Structure
  - 3.2. Organizational Embedding
  - 3.3. The Role of Feedback
  - 3.4. Summary of Autopoiesis
4. Knowledge As Coordination of Action
5. Model of Autopoiesis
6. Autopoietic Social Systems
  - 6.1. Self-sustainability
  - 6.2. Regional Enterprise Networks
  - 6.3. Amoeba Systems
  - 6.4. TCG Triangulation Networks
  - 6.5. Bat'a System of Management
7. Individuals in Networks

## Glossary of specific terms

**Autopoietic systems** are capable of producing and reproducing their own organization.

**Allopoietic systems** are capable of producing (and trivially reproducing) their own structure, not their organization.

**Heteropoietic systems** produce something else than themselves.

**Organization** is the network of rules of coordination. Organization drives the structure and structure follows organization.

**Structure** is a spatio-temporal arrangement of components and outcomes.

**Autopoiesis or Self-production** is a process generated through a closed organization of production processes such that the same organization of processes is regenerated through the interactions of its own products (components).

**Knowledge** refers to a purposeful coordination of action.

**Information** refers to symbolic description of action.

**Communication** occurs when received information is followed by action.

**Self-sustainable systems** are autopoietic and must be organized for autopoiesis.

**Sustainable systems** are heteropoietic because their sustainability comes from planned, system-sustaining activities of external agents.

## Summary

This article explores the fundamental differences between natural (spontaneous) and human engineered (designed) social systems. While man-made systems can be sustainable, natural systems must be self-sustainable. The differences between sustainability and self-sustainability are emphasized. Social systems are viewed as being knowledge producing and knowledge renewing networks. Social systems, especially economic systems, are based on recursive interaction and communication across the networks of participating components-agents. Spontaneous social systems are *self-producing (autopoietic)* networks while externally designed systems are only heteropoietic (producing) and often allopoietic (non-sustainable). Not all social systems are produced by social engineers or designing agents. Most effective and lasting networks are self-produced and self-sustainable. Self-producing systems or networks are called *autopoietic systems*. Autopoietic systems are governed and coordinated by internally embedded rules of behavior or rules of conduct (their organization) rather than by external commands, orders or instructions. *Organization and structure* of a system are two distinct and crucial categories that should not be confused or confounded. *Organization refers to the network of rules of coordination*. Organization drives the structure, structure follows organization. Organizationally closed systems are self-renewing; organizationally open systems are self-limiting. Self-organizing and self-managing systems, like spontaneously emerging and self-renewing cooperative networks, must be *organizationally closed* but informationally open to their environment. There are no “closed” (i. e. isolated, non-communicating) systems. Autopoietic social systems are organizationally closed and structurally open – self-renewing corporations and networks – are structurally coupled with their environment. This phenomenon of self-production can be observed in living systems. Although all living systems are autopoietic, not all autopoietic systems are living. However, all autopoietic systems must be social systems. In other words, all autopoietic, and therefore all biological (living) systems, are social systems. Because system organization is a circularly closed network of process-coordinating rules, then *system knowledge* (and its linguistic embedding) is defined as *purposeful coordination of action*. Knowledge producing systems are based on action and thus fundamentally different from data or information producing systems. Sustainability and self-sustainability are directly related to system organization and its self-production (autopoiesis). *Self-sustainable* systems are autopoietic and must therefore be organized for autopoiesis. Allopoietic systems necessarily deplete their environment. Self-sustainable systems must maintain their ability to coordinate their own actions – producing knowledge.

## 1. Introduction

Social systems are essentially knowledge producing and knowledge renewing networks. Knowledge production lies at the very core of all human systems and is therefore instrumental to their self-production, systems change and self-renewal. In this article we link the theory of knowledge production with the self-production (autopoiesis) and self-sustainability of social systems.

In current global information age, it is important to establish the differences between information and knowledge, information and data and knowledge and wisdom. Without such distinctions and proper definitions, the New Economy cannot be properly understood and its knowledge managed. We shall understand knowledge to be purposeful coordination of action and information as a symbolic description of action. This brings action, change, doing and performing into the center of social self-production.

New organizational patterns are not hierarchies but *networks*. Networks are predominantly rules-based rather than authority-based social orders. Rules of behavior and conduct, rather than commands and orders, are producing, maintaining and renewing network systemic cohesiveness.

To initiate, maintain and manage networks or network corporations requires a different set of skills, techniques and practices than those for traditional hierarchies. *Autopoiesis* offers the new theory of system self-production. In the world of global competition, it is increasingly less important what products systems produce and increasingly more important how systems produce *themselves* (i. e., how do they renew their own ability and capacity to produce). *Catalysis of action*, rather than just management, is the requisite coordination skill in networks. Autopoiesis is the organizational theory of networks.

## 2. Social systems

Social systems, particularly economic systems, are based on interaction and communication of components-agents. These agents, through their interaction, engage in coordinated and recursive action, producing knowledge as a requisite input for their subsequent action. Economic agents themselves are defined and produced only through their participation in social networks. They can have sole existence outside the networks that produced them. In reverse, through their interaction, these agents continually produce and reproduce the very networks that produced them. Social systems are self-producing (autopoietic) networks.

We can define social systems as renewable, self-producing networks characterized by internal (rather than external) coordination of individual action brought about by communication among network temporary agents-members. The key words are *coordination*, *communication*, and limited *lifespan* of individual agents.

Coordinated behavior includes both cooperation and competition (and all forms of conflict). Actions of predation, altruism, and self-interest are examples of different modes of coordination. Communication is physically, chemically, visually, linguistically, or symbolically induced deformation (or in-formation) of the environment – leading to individual and coordinated action in shared environment.

For example, an individual can coordinate his own actions in the environment only if they are coordinated with the actions of other participants in the shared network. In order to achieve this, one has to in-form (deform or change) the environment so that the actions of others is correspondingly modified. That is communication. As all other individuals are attempting to do the same, a *social network of coordination* emerges and, if successful, it is being "selected" and persists. Such a network improves one's ability to coordinate one's actions within the environment. Cooperation, competition, altruism, and self-interest are inseparable.

Social systems include human systems, but are not limited to them. Human beings simply in-form a specific meaning to the universal acts of coordination, communication, and birth-death processes in *general social systems*.

