Chapter 9
The Return of Philosophy: A Systemic Semiotics Approach

Berna Leticia Valle Canales

Abstract In this chapter, I review the nature of Systems Research to advance it as a way of doing complex and heterogeneous systems science. I examine semiotics and cybersemiotics as some of the thinking models that converge in systemics and describe the type of semiotic systems that can be studied with the Systems Research approach; as in the case of open systems and their transduction processes or semiosis. The representative systems of this kind comprise life and culture, yet, the study of society requires epistemic concepts of comprehensive scope, both philosophical and methodological, like the concepts in the cybersemiotic ontology and systemic-semiotic approaches. A brief comment on the relationship between systemic-semiotics and cybersemiotics is included in each section. Motivated by these ideas, the chapter's main tenet is to present a method to represent culture using network and graph models. The aim of this kind of representations is to understand how consciousness evolves within culture, in such a fashion that culture may be understood as an organism, as is postulated by cybersemiotics. Finally, the chapter closes with a discussion on the role of cybersemiotics and systemic-semiotics in the transdisciplinary thinking models, in particular within Systems Research.

Keywords Systemics · Philosophy · Semiotics · Information · Culture

9.1 Introduction

There is a consensus that establishes semiotics as the doctrine of all signs, but is there a parallel consensus within the science for Systems Research? Is Systems Research a science, a philosophy, or a methodology? What is the relationship between Systems Research, semiotics, and cybersemiotics? This chapter will elaborate on such inquiries in the following four sections. First, the section named "Is Systems Research a Paradigm?" offers a description of systemics as a fundamental change in the concepts and experimental practices for a number of scientific

B. L. Valle Canales (✉)
National Polytechnic Institute, Mexico City, Mexico

C. Vidales, S. Brier (eds.), *Introduction to Cybersemiotics: A Transdisciplinary Perspective*, Biosemiotics 21, https://doi.org/10.1007/978-3-030-52746-4_9

disciplines. We address the past 60 years as scientists have created new discourses about reality encompassing an integral, ecological, and holistic point of view, and following Thomas Kuhn's (1970) identification of the way in which the contemporary scientific worldview interconnects everything as a paradigm shift. In this sense, Systems Research is divided into three important categories: Systems Thinking, Systems Science, and Systems Engineering. Following this argument, the cybersemiotic approach serves as a Systems Thinking ontological foundation which studies consciousness. On the other hand, the systemic-semiotic approach is a foundation for Systems Science which studies semiosis.

The second part focuses on "Open Systems" and how a system is a point of view or a universe of discourse predefined by a reference frame. It consists of a set of general concepts conceived by humans as part of more or less identifiable patterns of coherence which are permanent in the real world (François 2004, p. 580). It is in this sense that the social sciences, the liberal arts, and the humanities are open systems. Social and cultural forces can change reality in many ways: energy into matter, matter into information, information into energy and matter, etc., in a process known as *transduction* by systemic-semiotics and cybersemiotics and which involves emerging properties occurring over non-living and living, intelligent systems (Laszlo 1987; Wilber 2001). Ashby (1961) described the transduction processes as transformation and exchange of variety. Other scholars, like Wiener (1954), Beer (1968, 1985), and Shannon (1948, 1949), suggested measuring this type of change within an information domain, and using entropy as a unit. Shannon stated that the goal of measuring entropy is to understand the actual state of a system. This section will also cover the interaction between systems with different amounts of variety, the transformation of matter, energy, and information within them, and how Ashby's law of requisite variety (1961) can be used to represent this type of changes. Separately, cybersemiotics tackles the problem through an interactive dynamic model between the universes of Peirce's phaneroscopy (Brier 2013).

A third section highlights "The Organization of Thought through Network Theory" and presents one of semiosis' main hypothesis: that intelligent systems organize ideas in network patterns which support entropy dissipation through an intricate interconnectivity, individual, and collective relations. Intelligent systems are networks fundamentally interconnected by semiotic organizations (Luhmann 1998). Thus, both the evolution and adaptation of cognitive subjects are actualized by semiosis because: (a) it habilitates the operations of consciousness which organizes pure, complicated, refined, sophisticated, accidental, etc. thoughts; (b) Intelligent systems could be understood as networks of semiotic systems networks, necessarily interconnected by semiosis; and (c) consequently, the systemic-semiotics' hypothesis postulates semiosis as its consciousness' unit of analysis.

Throughout this chapter, I will review the aspects of semiosis that enable an understanding as to why semiotics, semiosis, and cybersemiotics are part of the current epistemological foundations of Systems Research. Moreover, apart from whether specialists in the sciences of language and semiotics may or may not have reached a consensus, it is a fact that today's semiotics is part of the foundations of transdisciplinarity, systems sciences, systemics, and big-small sciences (Berg 2017);

all of these as components of Systems Research. Systems Research is a new way of doing science, sometimes called "postmodern" science, although in quite a different sense than the meaning of posmodernity in the liberal arts. The incorporation of semiotics and cybersemiotics as components of Systems Research occurred at a time when those disciplines were broadly fragmented and divided, in particular semiotics, and were confronted in open debate with formal linguistics. In other words, the rules of cooperation, and the consolidation of axioms and epistemic concepts about the processes of semiosis, surpassed a fragmented scientific community to such an extent that in some scientific circles it is often said that philosophy, its actions, and epistemic concepts, are extinct.

Transdisciplinarity, nonetheless, demonstrates how knowledge evolves for the benefit of intelligence in new environments. The inscription of semiotics within the foundations of Systems Science alongside meta-theories, meta-methodologies, ontology, epistemology, axiology, category theory, and praxiology, among others, situates it in its rightful position to answer a most important question: how and why do we signify reality? Semiotics, in the other hand, is the doctrine of all signs, and a sign is something that is in place of something else in any of its properties. This definition creates a path to understanding nature's randomness and poses the real phenomena as open problems. Under this view, semiotics integrates Charles Sanders Peirce pragmatic thinking and ideas. Then, Systems Research, cybersemiotics, and systemic-semiotics are very close to one another: cybersemiotics' scope is an important foundation of Systems Thinking because of its basis as a second-order cybernetics, rooted in human context and interest in intentionality, while a systemic-semiotics' scope is a foundation of Systems Science and is related to a first-order cybernetics.

9.2 Is Systems Research a Paradigm?

In semiotics research, there is an ongoing discussion as to whether cybersemiotics is a particular semiotics or a general semiotics framework. Its precedent and development come from biosemiotics, which was established in 1991 as a research area for general semiotics (Sebeok 1991), however, today it is considered a foundation of transdisciplinary research. Systems Research prevents cybersemiotics from being taken as a sub-area or discipline within language sciences. In this chapter, I consider that cybersemiotics is a discipline on its own right. I call this focus the systemic-semiotics approach in order to distinguish it from Umberto Eco's general and particular semiotics. Notwithstanding, there is a constant dialogue with cybersemiotics, because all theory needs a philosophical anchorage. The cybersemiotics ontology posits human consciousness as one of the foundations of evolution, thus, the ontological vision of all semiotics within Systems Research is that of an evolutionist perspective.

In the hard sciences, there are two ways of developing scientific knowledge: *big science* and *small science*. Berg (2017, p. 1504) provides notable examples of each.

Big science encompasses projects which cover multidimensional observations and have significant budgets, like the two Gravitational-Wave Observatories (LIGO), and the European Virgo interferometer. Both observatories separately observed the collision of two neutron stars in detail. According to Berg, these projects are the sum of decades of work and scientific experience. The detectors' observations gathered enough data to support several hypotheses and to produce new postulates within astronomy, physics, and other natural science disciplines. Thus, big science projects have clear objectives, stand on solid theoretical ground, and involve an exceptional group of researchers working on the supervision and improvement of the project.