A group of fish thrown together by a tide wave is a passive aggregation, not a social system. A swarm of moths lured to a porch light is an active aggregation, but not a social system. A flag-pattern of athletes constructed through bullhorn-shouted commands from a coordination center is a purposeful heteropoietic aggregation, not a social system.

All of these can transform into social systems as soon as *internal* communication patterns leading to coordinated action become established. Such patterns should temporarily persist (become autonomous), even after removing the external causes or triggers. Externally induced and externally

driven interaction of components is not sufficient: billiard balls interact and so do wind-blown grains of sand - they are not social systems.

Human waiting queues are often engineered and externally induced (enforced, not voluntary) interactions. To a large degree however, they do exhibit, at least temporarily, the voluntary self-organization characterized by its own specific behaviors, rules of conduct, choice of distance and modes of communication. So do schools of fish, swarms of bees, flocks of birds or packs of animals.

Any social system, in order to adapt and persist in its environment, must be capable of reshaping itself, controlling its growth, and checking the proliferation of individuals. In other words, the long-term persistence of a social system is critically dependent on harmoniously balanced birth and death processes. There can be no collective life without individual death.

Life of a social system, and thus life itself, is based on a dynamic and autopoietic harmony between birth and death processes. Life is necessarily a social phenomenon: the life of an individual cannot take place outside a social network, and the individual life itself must be socially embodied at the level of its components.

## **2.1. Free- market “invisibility”**

Free markets are spontaneously “organized” (self-organized, self-produced) networks of interacting firms and agents, while individual firms often remain islands of hierarchical order and command in the churning seas of spontaneous organization. Such firms are heteropoietically (externally) constructed or designed. Such man-made systems can be concatenated into networks *ex post*, even if they are not networks themselves. Market networks are dynamic and self-adjusting, but heteropoietic networks of firms are fixed and organizationally inflexible. Market networks are self-produced (autopoietic) while firms are merely produced (heteropoietic).

Free markets are not ordered by some mysterious “invisible hand”, but by very specific and highly visible *rules of conduct*. These rules of conduct form market *organization*. Short-term and invariant market organization (rules of conduct) drives the ever-changing, continually adjusting market *structures* (firms and institutions).

It is not that markets are “invisible” and governments “visible” hands of social orders, but rather that markets are autopoietic (self-producing) and governments (and firms) are heteropoietic (other-producing) agents of social orders. Free markets are *networks by definition*, continually self-producing and reshaping themselves. Current corporate networks are still mostly man-made approximations of the real self-producing, self-sustainable and self-adapting networks of the market. To overcome this limitation, network member firms have to be *internally organized* according to free-market principles and rules of conduct, forming the self-sustainable (regional, national or global) “web of webs”.

*Intracompany markets* are triggered by social engineering, but become natural enablers of flexible, adaptive and dynamic redefinition and reengineering of intercompany linkages – of *intercompany market* networks. Firms will cease to be islands of design in the sea of market spontaneity.

## **2.2. Social kinship networks**

Kinship networks provide another examples of spontaneous social orders. A kinship system constitutes an autopoietic system that is produced and maintained through the organizational rules (which could be codified) of a given society or culture. No matter what is the particular mix of its components (men, women, and children), the kinship system organizes its social domain and

coordinates its social action in a spontaneous and self-perpetuating fashion. It must continually adapt to the external challenges and interferences by governments, social engineers and social reformers.

Social networks, embodying kinship systems, are not static and unchanging structures, but highly dynamic ones. Studies of kinship systems established that the distribution of different types and roles of network participants (kin, friends, neighbors, formal ties) remains relatively stable, even though the names and faces of network members keep changing. In the language of autopoiesis: It is their organization that remains stable, while their structures and components continually adapt and change. Viewing families and kinship networks as autopoietic systems could lead to new understanding of the effects of residential mobility, divorce rates, death and disease disruptions, and loss of employment.

It was F. A. Hayek who first integrated concepts of self-production into social systems. Hayek wrote that although the overall order of actions arises as the joint product of the actions of individuals, the production of the overall order is not the conscious aim of individual action. The individual will not have any knowledge of the overall order.

Consequently, the individuals in a society spontaneously assume the sort of conduct and evolve the rules, which assure their continued existence within the whole. Their conduct and rules must be compatible with the preservation of the whole. Neither the society nor the individuals could exist if they did not behave in the self-preserving manner.

### **2.3. Boundaries of social systems**

In kinship social systems the boundaries are well defined. The distinction between family and non-family members is rarely ambiguous or subject to fuzzy interpretation. A definite family boundary can be established, even though it is not necessarily topological. Topological boundary is not necessary for autopoiesis but *connect* the system with its environment. They are not just "perimeters" but functionally constitutive components of a given system. Boundaries range from phospholipid bilayers, globular proteins, osmotic precipitates, and electric potentials, through cell layers, tissues, skins, metabolic barriers, and peripheral neural synapses, to laterally or upwardly dispersed boundaries of territorial markers, lines of scrimmage, social castes, secret initiation rites, and possessions of information, power, or money.

Social systems are physical systems because their components realize the network of productions in the physical domain (their components are cells, termites, lions, adult humans, employees, members, etc.). Computer simulations of autopoietic systems show that topological boundaries become visible to humans only when the minute rates of production processes are finely adjusted and harmonized. In other words, the underlying organization of processes has to be "tuned up." Otherwise, human observer might not be able to "see" or recognize any "topological" boundary. Yet, the organization remains functional and invariant and autopoiesis continues even if human observers do not see any boundary – the system remains autopoietic.

### **3. Autopoiesis (Self-Production) of Networks**

With the advancement of Internet, telework, telecommunications and remote knowledge sharing, we are witnesses to the emergence of distributed, self-produced and self-renewing networks or ecosocieties, interdependent communities of businesses, individuals and groups. Many social networks emerge spontaneously, i. e., produce themselves through the rules-driven, recursive interaction of their own components. Not all social systems are machine-like or mechanistic

contrivances produced by external agents, designed, controlled, planned, predicted, engineered and reengineered incessantly. Most new networks are self-produced and self-sustainable.

For example, consider the development of open-source software, like Linux operating system. Once the software core was “seeded” on the Internet, it started functioning as a catalyst for further programming action of many persons, who contributed their own ideas, effort and improvements, sharing their work freely with one another. With no centralized metadesigner, Linux has emerged as a spontaneous joint creation of thousands of people, spawning a worldwide community of Linux providers and users.