Conversely, small science presents discoveries made through open-ended questions and hypotheses that have been developed within small or individual research groups, such as the theory of relativity, the Laser Interferometer Gravitational-Wave (LIGO) detectors, and theoretical concepts like black holes and neutron stars. All of these smaller but highly specialized discoveries constitute small science (Berg 2017, p. 1504). Systems Research is similar to transdisciplinary research inasmuch as it is achieved via clear research objectives and theoretical foundations that require a large group of experts or an immense body of knowledge, data, and diverse laboratory experiences. During the last several decades, scientists, philosophers, epistemologists, and those interested in the theory of knowledge, have identified transdisciplinarity as the common language across specialized scientific disciplines. Reality in each highly specialized scientific discipline had reached such a degree of complexity that an entire discipline had to be developed: Complexity Science, so as to integrate the discoveries in each discipline. This is what Systems Research, systemics, or transdisciplinarity really boil down to as new ways of thinking: sharing, contrasting, and communicating outcomes and experiences across specializations.

Complexity Sciences and the General Theory of Systems are the most widely known theory and methodology models in Systems Research, although there are new approaches like systems biology, systems medicine, systems psychology, and systems economics. Nonetheless, beyond Complex Sciences and Systems Theory, Systems Thinking praxis involves integrating theory and practice of scientific research. In the hard sciences, this refers to all of the practical efforts of creating holistic solutions to complex challenges. Systemics' concepts, principles, and methods are designed to integrate knowledge across the boundaries of traditional domains; that is, beyond the limits of small science. Nevertheless, different systemic approaches address different dimensions of complexity, be it social, technical, environmental, etc., and apply a gamut of frameworks, and widely varied techniques. For these reasons, there are contrasting terminologies across different domains of knowledge.

A systems' scales and taxonomies may seem to be similar, but research groups do not necessarily share the same principles that sustain each worldview, culture, and criteria (Singer et al. 2012). As a result, systems researchers find numerous subtle differences in each specialization. To tackle such difficulties, the International Council of System Engineering (INCOSE) and The International Society for the System Sciences (ISSS) have devoted themselves to the task of creating work groups dedicated to the generation of a common language for Systems Research. The International Federation of Systems Research (IFSR) acknowledges at least three categories to refer to Systemics' language: (1) Systems Thinking, (2) Systems Science, and (3) Systems Engineering. Systems Thinking is focused in "understanding systems in a human context, and establishing human interest and intentionality with systems" (Sillitto 2012, p. 532). Systems Science encompasses all the systemic theories; while, Systems Engineering deals with the "choices about how to create and adjust a new system or modify an existing one to the better achievement of a purpose" (Martin et al. 2012, p. 11.)

The IFSR group has developed a way to integrate these ideas into one single framework, producing the "Systems Praxis Framework Brochure" (Fig. 9.1) (Singer et al. 2012, p. 2). The brochure presents three levels: the first level, at the top, is dedicated to Systems Science, its foundations, theories, and representations; the second level, the actual Systems Thinking level, presents the correlation between Systems Science and its approaches to practice; and, finally, the third level corresponds to Systems Engineering, and incorporates the ways in which to adjust or modify research through *hard methods* and or *soft methods*.

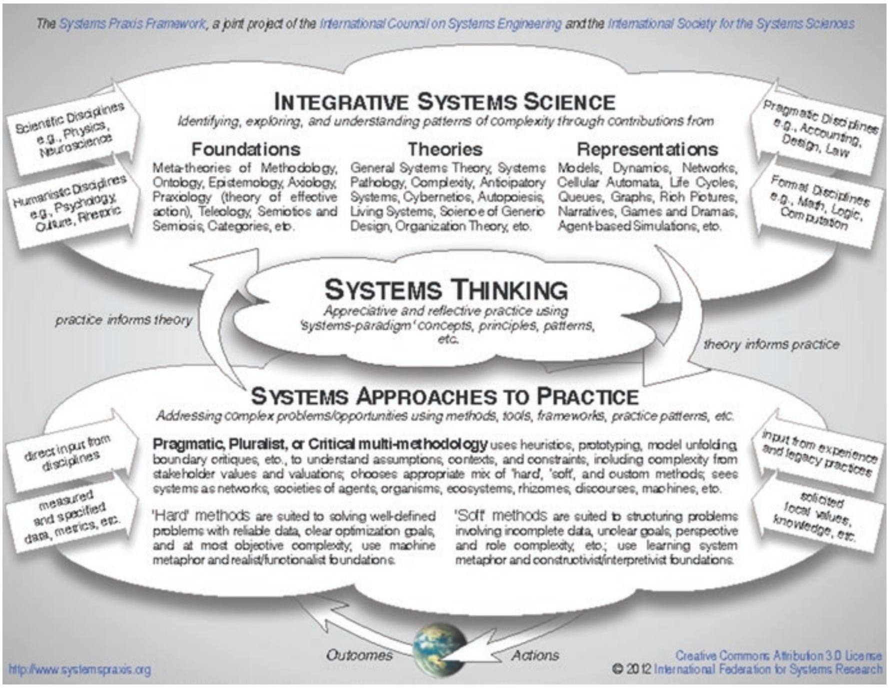

Fig. 9.1 The Systems Praxis Framework Brochure
Source: International Federation for Systems Research, released under Creative Commons Attribution 3.0 License. Credits: Diagram lead—Janet Singer, Narrative lead—Hillary Sillitto Team members—Johan Bendz, Gerhard Chroust, Duane Hybertson, Harold "Bud" Lawson, James Martin, Richard Martin, Michael Singer, Tatsumasa Takaku

The authors' classification of Systems Science into Foundations, Theories, and Representations is explained as follows: "Foundations help us to organize knowledge, learning, and discovery. Theories about systems allow us to identify patterns abstracted from and applicable across domains and specialties. Representations allow insight into, and communication about, systems and their contexts by describing, exploring, analyzing, making predictions, etc." (Singer et al. 2012, p. 2). One of the most important topics within Systems Research consists in ordering the varying hypotheses, representations, and theoretical concepts across Systems Science, Systems Thinking, and Systems Engineering. Among the approaches for organizing, learning, and discovering knowledge into Systems Science, there are meta-theories, meta-methodologies, ontology, epistemology, axiology, praxiology (or theory of effective action), teleology, semiotics and semiosis, category theory, among others. A brief outline of these frameworks is shown in Fig. 9.2 based on "The Objectives of the Foundations of Integrative Systems Science" contained in the *International Encyclopedia of Systems and Cybernetics* (François 2004) and its references.