Self-producing networks amount to communication and action-based *ecosocieties* (or ecocommunities), self-sustainable in their environment, coordinating their own action, creating their own language, making sense of their surroundings, interpreting its signals and producing survival-enhancing decisions.

The process of self-production is called *autopoiesis*, contrasting with heteropoiesis (production of the “other”). Self-producing systems or networks are referred to as *autopoietic systems*. Autopoiesis or self-production can take place when there are autonomous individuals or agents interacting and communicating in a specific environment according to specific organizational *rules of conduct and interaction*. On a lower level, also biological (living) systems are similarly autopoietic, based on coordination and communication of their components.

### 3.1. Organization and Structure

Business “organization” has become a misnomer because it does not allow us to distinguish between main network concepts of *organization* and *structure*. It is with the labels like *network “organization”* where the inability to separate organization from structure becomes a self-inflicted wound of organizational theory. We shall use labels like *business corporation* and *social system* in order to move the organizational research into its network stage, past the habitual labels. *Business corporation* can now have *both* organization and structure

Any dynamic system must be based on the notion of dynamics-generating process (or processes), not on the notion of function. Function is a purpose, goal or objective externally assigned by the observer, not internally constitutive of the system. Business system is defined by its key processes, or core competencies of production, service, transportation, transformation, communication, and so on. These processes require *coordinated action*, which are coordinated sequences of real (not merely represented) activities, operations, exchanges and transfers.

Coordination is traditionally carried out by command or instruction (go there, do this) and in the new economy *by rules* (if this, then do that), covenants and habits – all embedded in the requisite *language* of coordination. Processes are therefore not only coordinated but also concatenated into interrelated sequences and chains, forming complex and cross-dependent linkages of parallel and sequential processes – producing *networks of coordinated processes*.

The network of interrelated processes is driven and recursively coordinated by the rules of behavior, including response, cooperation, competition and communication. Order-command leads to non-recursive, externally driven one-time action (go there, do that), while rules assure internal replication and recurrence (if this, then do that).

#### 3.1.1. Concepts and definitions

Identical processes (networks of processes) can be coordinated by different rules (systems or networks of rules). It is the system of the rules of coordination, rather than the processes themselves, which define the nature of recurrent execution of coordinated action. Recurrence is the necessary condition for learning and knowledge production.

The network of rules of coordination is that what distinguishes and defines the *organization* of a business corporation or system. ***Organization refers to the network of rules of coordination.***

Every object, every corporation and every system is organized and characterized by its organization. Because any organization, being a network of rules, drives and replicates system action, it is at the foundation of system dynamics, executing and replicating its action.

*Structure* is fundamentally different from the network of rules of coordination (organization). It refers to the spatio-temporal distribution of outcomes or products of the rule-coordinated processes. Structure is a specific manifestation of the underlying organization within the specific context and conditions under which the rules were applied. The same organization (rules of coordination) can be manifested in a number of different structures. The same structure could only by chance or serendipity emerge from different organizations. Organization gives rise to structure, as action gives rise to outcome. ***Structure is a static “snapshot”, spatio-temporal arrangement of components and outcomes***, a manifestation of the underlying recursively dynamic organization of processes and their rules of coordination.

**Example.** Consider a chair. Its organization is a set of rules that make it distinguishable and recognizable as a chair and not a table or dresser. How do we recognize chair? By its organization, from the way it is put together: the legs (or base), the seat and the back are related according to certain rules. Back is more or less perpendicular to the seat, no table has the back, all chairs do. “Chairs” without backs are seaters or benches, not chairs. Organization allows us to recognize any chair as a member of the family or *identity class* of chairs. Structure here refers to a particular and specific manifested *form* of the underlying organization: material (wood, plastic, metal), curvature (linear, bent, ornate), padding (soft, hard, molded), incline (straight, reclining), etc. Structure allows us to recognize this particular chair, my chair, your chair, Morris chair. While organization refers to the identity class of chairs, structure refers to a specific, particular member of that class. The same is true for trees, dogs, persons, societies and, of course, institutions and corporations.

The common notion of *function* is fundamentally different from both organization and structure: function is *imputed externally* by an observer, more or less autonomously. An observer can stand on a chair, sit on a table, kneel on a bench or sleep on a billiard table - there are no limits to function. Corporation can serve as a Laundromat for dirty money. *Function defines neither organization nor structure, nor is it defined or implied by them.*

Corporations are identified by their organization (network of rules of coordination) and differentiated by their structure (specific spatio-temporal manifestations of applying the rules under specific conditions or contexts). Every corporation has its organization *and* its structure. The two are not the same. These two concepts should not be confused or their distinction blurred if the study of corporations and other social institutions is to proceed and progress.

Why is the blurring or ambiguity of the two concepts inadmissible or even dangerous? In order to understand and study the dynamics of a system (corporation), one has to first understand and study its organization, not its structure. One has to study the cause, not the outcome. If one wants to change a system (or corporation), one has to first change its organization (rules of behavior), not its structure (the arrangement of components and outcomes).

Changes in organization lead to changes in structure, *but not vice versa*. Changes in structure do not lead to changes in organization. *Organization drives the structure, structure follows organization. The observer imputes function.*

Confounding the three concepts of corporate organization, structure and function amounts to a self-imposed limitation. Organization, as a network of rules, if executed, leads to the recurrence and self-replication of the coordinated processes. In order to achieve recursive behavior, organization cannot be linear and open-ended, unidirectionally traversing from input to output, but it must be “closed upon itself”, i. e., *circular* and thus *organizationally closed*.

**Organizational closure** is a prerequisite for self-renewal, self-replication and recursive regeneration of the system. The coordination of processes in organizational closure assures that the same network of processes and their coordination rules is produced again. Thus, not any set of rules, but only a circularly “closed” set of rules brings forth the self-perpetuation and self-sustainability of a system. *Organizationally closed* system produces itself: it recursively recreates its own network or processes and rules of coordination that produced it. *Organizationally open* system is linear and unidirectional: it does not produce itself, it does not recreate the network of rules and processes that produced it. It “spends” itself in one direction and has to be repeatedly and externally triggered and re-triggered by either command or feedback. Without renewing the external trigger-input, it would exhaust its potential and cease its activity or production.