A meta-theory focuses on the general principles of knowledge construction. These involve transdisciplinary research when objectives belong to differing theories (Blauberg et al. 1977). Meta-theories aim to be somehow isomorphic with respect to concrete systems, so as to be functional if its properties are suitable for the world. Peter Caws (1968) describes Systems Theory as a way of looking at systems, notwithstanding theories by themselves are systems as well. Upon studying a

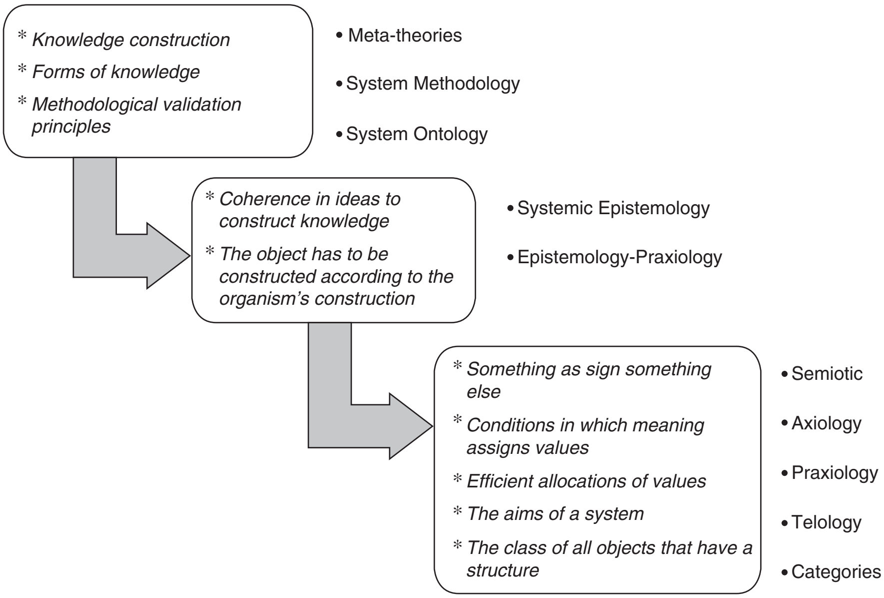

Fig. 9.2 The Objectives of the Foundations of Integrative Systems Science
Source: Author based on the "Systems Praxis Framework Brochure" (Singer et al. 2012)

system as a whole, this will look like a compound of parts related to one another through complex and dynamic relationships. In this sense, a meta-theory description of a system as a whole is similar to a cybersemiotics' idea —that of "feedback dynamics based on semiotic codes" (Brier 2009, p. 41). Caws (1968) indicates that the organizing function of theoretical arguments is to anticipate the behavior of physical systems: "If in theory the device blows up, in practice it had better not be built that way" (p. 3). The purpose of meta-theories is to find answers to the problems arising from changing the scale of observation in one discipline to another. There are those sciences where units of analysis and mechanical laws apply fully within their constitutive limits, such as cells; however, it is unintelligible to implement the same mechanical and statistical rules if the study comes from classical physics, quantum physics, or anthropology. Each change in the scale of observation involves different states of what are called *unit of analysis*, *identity*, and *limit*. Consequently, in each case, the meta-theories search for specific isomorphisms[1] "between the models of the respective discipline and the concrete systems." (François 2004, p. 377).

On the other hand, Systems Methodology refers to meta-methodology research, rather than to the construction knowledge. Meta-methodologies can compare particular methodologies between each other and "can be used to validate several methodological principles based on the methods already investigated" (Klir 1991, p. 106). Computers are the most convenient tools for carrying out this type of research, but there are several other meta-methodological tools in soft methods (Checkland 2000). In this context, cybersemiotics as a "transdisciplinary theory of signification and communication for living, human, social and technological systems" (Brier 2009, p. 28) is a type of meta-theory in Systems Thinking; while systemic-semiotics is a set of meta-methodologies in Systems Science.[2]

Systems Ontology implies a worldview and a hypothesis about the forms of knowledge Boscovich's conjecture (Boscovich 1758). This worldview is opposite to the classical science foundation, which has the firm belief that the possibilities of objectively observing nature are not the same as the possibilities of postulating something about the objective existence of nature. What is the difference between Systems Ontology and the classical point of view? The answer lies in the distinction between big science and small science. In the classical view, the ideas ascribe the absolute value of an object to the observed facts, without taking into consideration that phenomena are constructed through perceptual and conceptual filters, and according to human physiology and the brain's properties. Meanwhile, the central hypothesis of Systems Ontology establishes that humans coordinate, through sensory stimuli, mental structures of deep level within recurrent structures, which in return, are shallow mental structures. In this sense, whether or not these structures

[1] I understand isomorphisms as maps involving "a correspondence of elements from one to one, preserving the operational characteristics of the systems involved" (Beer 1968, p. 108). Stafford Beer (1968, 1985) illustrates that the result of an operation in the elements of a set of variety of states corresponds to the result of the similar process in their counterparts of another group.

[2] For Umberto Eco, a semiotic system is a structure (1976).

are remarkably ontological cannot be proved. The hypothesis assumes confirmation comes from individual data occurring frequently and adequately in human experience, and so, invariant co-occurrences or covariances can be established (Boscovich 1758; Fischer 1991, p. 96; Glasersfeld 1988, p. 13).

Opposite to Systems Ontology, cybersemiotics ontology tries to avoid this reductionist worldview. Cybersemiotics proposes a third non-reductionist path for knowledge production, one with a scope seeking to understand the role of consciousness within nature and culture. Søren Brier (2013) introduces such a path with this question: "What is the role of consciousness, signs and meaning in the development of our knowledge about evolution?" (p. 220). But before this question can be answered, it is important to distinguish the non-deterministic scope of second order cybernetics (Bateson 1972), and systems' probabilistic evolution (Prigogine 1993). Ilya Prigogine proposed that matter and energy are transformed from a trajectory which starts at a microscopic and unstable level; then it evolves into an irreducibly statistic level, by which a rupture of the temporal symmetry takes place; that is, once it enters this state, it cannot be reduced to its initial components. At the macroscopic level, energy and matter find a balance, and the final result is irreversible (Prigogine 1993). This succession from instability (chaos) → probability → irreversibility involves properties of probabilistic evolution that can be measured. Currently, within the culture dimension, these probabilistic and non-deterministic phenomena can be observed through virtual environments and their probabilistic evolution, as in networks topology. This entails the formalization of social phenomena, a cybersemiotic non-reductionist basis, and a systemic-semiotic methodology aimed toward probabilistic evolutions.

Another example in this area is Geoffrey West's *Scale* (2017). In his work, the author presents the essential application of these ideas within the Complex Sciences' framework and the Universal Laws of Growth. West demonstrates the use of allometric systems, from network theory and statistical structures of power laws, his attempt being the quest for scale invariance (co-occurrence). He is currently leading the way towards covariance across all dimensions, as Schrödinger suggested some decades ago (Schrödinger 1992). Furthermore, in Systemic Epistemology, it is important to say it embraces the meta-theory and Systems Ontology perspectives, although it has not developed into the macroscales of cybersemiotics. Thereby, Systemic Epistemology includes research instruments used to discover coherence and organization in the ideas that "emerge while constructing knowledge, models, and particular orientations of these approaches" (Kargl 1991, p. 580). Epistemology is an activity which examines facts and turns the gaze back to the observer to compare perspectives. In addition, Vallée (1987) articulates an epistemo–praxeology to emphasize subjectivity over objectivity, without excluding the latter entirely. The "interaction between subjective and objectiveness reduces substantially the efforts of meta-theories to achieve radical reductions" (p. 45–46). It is important to emphasize that, whether the knowledge process subjectivizes or objectifies the research process, this does not diminish the chances of reaching a reduction of qualities within the concrete system. The coherence of knowledge and types of knowledge depends on the organism's subjective experience.

In this sense, the intersubjective and subjective concepts of cybersemiotics and systemic-semiotics are very similar. Intersubjective interactions have limits across multiple spheres of knowledge, but have their bases in individual experience, although Systems Research has more radical constructivist approaches. An object has to be the product of an organism's construction regardless of whether it is believed that its concept corresponds to a thing-in-itself, existing "out there independent of any organism's experience" (Glasersfeld 1976, p. 116). Even if we do believe that perception is the mere replication of an objective world, we cannot consider the concept of an object as simply given, because the organism's sensory experience of the object will never be the same twice. There can be no object until we coordinate several experiences of it, thus constructing an invariant concept of the object (Glasersfeld 1976).