Organizationally closed systems are self-renewing; organizationally open systems are self-limiting. Self-organizing and self-managing systems, like spontaneously emerging and self-renewing cooperative networks, must be *organizationally closed*.

### 3.2. Organizational Embedding

The requirement of *organizational closure* should not be confused with the simpler and mostly artificial notion of so called “closed” and “open” systems in the traditional systems theory or theoretical physics. There are no environmentally “closed” systems. Organizationally closed system is not “closed to its environment”, nor is it somehow insensitive or irresponsive to environmental signals and perturbations. Organizationally closed systems thrive on active, highly evolved and often intense environmental interactions. Rules-driven systems, lacking external command and information feedback, persist only through their effective adaptation to external perturbations.

Environmental perturbations, signals and triggers affect the structure of the system. System's organization, being closed in the sense of self-consistency, is not that easily perturbed. Autopoietic system is not only open to its environment (like through a specific feedback channel), but it is closely and intimately *coupled with its environment*. We can conclude that such a system is *structurally embedded* in its environment, while remaining organizationally autonomous and closed. Only organizational autonomy and stability, combined with structural adaptability and environmental coupling, can assure system's persistence in a chaotic and inchoate environment.

Rose is a rose is a rose ... Chair remains a chair, even when its structure is continually remade to fit the circumstances. Wolf remains a wolf even though it sheds and “remakes” its coat with changing seasons. Harvard remains Harvard and IBM remains (hopefully) IBM even if their components and structures are continually adapting to the changing circumstances. *Self-renewing corporations are organizationally closed and structurally open*. A rabbit survives in a harshly changed environment not by ceasing being a rabbit (dissolving its organizational closure), but by changing and adapting its structure (coat, food, reflexes and preferences). Corporation survives through maintaining its organization (closure) while adapting its structure by coupling it better with its sustaining environment.

One should see, after some reflection, that it is the *organizationally open* systems (hierarchies, command systems, input-output and information-feedback mechanisms) that are less responsive to their environment, structurally more rigid and thus less adaptable. It is the *organizationally closed* systems (self-renewing networks, markets, and spontaneous social orders) that are more “open” to their environment, crucially depending on their structural embedding within it.

### 3.3. The Role of Feedback

We should elaborate on the role of feedback. Feedback is often considered to be a crucial link with the environment, assuring the “openness” of the system via (symbolic) information linkages.

Any system that is separated from its environment by nonpermeable boundaries or information filters, can “read and calculate” its environment only through symbolic, interpretational *information feedback*. Such feedback often provides the only link or channel of communication with the environment. Without such a “channel” the system would become a “foreign body” within its own environment.

This is why hierarchical command systems - organizationally open and structurally closed – must be equipped with the infrastructure of channels that is redolent of feedback. Data collection, data interpretation, information gathering, questionnaires and polls, special information channels, special information processors, consumer research, promotion, calculations and modeling, are main connections penetrating the otherwise impermeable boundaries.

Strong presence, large variety and technological effectiveness of information feedback are the best evidence of system’s relative “closure” and its essential separateness or “decoupling” from the environment.

Organizationally closed and structurally open systems do not depend on specific channel processing of symbolic information. Structurally embedded systems respond to *action itself* (to information), not to a symbolic description of action (information).

Responding to action is a sign of structural coupling, responding to the description of action is a sign of information feedback.

Expressed more succinctly, through managerial conventional wisdom: “It does not matter what they say they’d do; what matters is what they actually do.” The difference between action and its description is clear, as is the difference between feedback and structural coupling of a corporation.

Organizationally closed systems respond to coordinated action and do that by structurally coupling themselves with their environment. Organizationally open systems can only respond to information (description of action) feedback *because* they are not structurally coupled with their environment, but are essentially separate from it.

**Example.** We can gather the information - through feedback - about consumer preferences: flavor, container size, consistency, level of expected demand and shelf life of, say, yogurt. Then we respond to this environmental “signal” by producing the requisite containers, flavors, quantities, etc. Our level of separation from the environment remains high and essential. Or we can couple the system with the environment of its consumers: allowing the consumers to become part of the production process and allowing them to express their preferences directly through the action of choice. That would mean choosing the flavor, container size, quantity and consistency (of yogurt) directly, through completing the production process and not far from the point of consumption.

While such *mass customization* is based on action and structural coupling, traditional mass production is based on the description of action and information feedback, on the separation from the environment. Traditional hierarchies of command are dependent on mass consumption and

production, consumer research, forecasting and anonymous “shelf transaction”. Self-renewing corporations and networks thrive on mass customization, prosumerism, on-line responsiveness and fully individualized (non-anonymous) market transaction.

Structural coupling of corporations with their environment is an important concept, going way beyond the traditional feedback. Structurally coupled corporation responds to action, not to its description or prediction.

### 3.4. Summary of Autopoiesis

Varela, Maturana, and Uribe have initially introduced the concept of autopoietic systems in biology. An autopoietic system has been defined as a system that is generated through a closed organization of production processes such that the same organization of processes is regenerated through the interactions of its own products (components), and a boundary emerges as a result of the same constitutive processes. Autopoietic organization is conceived as an autonomous unity of a network of productions of components, which participate recursively in the same network of productions of components, which produced these components, and which realize such a network of productions as a unity in the space in which the components exist.

Such organization of components and component-producing processes remains relatively invariant through the interaction and turnover of components. The invariance follows from the definition: if the organization (the relations between system processes) changes substantially, there would be a change in the system's categorization in its identity class. What does change is the system's structure (its particular manifestation in the given environment) and its parts. The nature of the components and their spatiotemporal relations are secondary to their organization and thus refer only to the structure of the system.

System's boundary is a structural manifestation of the system's underlying organization. The boundary is a structural realization of the system in a particular environment of components. In physical environments this could take the form of a topological boundary. Both organization and structure are mutually interdependent.

The concepts of the autopoietic nature of a system were developed in terms of a living (biological) system as a model of self-production. Yet self-production has the potential to mean and be interpreted through many different ways by a variety of observers. "Autopoiesis" has been coined (not translated from Greek) as a label for a clearly-defined interpretation of "self-production." This phenomenon of self-production can be observed in living systems. A cell, a system that renews its macromolecular components thousands of times

nonliving systems abound and form precursors to living systems.

*All autopoietic systems must be social systems.* In other words, all autopoietic, and therefore all biological (living) systems, are social systems. Also, the topological boundary, that has been necessary to describe an autopoietic system within a favorable environment of physical components (such as those within and around a cell), may not necessarily take a physical form in other types of systems, e. g., in social systems.

In social systems, dynamic networks of productions are being continually renewed without changing their organization, while their components are being replaced; the birth or entry of new members replaces perishing or exiting individuals. Individual experiences are also renewed; ideas, concepts and their labels evolve, and these, in turn, serve as the most important organizing factor in human societies. The organizing core for the implementation of ideas must be the emergent society as an autopoietic entity.

Autopoietic systems can persist in their autopoiesis for many decades (humans, trees), for many days (cells) or for mere flashes of hours, minutes, seconds, or milliseconds (osmotic growths). The "lifespan" of autopoiesis in no way enters (or should enter) into its definition. Autopoiesis is bound to exhibit gradation: it does not "jump" into being in magic instant - it becomes. It also gradually degrades itself as the processes of autopoiesis weaken and dim more or less rapidly.

#### 4. Knowledge as Coordination of Action

Structurally closed corporations are producing knowledge; structurally open corporations are producing data and information. The difference is fundamental. System organization is a circularly closed network of process-coordinating rules. Because system knowledge (and its linguistic embedding) is defined as a *purposeful coordination of action*, system organization is the source of production, renewal and depository of system knowledge.

While information, a description of action, is just input into organizationally open, linear input-output system, knowledge is the *action itself*, coordinated by organizational rules.

Modern corporations have to draw a clear distinction between action and its description, i. e., between knowledge and information.

We can say that we *have knowledge* when we can coordinate our action purposefully; we *have information* when we have a (symbolic) *description* of action and its coordination. Information is input, knowledge is the process itself. Knowledge producing systems are fundamentally different from data and information producing systems. The former are rules driven, organizationally closed and structurally open, the latter are the opposite: command driven, organizationally open and structurally closed.

In this sense, any corporation serves a twofold purpose: 1. To produce and consume something else than itself, i. e., output, product, service or information - through its *heteropoiesis*; and 2. To produce and consume itself, i. e., its own ability to coordinate action, in order to produce goods, services or information - through its *autopoiesis*. In order to produce something, a corporation has to be first able to *produce itself*, i. e., recreate and renew its own ability to produce, to coordinate its own action. Producing a product presents different focus and different challenges than producing the knowledge necessary for producing that product.

Like with any living organism, in order to produce the "else" - product, replica, and copy - a corporation has to produce the "self", its main prerequisite for producing "the other". The self-production of a corporation, its ability to coordinate its actions, is autopoiesis. At certain stages, it is heteropoiesis that dominates business concerns: what, where, how much and when to produce. At other stages, it is autopoiesis that dominates the focus: how and why to produce *anything, anywhere, anytime*. Information is the input of heteropoiesis; knowledge is the stuff of autopoiesis. Autopoiesis is the prerequisite of heteropoiesis, not vice versa. Modern corporation (self-renewing network) produces knowledge first and its product second. Traditional hierarchy produces product first and the knowledge-production is left to spontaneous forces, not explicitly managed and not even viewed as a main competitive advantage.

At the dawn of the third millennium, the world has changed fundamentally. It has moved from information to knowledge, from organizational openness to organizational closure, from feedback to structural coupling, from hierarchy to network, from commands to rules and from heteropoiesis to autopoiesis. Business and economic systems are no longer viewed as machines and contrivances

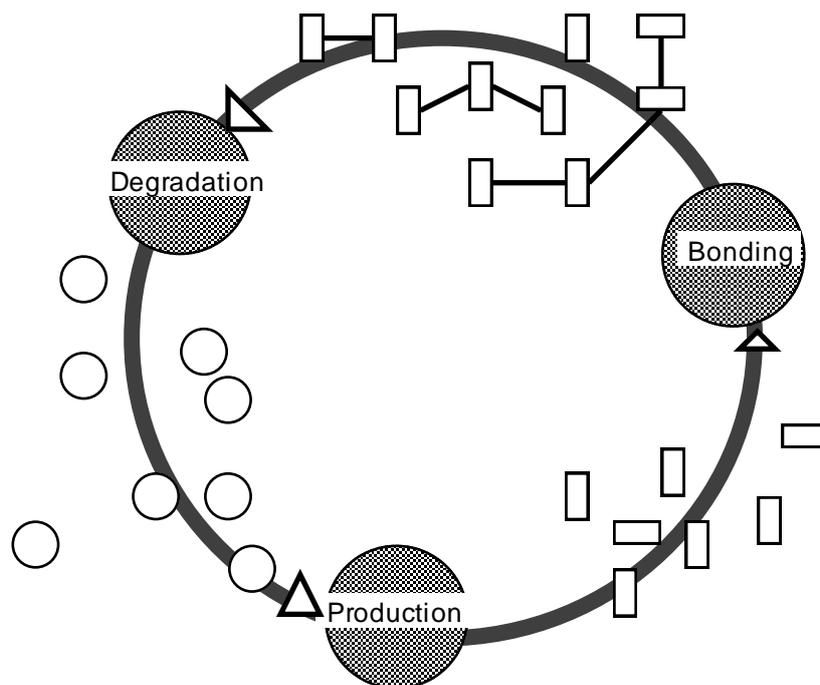
(products of heteropoiesis) but as organisms and ecologies of organisms (products of autopoiesis).

## 5. Model of Autopoiesis

Autopoietic organization is defined as a network of interactions and processes, involving at least the processes of:

- 1) *Production (poiesis)*: the rules and regulations governing the entry of new components, such as emergence, input, birth, membership, acceptance.
- 2) *Bonding (linkage)*: the rules governing associations, arrangements, manufactures, functions and positions of components during their tenure within the organization.
- 3) *Degradation (replenishment)*: the rules and processes associated with the exit or termination of membership like death, separation, consumption, output and expulsion.

In Figure 1, the three poietic processes are interconnected into a *cycle of self-production*. Observe that all such circularly concatenated processes represent productions of components necessary for the subsequent processes, not only the one labeled as "production." Although in reality hundreds of processes could be so interconnected, the above three-process model represents the minimum conditions necessary for the autopoiesis to emerge.