How does the objective world depend on sensory experience? Peirce's phenomenology of experience addresses the discussion of objectivity, subjectivity, and its effects over the development of science; systemic-semiotics and cybersemiotics follows suit. Peirce's semiotics proposes that something may be built and stand for something else through experience and demonstrates that a sign is determined by a real object which generates an experience in the brain, and an idea in the mind serving as an *interpretant sign* (Peirce 1931). But *interpretant signs* can only be known through other signs, because a sign cannot function by itself, it needs a mind to be interpreted as such. In this sense, meaning emerges from this interaction between thoughts and objects using signs. *Interpretant signs* provide evidence for the existence of other minds. Meanwhile, culture supplies a third kind of sign to communicate the meaning of the *interpretant*: a vehicle which expresses *interpretant signs* known as *representamen sign*. This process necessitates at least three entities and two or more links, as shown in Fig. 9.3.

The components which determine a semiotic representation have a special relation of matter (m), energy (e), and information (i). "Current state of affairs" or *objects* correspond to the magnitude of matter m. *Interpretant signs* are based on neurochemical reactions which generate, store, and discern *objects* in the brain, corresponding to the level of energy e and its relations to matter m. Culture and society construct conventional elements to represent the relation between objects and

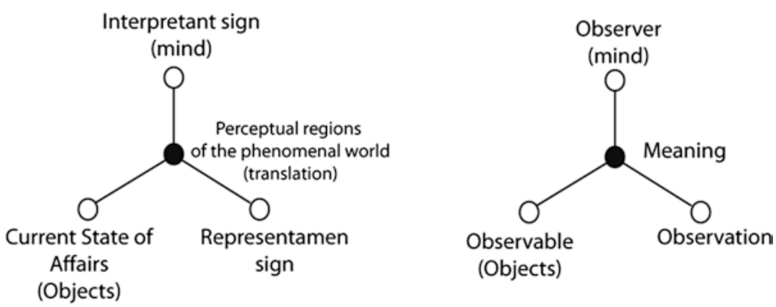

Fig. 9.3 Components determining a semiotic representation
Source: Author, based on Charles Sanders Peirce's triadic relations

interpretants, called representamen signs and they correspond to the magnitude of information, which emerges from matter and energy. Peirce (2012) developed semiotics in the nineteenth century, defining it as the necessary laws of signs. Independently, Ferdinand de Saussure (2011), at the beginning of the twentieth century, proposed the term "semiology" as the science of signs or the study of what happens when humankind tries to signify thought using necessary conventions. While semiotics studies all types of representations and systems of meaning, linguistics only studies to systems of verbal communication or languages. Linguistics' models cannot explain the processes of meaning generation within particular cultures because they are limited to the description of the rules and words that conform the grammar of natural languages. This is one of the reasons for which Systems Sciences resorts to semiotics as part of the foundations for its epistemic interpretations.

Semiotics is predicated on the idea of signs as the interaction of four entities: (1) real-world objects; (2) individuals' experiences in the real world; (3); interaction between self and signs; and (4) signs encoded in the minds of these individuals through vehicle signs with which individuals generate and communicate meaning amongst them—such that signs operate in an intersubjective or the cultural level. LaCalle (2001) conceives the fourth entity a socio–semiotic concept which enables a level of visualization of what is singularity across private and public spheres, as shown in Table 9.1.

In this sense, semiotic representations emerge as the result of the interaction of these levels:

> … [a] sign, or representamen, is something which stands to somebody for something in some respect or capacity. It addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call interpretant of the first sign. The sign stands for something, its object. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the ground of representation (Peirce 1974, p. 135).

The relations between object, interpretant and representamen are understood as the triadic model of the sign. Peirce's principles establish icons, indexes, or symbols as kinds of signs in the following way: (I) an icon is a sign that resembles something else based in similar material properties; such as a portrait or a photography can resemble a person; (II) an index serves as a sign to indicate other things, in the

Table 9.1 Micro-universe: four entities needed for the assembly of signs

Visibility within cultural relations	Concrete objects (1)	Foundation or ground (2)	Interpretant signs (3)	Representamen signs (4)
Private	States of things of the micro-universe	Individual experience	Interaction between self and signs	Signs encoded in the electrochemical visual memory
Public	States of things of the macro universe	Interaction between objects of the concrete world	Semiotic systems Symbols	A mind encoding and decoding limits

manner in which an idea is associated to the potential or causal form of an object, as the sight of a type of cloud is associated to the possibility of a storm; (III) a symbol is a social agreement that something will be in place of something else, independently of pre-existing iconic or indexical relationships—for example, words in natural languages, the dance of bees, birds' sonation systems, the pheromones plants use to attract insects for pollination, or writing systems (Guddemi 2000; Hoeschele and Fitch 2016; Spierings et al. 2016; Kuenen and Gilbert 2014; Kuenen et al. 2014; Dakin et al. 2016).

For Peirce, there are three ways in which objects can be or exist in experience: *firstness*, *secondness*, and *thirdness*. "Firstness corresponds to the positive quality" of the possibility of becoming; the first time that a conscious brain experiences something. "Secondness corresponds to the current facts"; it is the action of memory when it identifies an activity from past knowledge and experiences. Finally, "thirdness corresponds to the laws governing cultural circumstances"; it is the common knowledge over actions without the constraints of the distant or immediate past (Peirce 1974, p. 171–286). These are the three primary categories of Peircean thinking. However, if a sign is circulating in social interaction, its behavior, meaning, and semiosis change dramatically. There are instances in which a sign does not mean anything. For example, the aim of a work of art is not to communicate something or to be the formal equivalent of something else. According to John Dewey (1980), art is pure experience or firstness, which means the intention of this kind of code is expressive and not communicative. Cybersemiotics considers firstness as the first state of consciousness and Niklas Luhmann named it "first autopoiesis". In both theories, this level depends on the biophysical and psychological barriers of the individual (Brier 2013; Luhmann 1995).

Alternatively, systemic-semiotics is based on the first-order cybernetics definitions by Phillip Guddemi (2000). Guddemi explains that the evolution of the concept *sign* is associated with Peirce's phenomenology of experience and associates the construction of signs with Maturana's (2002) *structural coupling*, which is a path which enables the evolution of categories of experience: from pure experience or firstness, towards second experience or secondness, to the third category, or thirdness. In cybersemiotics, firstness is everything which expresses something as a level of consciousness, and which habilitates the capacity to distinguish the objective of communication from its medium. Secondness corresponds to the classification of reality; it is the establishment of meaning, which depends on the biological properties of individuals. Thirdness is the socio-communicative interaction between individuals and can only be possible across social interaction; it is where the acknowledgement of the Other takes place. Brier (2013) argues that it is not possible to "generate knowledge without first accepting the reality of the other, your own body and consciousness, as well as the language you use" (p. 247).

Systemic-semiotics is based on Guddemi's interpretation of Peirce's phenomenology of experience, unlike cybersemiotics, in which principles stem from biosemiotics and Luhmann's triple autopoiesis (Brier 2009, 2013; Luhmann 1995). Nevertheless, the full consequences of these principles have yet to be determined, as does the role of cybersemiotics and systemic-semiotics in Systems Research.