**Figure 1.** Circular organization of interdependent processes and their "productions"

An organization becomes autopoietic if *all three* types of constitutive processes are well *balanced* and function *in harmony*. If one of the three types is missing or if one or two types predominate (out-of-balance system), then the organization can either be heteropoietic or allopoietic, i. e., capable of producing only "the other" rather than itself. For example, production and bonding without requisite degradation would quickly deplete the environmental substrate and come to developmental halt, like crystals and crystallization. Production and degradation without effective bonding would lead to ephemeral and oscillatory systems, and so on.

Any self-sustaining system will have the processes of production, bonding and degradation concatenated in a balanced and harmonious way, so that the production rate does not significantly exceed the replenishment rate, and vice versa. *Self-sustaining systems will be autopoietic in an environment of shared or common resources.*

## 6. Autopoietic Social Systems

Autopoietic social systems, in spite of their rich metaphoric and anthropomorphic meanings and intuitions, are simply networks characterized by *inner coordination (or harmony) of individual actions achieved through communication among temporary member-agents*. The key words are coordination, communication, and limited individual life span. Coordinated behavior includes *both cooperation and competition*, in all their shadings and degrees. Actions of predation, altruism, and self-interest are only examples of different and interdependent modes of coordination. Communication could be physically, chemically, visually, linguistically, or symbolically induced *deformation (or in-formation)* of the environment and consequently of the individual action taking place in that same environment.

So we, as individuals, can coordinate our own actions in the environment only if we coordinate it with the actions of other participants in the same, intersecting or shared network. In order to achieve this, we have to in-form (change) the environment so that the actions of others are suitably modified; *we have to communicate*. Communication without action is just information processing. As all other individuals are attempting to do the same, a *social network of coordination* emerges, and, if successful, it is being "selected" and persists. Such a network improves our ability to coordinate our own actions effectively. Cooperation, competition, altruism, and self-interest are inseparable.

### 6.1. Self-sustainability

Any self-sustainable system must secure, enhance and preserve communication (and thus coordinated action) among its components or agents as well as their own coordination and self-coordination competencies. Systems with limited or curtailed communication can be sustained and coordinated only through external commands or feedback; they are not self-sustaining. *Hierarchies of command are sustainable but not self-sustaining.*

Consensual (unforced) and purposeful (goal-directed) coordination of action is knowledge. Self-sustaining systems must be organized so as to continually "produce themselves": their own capability of their own action coordination. Even though we often talk about sustainable systems, it is the *self-sustainability* of systems that is of real interest. The question is not How can *we* sustain a given system, but How can a system sustain *itself* in a given milieu?

Sustainability and self-sustainability are directly related to system organization and its self-production (autopoiesis). How are systems organized is much more important than how its individual agents think or what values they uphold. *Self-sustainable* systems are autopoietic and must therefore be organized for autopoiesis. Merely *sustainable* systems are heteropoietic because their sustainability does not come from within (from their own organization) but from without: from planned, system-sustaining activities of external agents. *Non-sustainable* systems are allopoietic, i. e., they are organized to produce things other than themselves. Allopoietic systems necessarily deplete their environment.

Heteropoietic systems can be sustainable as long as external agents sustain their system-sustaining efforts. Only autopoietic systems replenish their own environment and thus can become self-

sustaining. Self-sustainable systems must maintain their ability to coordinate their own actions – producing *knowledge*. Self-sustaining systems must be knowledge producing, not only labor or capital consuming entities.

In summary, the presented view of sustainability can be characterized as follows: both sustainability and self-sustainability are time and context dependent system properties emerging from system organization. System organization must be continually produced or renewed via operating a common, shared resource system, optimally managed through competition and collaboration of agents. Continued functioning of the organization requires continued coordination of action, i. e., continued production of knowledge. Most systems can be sustained over long periods of time through an external supporting, agent disbursing ideas, effort, money or resources. Once this external agent withdraws its support, system's sustainability can be directly challenged. *Externally sustainable systems do not have to be internally self-sustainable*. Any relationship (External agent ---> Sustainable system) can be transformed into a *self-sustainable metasystem* (External agent <---> System). While an external agent can in principle make any system sustainable, only an integrated agent-system can become self-sustainable: through making the external agent an internal part of the system.

## 6.2. Regional Enterprise Networks

Regional enterprise networks (REN) of small and medium businesses must be self-sustainable in their own environment. Increasingly, modern electronic networks enable small businesses to tap into the global reservoirs of information, expertise, and financing that used to be available only to large companies. Even individual agents become empowered through this process, and gain significant autonomy that enables them to participate in the autopoiesis of temporary corporations.

Free markets connect business agents into networks quite spontaneously, based on trade and other exchanges of mutual interest. In these tacit networks firms remain interconnected on the basis of short-term collaboration in order to execute transactions, recurrently establishing, canceling and re-establishing their multidirectional relationships. Such networks are dynamic, reshaped and reformed according to changing contexts, interests and conditions.

The industrial districts (ID) of Italy are local hypernetworks based on autopoiesis and innovation. A good example is the Prato region. In 1970s, a failing textile mill was broken into eight separate companies and major portion of the equity sold to key employees. This was the seed, which had catalytic properties: by 1990, more than 15,000 small textile firms (averaging less than 5 employees) were active in the region. Textile production has tripled while the textile industry has declined in the rest of Europe.