Deeper research needs to be conducted into Maturana's structural coupling in order to understand the difference between cybersemiotics and systemic-semiotics approaches. As Maturana (2002) states, "The organization of a system is only one aspect of the relations occurring in its structure and does not exist independently from the structure in which it happens. A system maintains its class identity and remains the same under these circumstances, even if its structure changes, but only if, throughout the structural changes, the system's organization is preserved" (p.1). Structural coupling is critical to understanding the direction in which changes occur and the moment they affect the levels of other scales. For example, the disproportionate growth of cells in a next-one-up structural level, the tissue, can produce far-reaching changes which, in turn, affect the next fundamental tiers, as in metabolism or a living organism's development.

> I have named structural coupling to the dynamics of congruent structural changes that occur in a spontaneous way between systems in recurring actions (in fact, recursive), as well as the coherent structural dynamics that result from it. Living systems, as well the non-living environment in which they recursively interact, are systems structurally determined, with plastic structures that follow a course of change that emerges modulated by the flow of its interactions. As a result, living systems and their non-living environment change conjoined and congruently, forming a biosphere in the form of a multidimensional network of reciprocal structural coupling which emerges spontaneously as a result of the conservation of the autopoiesis of the living systems (Maturana 2002, p.1)

Cybersemiotics, as a type of second-order cybernetics, proposes an idea in which the production of signification in biological systems depends on structural coupling. Therefore, the study of meaning in humans must aim to complete the lack of knowledge about "the self-organization of cognition and the structural coupling of observers" (Brier 2008, p. 101; Vidales 2017, p. 25). According to Brier (2013), Peirce's semiotics combined with a cybernetic and systemic vision, such as that of Luhmann, is what constitutes the cybersemiotics framework. However, an ontology based on Luhmann's theory of socio-communicative beings can only conceive biological systems autopoiesis. These systems perform complex tasks with an efficiency as yet out of the reach of artificial systems. In this way, the cybersemiotics theoretical background cannot solve the incommensurability amongst machines, consciousness, and artificial intelligence.

Biological processes are complicated and have definite variables. Conversely, the way in which humans think and make decisions employing imagination has not been formalized. This is one of the current challenges for semiotics, although systemic-semiotics is focused on solving it. For example, fake news within any social network website is a disproportionally growing system: gossip is a vehicle for fake news. A super viral cascade[3] can be created and cause various changes in the original meaning or semiosis, and at this level, can affect the lives of people or

[3] When a difference of interpretation is large enough, between the individual and the collective, cascades of viral information arise, in which hundreds, thousands or millions of subjects share facts (true, suspicious, or false).

individuals. It produces variations of great depth[4] which in turn influence the next evolution of semiosis. An initial meaning can have many alterations stemming from the flow of fake news into the network. Long-range networks produce effects in the lives and decisions of people who decide to pay attention to fake news. In many cases, fake news can affect the functioning of a community and lead to crises.

Cybersemiotics addresses these phenomena within the range of biological beings. But the systemic-semiotics approach offers to measure the trajectory of meaning by its probabilistic evolution in biological and artificial systems. Measurements of meaning trajectories can be carried out based on the concrete limits of reality: the limits of life, time and interpretation (Valle 2015, 2017; Valle et al. 2015, 2016; Valle and Morales 2017). From the perspective of systemic-semiotics, founded on Peirce's phenomenology of experience, semiosis is a process in which an entity acquires meaning as icon, index, or symbol. The evolution of signs in network representations allows for the observation of the limits and types of semiosis. Through the network, it is possible to visualize how the other scales of life, physics, and society—as cells, tissues, organs, body, family, community, and society—transform the elementary constitution of meaning every time they cross the limits of life, time and interpretation.

Cybersemiotics and systemic-semiotics share the same theoretical background, but their scopes of understanding are not mutual. Subsequently, while sharing common interests, both have particular concerns. Cybersemiotics takes into account semiosis as a key element, but it is just one concept amongst many. Instead, systemic-semiotics is based on the tracking of semiosis through cultural scales as it engages science models through isomorphisms and, in this way, attempts to provide a theory of meaning to cybernetics. A sign is neither a physical entity nor a fixed semiotic entity. A sign is the meeting ground of the relations between elements of two systems, the transceiver and the receiver. Considering *sign-function*, Umberto Eco (1976) argued that:

> A sign-function arises when an expression is correlated to a content, both the correlated elements being the functives of such a correlation. […] Properly speaking there are no signs, but only sign-functions. Hjelmslev remarked that "it appears more appropriate to use the word sign as the name for the unit consisting of content-form and the expression-form and established by the solidarity that we have called the sign-function" (Hjelmslev 1943:58). A sign-function is realized when two *functives* (expression and content) enter into a mutual correlation; the same functive can also enter into further correlations, thus becoming a different functive and therefore giving rise to a new sign-function. Thus, signs are the provi-

[4] I understand dissipative structures as by-products of an interpretative semiosis which operates when there is a big difference in the interpretation between the public and the private meaning of a sign. These structures are called information cascade. Eric Sun, Itamar Rosenn, Cameron Marlow, and Sun et al. (2009), were the first to research this type of cascade phenomena with real Facebook data. According to these authors, the models of statistical evolution contributed to the comprehension of how diseases transmitted and, also, of how ideas between people transmitted through diffusion systems. These can be small structures at the level of a family, in a face-to-face discussion, or it can very well scale to the viral information; which, in its more outstanding cases have effects on the objects of a concrete situation and over the things of a virtual environment. (Friggeri et al. 2014).

> sional result of coding rules which establish *transitory* correlations of elements, each of these elements being entitled to enter—under given coded circumstances—into other correlation and thus form a new sign (p. 48–49).

Therefore, the definition of code in Eco's semiotics implies a process of structural coupling, between the elements of different systems. These systems are (A) a set of possible behavioral responses, (B) a set of states of things in the world, and (C) a set of signals correlated by arbitrary combining. To distinguish his code definition from Shannon's, Eco denominated it "S-code" or code as a system (Eco 1976). Another way of naming S-codes is "semiotic systems." One of the most studied semiotic systems, as a particular semiotic, are social institutions (Klinkeberg 1996). On the other hand, the simplest semiotic systems are the color codes on traffic lights, or underground signals combinations (Eco 1976). For Eco, a semiotic system is a structure, an S-code, capable of replacing the purpose of meaning that associates elements of different systems. Hence, they can be studied by a theory of information, structural generative theories, or by "a theory of codes" (Eco 1976).

From this perspective, if a semiotic system has, at the same time, exceptional longevity and actuality, as do language, kinship relations, or economic organizations, then the tracking of semiosis via networks models will be possible as an information structure. The tracking of semiosis through digital networks therefore, allows us to see that the vulnerability of the individuals grows as they contrast the signs meaning with concrete systems. Digital networks enable us to observe the interaction between the consciousness of individuals. Many of the networks correspond to the brain operations in which real, complicated, valuable, complex, or accidental thoughts are formed. Digital networks are also based on a specific process consisting in networks of networks of signs articulations. In this manner, the idea of semiotic systems is similar to the concept of autopoiesis' triple articulation by Luhmann (1998), although these systems are interconnected through semiosis. Consequently, the systemic-semiotic hypothesis posits semiosis as the unit of consciousness analysis and network representations as a theoretical and methodological tool to experimentally observe the evolution of meanings. Meanwhile, cybersemiotics contributes to the ontological framework of all evolutionist theories of meaning within Systems Research.