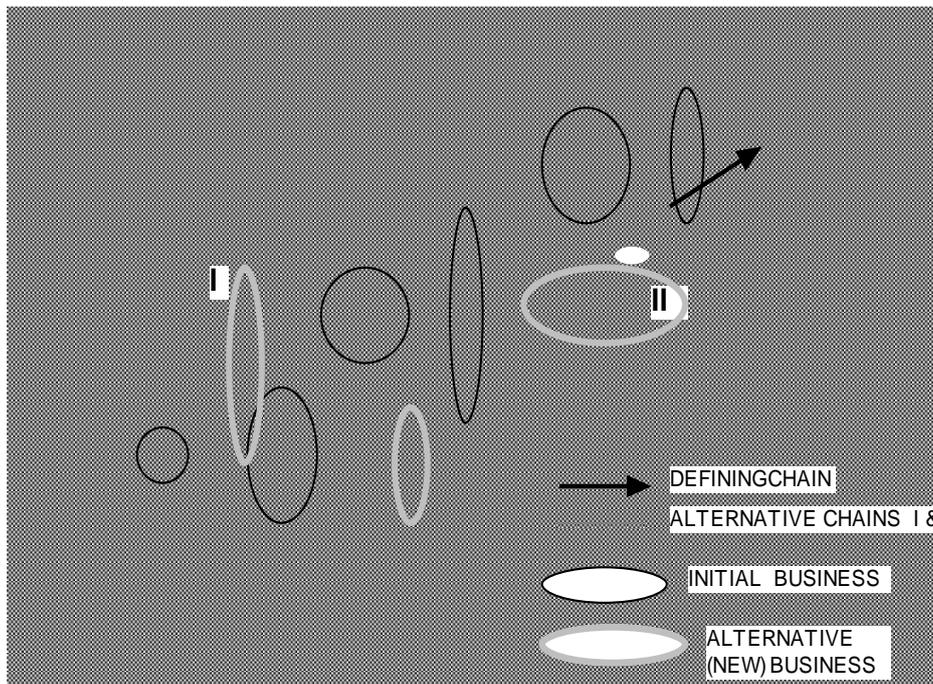
What is at the core of ID success? The answer appears to lie in the mastering and controlling the entire customer-supplier value chain, that is, the entire production process. The ID small businesses are not just separately scattered competing units, nor are they simple appendices to large companies or conglomerates. Instead, they respond to customer markets directly, through activating linkages most suitable for specific customization. They emerge, persist and disintegrate according to alternative manifestations of customer-supplier value chain.

In Fig. 2, the chain (or network) of small businesses covering the defining (initial) value chain is sketched. As the alternative chains develop (in response to new customers, technologies or products/services), like chains I and II in Figure 2, the original businesses lose the competency to “cover” all activities of such newly concatenated process sequences. A space for new businesses or business expansions has opened and is flexibly filled. Some original companies, unable to adapt, may go out of business, their knowledge agents reabsorbed into newly emerging units. As long as

the ID responds and “covers” the ever-changing chains, the network remains self-organizing (autopoietic) and self-sustaining.

It is the chain- or process-induced productive synergy, which distinguishes ID from a simple collection of scattered, independent businesses.

There are many types of network organizations, driven by different goals and purposes. Some of them are simple tax/financial alliances, others aim at sharing or controlling the market. There are networks that are “covering” the entire value chain and are flexible and adaptive enough to maintain and expand their “coverage” through dynamic reshaping of their own linkages - such networks survive and prosper.



**Figure 2.** Industrial-district formation along the value chain

Such dynamic networks are capable of directly competing with the superlarge companies of global competition. Networks of small businesses and regional enterprise networks represent a newly emerging mode of production, well suited for global competition, innovation, flexibility and knowledge production - they have a potential to become autopoietic (self-producing) and thus self-sustainable in an ever-changing global environment.

Autopoietic industrial districts have to adapt to the global environment and adopt the ways of strategic mass customization, knowledge production and development of intracompany markets. Mass customization will allow them to reach new and changing customers on a global scale, knowledge production assures innovation, sharing and propagation of knowledge along the chain or network, and intracompany markets make these businesses flexible, efficient and highly productive. Whatever socio-institutional arrangements can bring forth and strengthen these three basic requisite competencies will stay at the core of ID future success

### 6.3. Amoeba Systems

The self-sustaining organization has found its corporate embodiment in the “amoeba system” of Kyocera Corporation. The "amoebas" are independent, profit sharing and semi-autonomous teams or departments of three to fifty employees. Each amoeba performs its own statistical control, profit system, cost accounting and personnel management. Amoebas compete, subcontract, and cooperate

among themselves on the basis of the intracompany market characterized by real market-derived transfer prices.

Depending on the demand and amount of work, amoebas can divide into smaller units or integrate with other amoebas into larger wholes. All amoebas are continually on the lookout for a better buyer for their intermediate products. Some amoebas can even produce the same or similar products or services. They are authorized, as in the famous Bata-system, to trade intermediate products with outside companies. If the internal supplier is unreasonable, the buyer-amoeba will search for a satisfactory supplier outside the company.

A most remarkable feature in the amoeba autonomy is the personnel trading. Heads of amoebas form alliances, lend and borrow team members, compete for experts and human resources – and so eliminate the losses caused by surplus labor. Kyocera's amoebas multiply, disband, and form new units according to the autopoiesis (self-production) of the enterprise. Amoeba division and breakup are frequent occurrences and are guided by the criteria of output and added value per hour and worker.

This concept of ultimate flexibility is best summed up by Kyocera's founding President Inamori: "Development is the continued repetition of construction and destruction", an insight extracted directly from the systems theories of autopoietic self-organization. Neither age nor training are essential for becoming the head of an amoeba - only the faculty for the job under the immediate circumstances. If unsuitable, amoeba heads are being replaced immediately.

Amoeba system represents quite a revolutionary step beyond the traditional Toyota "just-in-time" philosophy. At Kyocera, orders received by the sales department are passed directly to the amoeba of the final process. The rest of the amoebas in the preceding processes are then given a free rein in working out mutual contracts: the intracompany market takes over. Kyocera Corporation remains one of the most profitable companies in Japan.

### **6.3.1. Biotic amoeba analogy**

It is instructive to invoke biotic amoebae as a useful analogy to corporate amoebas described above. Amoebae or Cellular Slime Mold is a good example of autopoietic social system. The slime molds (Gymnomycota) are an example of a fungus-like protist. They are decidedly fungus-like at some stages and animal-like at others. Their life cycle includes an amoeboid stage and a sedentary stage in which a fruiting body develops and produces spores.

In *Dictyostelium discoideum*, the vegetative cell is amoeboid. Amoebas are individual cells moving around in search for bacteria to feed on. They will grow and divide indefinitely. Often they digest so much and produce new amoebas so rapidly that their food supply has no chance to replenish itself. When the food supply has been exhausted, they move rapidly to a central point, collecting themselves into a well-differentiated spontaneous aggregation (center cells, boundary cells, etc.) – a pseudoplasmodium. The aggregation is triggered by the production of cyclic adenosine monophosphate (AMP) which attracts other amoebas in a chemotactic fashion.

The group then assumes the shape of a "slug" with a head, tail, and an apparent "purpose": searching collectively for a new, potential source of food. Around the outside is secreted a mucoid sheath (aggregate boundary). It migrates as a unit across the substratum as a result of the collective action of the amoebas. The changing of the roles of individual amoebas is prevalent; the original leaders who formed the center of attraction are dispersed throughout the "slug", and new leaders emerge, forming the "goal-seeking" head.

The head of the home hunting "slug" is formed of the fastest-moving amoebas. The "slug" is just a spontaneous temporary metaorganism, preserving each amoeba as a separate individual. The slug is positively phototactic (migrates toward light), and it usually migrates for a period of hours. Its behavioral responses are essential "to ensure" that the spores will be borne in the air and so can be effectively dispersed.

Fruiting body formation begins when the slug ceases to migrate and becomes vertically oriented. The amoebas change quickly from the first to the last. The head of the slug forms the base of a stalk which follower-amoebas continue to build (they secrete cellulose to provide rigidity) up into a mushroom-like metaorganism. At its top, hundreds of thousands of amoebas differentiate into spores that are embedded in slime and, after the mushroom "head" matures, it bursts. It disperses the spores to new and potentially nourishing environments. When they fall to earth, they change once again into the individual amoebas, which reproduce, by cell division. This ecological cycle is then repeated.

#### **6.4. TCG Triangulation Networks**

Australian TCG (Technical Computer Graphics) provides a good example of a self-producing network in a business-firm environment. There are no coordinating divisions, "leading firms", or management superstructures coordinating or "managing" TCG's twenty four companies; the coherence, growth and maintenance of the network is produced, according to J. Mathews, by a set of *network-producing rules*:

1. Mutual independence, binding firms through bilateral commercial contracts. This prevents the formation of an internal hierarchy.
2. Mutual preference among member firms in the tendering and letting of contracts.
3. Mutual non-competition among members, in order to establish requisite levels of self-denial and trust.
4. Mutual non-exploitation among members, based on "cost-plus" contracting, not on profit maximization.
5. Flexibility and business autonomy: no need for group approval of any transaction – if no rules are broken.
6. Network democracy without a holding company, "central committee", major owner, controller or formal governance structure.
7. Non-observance of rules leads to expulsion.
8. All members have equal access to the open market.
9. Entry: new members welcome, but financed by debt, not through drawing on existing group resources.
10. Exit: no impediments to departing firms.

The above ten rules constitute corporate covenant and autopoietic organization of TCG network. They insure that the network continually produces itself and maintains its coherence over time. There has never been a bankruptcy within the TCG network. In a changing environment, TCG network grows outwards and adapts to a global market place through a "triangulation process" of collaborative alliances and through spinning-off new companies. A triangle is a strategic alliance of <TCG + external company + customer>. The bonding and concatenation of "triangles" expands the network.

#### **6.5. Bat'a System of Management**

Bat'a-system of management is a prime example of an early knowledge producing, self-producing autopoietic enterprise. Tomás Bat'a discovered the enormous hidden powers of corporate

organization. He introduced a highly decentralized system that he termed *industrial autonomy*. Similar to Kyocera's amoebas, he divided his workforce into several profit centers, each consisting of about 50 shoemakers headed by a manager, to whom authority and responsibility were delegated. He drew up a profit-sharing plan whereby each group received premiums equal to as much as 25 percent of base salary for producing more efficiently. Bat'a believed that maximum profitability could not be achieved by strong central controls from above. He worked out a system of daily production plans for each workshop and a rapid reporting system that fed back hourly figures on the output of shoes from each stage of production. He introduced a sophisticated costing system that enabled every worker in the leather-cutting department to monitor his or her group's performance and a daily financial statement that gave immediate feedback on profitability. He posted all these figures so everyone would be fully aware of the company's results.

Bat'a wanted to turn each worker in the factory into an entrepreneur and a capitalist, who would constantly contribute new ideas on how to improve production. He decentralized quality control so that every worker was responsible for inspecting the work of the previous operation. This system eliminated repetition of errors, since they were caught as soon as they were made; and it created an atmosphere of peer pressure, which discouraged shoddy work by any operator. His goal of an organization that would function automatically had been achieved. The autonomy of local profit centers had evolved into a decentralized structure of autonomous operations, which functioned efficiently without any direction from the head office. The organization became self-producing, the system autopoietic.

The corporate structure constitutes only the passive and external component of corporate organization, the one depicted in organization charts. The corporate organization, its rules of behavior and conduct, establishes corporate character, individuality and autonomy. It imposes common rules, regulations, standards, and strategies on the various departments and divisions. It coordinates the activity of all the company's resources and integrates activities at different levels of the company to ensure smooth and harmonious operations. It translates knowledge into action. Autopoietic organization makes the corporation come alive. It allows an individual to become interested, motivated, overflowing with energy. Individual work becomes an avenue for personal growth. When an organization genuinely commits itself to the personal growth of individuals, it creates both the right inner motives and external conditions for such growth. The individuals come to identify their personal seeking more and more with the company's progress and find personal fulfillment by giving themselves to it through service.

## **7. Individuals in Networks**

Individuals are substantially defined by networks in which they are embedded. Also corporations can only be as good as the networks they are parts of. This is not true of only human systems. Every organism, even if spatially and temporarily isolated, can emerge, survive, and reproduce only as part of a larger societal network of organisms. Similarly, each cell, organelle, or neuron can exist only as part of a group or society of cells, organelles, or neurons. Each component of an autopoietic system can emerge, persist, and reproduce only within the complex of relationships that constitute the network of interconnected components and component-producing processes.

Survival (economic and ecological) activities of separate organisms *directly* form and reform their local communities of interactive populations that are further concatenated into regional networks and full ecosystems. Reproductive activities can take place only within co-produced and co-evolved networks and so assure *their own* (i. e., networks') reinforcement and self-production. Organisms cannot be separated (except through artificial cleavage) from their economic, ecological, or social environments which they themselves co-produce and mutually provide to each other. Only a temporarily disembodied human mind can imagine removing itself, even temporarily, from its social surroundings – from its own life base.

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## **Author Biography**

Milan Zeleny, Professor of Management Systems, Fordham University, New York, recently published *Handbook of Information Technology in Business*, for Thomson International, and *New Frontiers of Decision Making for the Information Technology Era*, for World Scientific. Current

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