The systemic-semiotics approach provides a different interpretation of Luhmann's concepts than that of cybersemiotics. While cybersemiotics ontology is focused on triple autopoiesis of the socio-communication theory of being, systemic-semiotics attempts to support a dialogue and collaboration with other disciplines to understand the evolution of semiosis, as well as the social and artificial properties of consciousness. Some of the most important disciplines in dialogue with semiotic-systemics are axiology, praxiology, teleology, and category theory. Thus, to build a network model which represents the trajectories of semiosis with the greatest fidelity, it is necessary to know the conditions in which meanings are assigned and, therefore, the values of context in culture. Axiology studies the nature of emotions, and how they affect the assignation of values to objects. According to François (2004), the systemic scope has had an impact on axiology for the following reasons:

1. To the extent that it establishes a hierarchy of nested and interdependent systems, the systemic scope must lead to a new examination of the rights, responsibilities, or reciprocal needs of each system and co-system within corresponding supra-systems and infra-systems.
2. It introduces a strong temporal dimension, obligations, rights, and responsibilities which must be considered within a future perspective, corresponding to different time scales.
3. By proposing a specific way of understanding the observer's relationship with that which is observed, and, in particular, with the relationships between several observers, systemic axiology should focus on consensus and co-participatory decision-making.
4. Systemics introduces a new understanding of the nature of cultural differences, while systemic axiology should strive to find satisfying transcultural values (François 2004, p. 56).

Efficient allocations of values and semiosis depend on the series of necessary conditions which are studied by praxiology, according to Kotarbinski (1995). Praxiology is "the discipline of the efficiency conditions of all action, practice and praxis" (p. 32). It is a specific methodological approach, which empirically explores ways of doing activities and praxis. Its scope is the philosophical and theoretical foundations related to action, in general. Cyberemiotics is based on Luhmann's principles (1995), where sociocultural evolution is a basic process that produces elements of communication acting and interacting with other elements to generate social systems. The principles of praxiology are very useful to understand the cybersemiotic relations among actions and elements, and between the act of communicating and its relationship with information.

McWhinney (1997) observes that practice and praxis are different, as concepts, because practice focuses on the habitual and the systematic processes of a task. "[T]he mode [of doing something in practice] follows a set of implicit rules of theories and also follows a program." In contrast, praxis "is the study of practices to achieve goals" (McWhinney 1997, p. 80). It focuses on the intention, without the limitations of a definite set of rules. The study of "achieving goals, objectives, and the purposes of a system" is carried out by teleology (Young 1974, p. 299). According to Bohm and Peat (1987, p. 43), "it is a metaphor of mechanism." It is also "the study of directed behavior" (Bertalanffy 1956, p. 7). These principles imply that any deterministic mechanism would seem to pass on an inevitability of definite future states; in this sense, "teleology involves Newtonian and Laplacian type mechanisms without any necessary reference to the purpose" (François 2004, p. 616). It is important here to make a pause. At the beginning of this chapter, I questioned whether Systems Research was a paradigm shift or not. Later, I introduced the ISFR discussion of the topic. ISFR divides Systems Research into three categories: Systems Thinking, Systems Science, and Systems Engineering. Up to this part of the text, the cybersemiotics ontology and system-semiotics have been used to focus on Systems Science, as well as on axiology and teleology. However, these do not offer an exclusive perspective. We can also reflect on Systems Thinking, Systems Science and Systems Engineering as philosophies.

Contrary to Systems Science, the study of achieving objectives (teleology) from a Systems Thinking perspective posits the concept of "purpose" as non–deterministic in Newton and Laplace's terms. It could even be understood as an objective of the system or probabilistic evolution (Young 1974, p. 79). Hence, research on teleology requires knowing the purpose of a system "to avoid causality problems" (François 2004, p. 616). Then, the deliberate reactions that control the error in feedback are the purpose of the system. Such is the difference between the state of an object, at any time, and its final state; none are fully deterministic, but both are probabilistic (Rosenblueth et al. 1943). The final tool for the foundations of Systems Research related to semiotics is *category*. It is a defined set in a classification system of objects, processes or relationships. Joseph A. Goguen and Francisco J. Varela (Goguen and Varela 1979) wrote:

> The intuitive idea of a category is that it embodies some structure by exhibiting the class of all objects having that same structure, together with all the structure-preserving mappings or morphisms among them. (Somewhat more technically, categories assume there is an associative operation of composition on those morphisms whose source and target match.) This idea is due to Eilenberg and MacLane. […] Usually, we are interested not only in objects from various categories, but we are even more interested in certain constructions performed on the objects of one category to yield objects of another category (p. 39).

For systemic-semiotics, the importance of categories is to find isomorphisms between disciplines. This condition indicates that isomorphic relations are much more interesting than the structural relations of a system, which are the historical ties to a circumstantial space. While an isomorphism can be considered the "perfect" analogy, "no model is entirely isomorphic to the modeled object" (François 2004, p. 322). Isomorphism based on the structures and functions of different systems admits the creation of classes of models with similar properties, for which generalizations covering multiple concrete systems and time scales can suitably operate (Beer 1968). Also, isomorphisms "allow a certain degree of algorithmization of knowledge for numerous entities and complex situations", which may be more or less similar (François 2004, p. 322). This property leads to an algorithmic understanding of semiotic knowledge so long as semiotics is considered "the doctrine of the essential nature of semiosis and the fundamental varieties of possible semiosis" (Peirce 2012, p. 497–498).

Indeed, there is a distinction between isomorphism and homomorphism. According to Vallée (1990), the multidisciplinary or transdisciplinary character of systems theory has, as its fundamental purpose, to find the structural isomorphisms between systems that belong to different disciplines or between representations of the same order. Wiener refers to such isomorphisms as mere homomorphisms in his work *Cybernetics* (1954). The search for this type of isomorphism, or proper homomorphism, leads to the concept of a model that allows the representation of a category of systems. The model of an isomorphic representation may result, however misleadingly, because, as Korzybski states, "the map is not the territory" (Vallée 1990, p. 56). Beer (1968) establishes that "[H]aving improved the concept of models, and the contents of our opinions […], the scientist produces two deep levels of homomorphic models, and these can be isomorphic with each other" (p. 113). As for homomorphisms, they can be known through the isomorphic process of interaction, and then operate regulating the content of messages. In this sense, "the interaction between systems or parts of systems with a pre-arranged code" is the second best-known definition of communication from the systems paradigm (Young 1978, p. 290). The isomorphism between cybersemiotics and semiotic-systems is related to the limits of biological systems and the traceability of semiosis into social systems. Thereby, the suggestion is that isomorphisms in communications and semiotic theories are best understood as entropy and information because these structures are present in all domains of semiosis.

Summarizing, at the beginning of this section I tried to answer the question: Is Systems Research a paradigm? All the briefly revised frameworks are part of the influence of systemics in some foundations of the theory of knowledge. However, they do not carry a paradigm shift, nor do they imply an innovation in the form of doing science. On the contrary, Systems Research requires classical or small science. The reductionist knowledge of small science takes place in the three categories of Systems Research: Systems Thinking, Systems Science, and Systems Engineering, although the dialogue between them requires a transdisciplinary foundation. Systems Engineering is a consequence of the evolution of scientific knowledge. The best way to label this framework is to see it as the modern way of scientific dialogue across small sciences within big science. It is the return of first-order philosophy, and one of the many paths to access it is through the systemic-semiotics approach.

Systems Thinking involves a deep reflection on what knowledge is in a complex and complicated world that evolves dynamically. The central notion is how does meaning emerge across intersubjectivity, avoiding mechanistic schemes of explanation. A second-order philosophy is required and cybersemiotics ontology is the most suitable aid. Systems Science requires a lot of isomorphism to pair one meta–theory with another in a transdisciplinary field. Maybe in the near future, there will be a third-order philosophy emerging from the dialogue between transdisciplinary knowledge. At the moment, the argument is taking us to the convergence between the cybersemiotics and systemic-semiotics approaches. The proposal is that isomorphisms between them are best understood as entropy and information. Both processes have in common that they act over open systems. Next, we will review what are open systems, how do they treat information, and how is this relevant to cybersemiotics and systemic-semiotics research.

9.3 Open Systems

Cybersemiotics ontology has its basis in the Peircean work, whose "semiotic philosophy seems to be the only place to turn if one wishes to include human consciousness in the theoretical foundation of an evolutionary theory that also contains a material world, living systems as well as language, and the social-cultural world of intersubjective linguistic communication" (Brier 2009, p. 32). Cybersemiotics establishes that it is possible to integrate emotions and causality in an ontological view, which suggests that autopoiesis' triple articulation permits the differentiation of an event of self-consciousness from a biological behavior (Brier 2013). This ontology sets a philosophical foundation for cognitive semiotics to explain how self-consciousness evolves towards a point of creation of signs and language games. In this sense, cybersemiotics places information as a basic conceptual component of its ontology (Brier 2008, 2013). In other words, the transdisciplinary perspective of cybersemiotics leaves aside the processes of information as flow, spread or order. It takes up questions about the information processing from semantic and pragmatic perspectives, different to those which are generative and reductionist. Thus, it is propped up as a transdisciplinary science of information (Brier 2008). Still, the great problem of cybersemiotics is how it deals with real-world open systems. How do we study and define open systems without resorting to reductionism? How do we restrict a cybersemiotic and transdisciplinary interpretation? Both second-order philosophy and first-order philosophy have the same transdisciplinary object in common: open systems. This section explores open systems as a systemic concept and how this concept is treated in a first-order philosophy like systemic-semiotics, and in a second-order philosophy, like cybersemiotics.

A system is a point of view, a universe of discourse predefined by a frame of reference (Weinberg 1975; Pask 1968). The idea of a system comprises a set of general concepts conceived by man as involved in, more or less, identifiable and permanent patterns of coherence in the real world (François 2004). Ilya Prigogine (1993) postulated that dissipative systems are non-equilibrium dynamic systems, open and with internal gradients. They maintain a low stable entropy condition by transporting matter and energy beyond their limits, consuming energy, and presenting cycles of matter and energy, which can also be understood as the development of complexity by exporting and dispelling entropy to the environment (Prigogine 1978; Prigogine and Nicolis 1967, 1971).

The core topic in systemic-semiotics reflection about culture is whether the difference between personal and collective interpretations generates dissipative structures of entropy to maintain the dynamic equilibrium of society. Hence, if a virtual meaning is not consistent with a concrete environment, it does not comply with the dynamic stability, and it therefore becomes unstable. Subsequently, the system will exhibit strong fluctuations that will lead to a very slow relaxation towards a state of equilibrium, that is, towards its extinction. Those points of instability generate a crisis (Haken 2013). In the third section of this chapter, I demonstrate how the so-called information cascades are dissipative structures. Sun et al. (2009) were the first to study this type of phenomena with real Facebook data. According to the authors, models of statistical evolution as well as their dissemination models have the ability to explain the contagion phenomena; ranging from social movements to the spread of diseases. However, others have wondered about information and its relationship with dynamic systems and dissipative structures, Erwin Schrödinger (1992) stated, in a dissertation on the Second Law of Thermodynamics, that changes and relations between physical energy and matter have a strong correlation with the evolution of thought and consciousness. The paradox he described establishes that entropy (thermal disturbance) increases invariably in any isolated system, however, this does not occur in open systems, like living and social systems; as organization scale increases, a much more complex shape can be found in the order of the parts (Schrödinger 1992).

Modern biochemistry acknowledges that electron influx provides energy to all organisms, which explains how almost all living beings receive energy directly or indirectly from the sunlight radiation. Nonetheless, the capacity of cells to receive and act on the signals that come out of them requires a process of chemical change, known as *signal transduction* or *biosignaling* (Nelson and Cox 2015). Biosignaling is a process that makes visible how living systems generate order from order; in contrast to complexity sciences, where disorder creates order (Mitchell 2009). Modern biochemistry explains that organisms evolved to import high-quality energy from ordered systems. This allows them to prolong their existence in a universe governed by the second law of thermodynamics. Thus, according to Schrödinger (1992) and Schneider and Sagan (2008), both the operation and the self-organization of a living system are related to its context, and the hierarchy in which energy and matter have organized and transformed.

Biosemiotics provides an explanation of communication processes beyond human reference. Thomas A. Sebeok (1991) studied communication transversely into different biological species. Biosemiotics is divided into zoosemiotics for the study of biosignaling, while anthroposemiotics studies the processes that generate semiosis. Cybersemiotics is the direct heir of biosemiotics, not a disciplinary branch, as Brier (2008) explains, its philosophy is part of the foundation of Information Science. Thus, as a central challenge for cybersemiotics, lies the study of communication between species, and the properties that make the human species unique. For cybersemiotics, a holistic view of structural coupling between life, society, physics and intersubjective semiosis, is at the core of conceptualizing cognition, communication, life and an ethological paradigm. Like biosemiotics, cybersemiotics is a science of living systems' signs, with a transdisciplinary aggregate, and whose purpose is to unify knowledge into natural and social sciences. Conversely, a first-order philosophy as a systemic-semiotics serves as a meta-methodology, whose purpose is to describe the trajectory of signs across the changes of variety in the states of the reality. Systemic-semiotics has a unique starting point: semiosis, with which, consequently, follows the material transformations of signs by the effect of human volition.

Human beings are dynamic and complex system depending on tissue density and conductivity, metabolic heat produce by organs, and their spatial distribution (Werner and Buse 1988). Even for a system that focuses on importing high-quality energy as a living system does, mechanisms to dissipate entropy and maintain thermal equilibrium are required. It is remarkable that the temperature of the human body, regardless of the environmental climate, ranges approximately at 37 degrees Celsius, which means that the thermal stability of a "human" unit requires a system to dissipate heat and steady its temperature. Prigogine's dissipative systems imply that the creation of meanings through biological consciousness, like that of humans, requires a constant process of energy transfer across its limits. Meanwhile, the internal energy of the system must maintain a continuous temperature due to the thermal difference between the system and its surroundings. In other words, the molecules and ions of a living organism differ depending on the type and concentration of those found in their environment. As a result, living beings have a composition distinct from that of their environment. This "keeps them in a dynamic stationary state because they are never in balance with their ambiance" (Nelson and Cox 2015:21). Within this "steady and dynamic state", the population of molecules of any organism is far from static; it continuously synthesizes and degrades molecules through chemical reactions that require a constant flow of mass and energy. When a cell is unable to get energy, it dies and initiates its degradation towards equilibrium with its environment (Nelson and Cox 2015, p. 21–22).

Here, a question regarding life and conscience arises: what and how are we? After age 30, we are far from being the pair of haploid cells that gave life to us. And yet, we are identities with individual histories in a dynamic and stable state. Perhaps an answer lies in the physical foundations of our nature. Physics textbooks explain that the value of temperature and internal energy of a system are variables of a state due to their dependence on current thermodynamic phases, and not to the process that led them to that state (Serway and Jewett 2014). The process that led us to be individuals of 30 years of age consists of the microstates of the human system; however, current thermodynamic phases are our macrostate. Ostensibly, a macrostate is only possible after a series of microstate transformations, occurring during our 30 years of life. As a zygote develops, the number of microstates and opportunities to continuously improve and constitute a macrostate increase over 30 years or more. An increment in opportunities entails a growth in statistical uncertainty, which is known in thermodynamics as "entropy or lack of information" (Serway and Jewett 2014:669). Whether a biological system has many or very few microstates is not relevant, "the most pertinent is whether those microstates are ordered" (Nelson and Cox 2015:23). If a system has microstates in random distributions, they would be very rich in entropy and would not contain much information. Instead, a system which has distributed microstates, of specific and limited orders and behaviors, is a system with low entropy and a lot of information: that is a dynamic and steady state.

Human nature, its physics and biochemistry, leads to other questions: (1) are there ways in which our biological configuration defines our semiotic and cultural arrangements? (2) Do organic designs determine human behavior? (3) Do biological structures determine the possible range of choices in life? (4) Where do genetic conditions end, and cultural conditions begin? These ideas and questions are not strange for cybersemiotics. The place where semiosis and life match could be modeled by Complex Adaptive Systems (CAS), a term which is a synonym for open systems on a thermodynamic gradient:

> The term CAS means an open system in a thermodynamic gradient (i.e. one far from the equilibrium). This is in part what Prigogine (1980) called "dissipative structures" but with many non-linear connections, and feedback mechanisms added. These systems are pre-

stages to memory functions; they often have complex dynamic networks, which are locally differentiating and have emergent and holistic properties. Still, I would argue that these concepts need to be placed on a Peircean foundation, since I am unable to see how a physicalistic evolutionary foundation combined with the idea of emergence can function to make consciousness appear from totally inert matter in autocatalytic closed circuits (Kauffman in Brier 2009, p. 43).

Brier (2009) points out that there is a theoretical and philosophical problem when combining the theory of evolution with the emergence of consciousness. The former has a reductionist source, while the principles of the latter belong to second-order cybernetics. Another way to solve this is by applying Systems Research concepts like macroscopic and microscopic; however, these prefixes, macro-, mega- and micro-, could be confusing. Silvano Arieti (1969) suggested a level at which human cognition operates. It is an intermediate point between the magnitudes scale of the macrocosm of physics and the microcosm of atoms. This intermediate scale is related to living and human beings; he defined it as *mesocosm*: "life exists in the mesocosm [t]o originate and evolve, it had to incorporate mesocosmic laws" (Arieti 1969, p. 206).

Some years later, Joël de Rosnay (1975) applied the macroscopic concept as a conceptual instrument to observe what Arieti called mesocosm, that is, the scale of observation and experience where social phenomena occur. Life develops and ecological systems and socio-economic environments co-evolve. Within the approach of systemics and first-order cybernetics, attempts were made to unify the terminology proposed at the time by Arieti (1969) and De Rosnay (1975). The goal was not to create numerous terms competing with each other. Currently, the Systems Research is set to stop using the term 'mesocosm' and instead use *microcosm*, *macrocosm* and *megacosm*. (François 2004) Therefore, the prefix micro- is used for those levels that can be observed with the help of microscopes, Geiger counters, radio frequencies, etc. The term macro- is used for our natural level of observation, what we are able to perceive with only our senses; and the prefix mega- is for those levels that can only be observed indirectly, through telescopes and astrophysical instruments; these latter being studied based on observations and general theories (François 2004).

Edgar Morin (1972) also developed an idea of macrocosm as a double principle, resulting from the interrelation between a system and its ecosystem. Moreover, social systems, at least complex social systems, generate events. These processes of self-generation would be halfway between biological developments (which include the neuronal interactions typical of individual semiosis and interpretive signs) and accidental developments (which occur as a result of random encounters between systems and events). While individual systems respond to disturbances with their own determinism, or internal laws, the ecosystem responds randomly, or in a decentralized way (Morin 1972). In this sense, within the epistemology of systems the difference between event and element is basic: "the notion of element is a spatial ontology. The notion of event is a temporal ontology"; however, any element can be considered an event insofar as it is "considered to be situated within a temporal irreversibility as a manifestation or actualization, that is, according to its appearance and its disappearance, as a function of its singularity[5]" (Morin 1972, p.13); time allots a *coefficient of event* to all things. Consequently, at macroscopic level, there are at least three scales at which culture operates: limit of time, limit of interpretation, and limit of life. All of them interact with virtual and concrete environments (De Rosnay 1975). Hence, the processes of signification are subject to the laws of thermodynamics, to the physical laws of the universe, and to the complex structures by which we exchange and create meanings.

Brier (2008), Wilber (2001) and Ervin László (1987) have called this model *ecosystemic*; but each one of these authors has proposed a different framework to represent the model. The cybersemiotic proposal contemplates the relationship of human linguistic motivation as opposed to the ethological motivation of other living creatures, both correlated by means of embodiment[6] (Brier 2009). Systemics considers that biosignaling possesses configurations of macroscopic control, which redundantly operate in the system microstates' configurations of order. This correlation between organizational scales is essential for the understanding of the system as a whole. Macroscopic control configurations cannot be established at the same scale as cells, molecules, tissues or organs, as the components of a human body cannot exist independently; the whole anatomy is a product of the continuous interaction of its elements. The permanent arrangement of the parts allows the configuration of a whole, and such is the Circular Causation Principle described by Hermann Haken (2012, 2013): (a) in a self-organized system, its components determine the parameters of order behavior that successively define the response of the individual components; and (b) individual components are numerous, while parameters of order are rather few.

However, parameters of order compete with each other to govern the behavior of the entire system. The winning parameters of order will determine the actions of individual parts. Once one parameter dominates over others, they will all operate as a set, so that they can cooperate or naturally coexist. This is called *slaving principle*, when one of the settings enslaves some or the whole of the parts. Under such conditions, cooperation, coexistence, competition, and submission are the basis of self-organization (Haken 2012, 2013). Thus, if a single order parameter does not comply

---

[5] "La notion d'élément relève d'une ontologie spatiale. La notion d'événement relève d'une ontologie temporelle. Or, tout élément peut être considéré comme événement dans la mesure où on le considère situé dans l'irréversibilité temporelle, comme une manifestation ou actualisation, c'est-à-dire en fonction de son apparition et de sa disparition, comme en fonction de sa singularité. Le temps marque d'un coefficient d'événementialité toute chose."(Morin 1972, p. 13).

[6] "Human beings and animals are always anticipating meaningful contexts connected to their forms-of-life. It is the inability to extract the person from his embodiment that anchors meaning in our psycho-biological being as something to be classified and developed by language and culture (Brier 2003). This is also clear in the development of the idea of the role of the body from Husserl to Merleau-Ponty's "naturalized" phenomenology. Therefore biology matters. But a mechanistic molecular biology does not have the philosophical, especially the ontological, foundation capable of explaining the inner experience of biological systems, their cognition through signification, and from there on to engage in communication, leading through evolution to the foundation of human language. For this, biosemiotics seems necessary" (Brier 2009, p. 38–39).

with the dynamic stability —if it is unstable— the system will fluctuate inducing relaxation and subsequently instability, and furthermore crises or death (Haken 2013). In a living being, the configuration of control is the principle of circular causality. The maintenance of that dynamic stability is due to the order parameters, this is, what keeps its parts ordered. All this structural dynamics is what Maturana and Varela call structural coupling (Maturana 2002). As we scale-up in the application of the mechanical laws in a living being, greater will be the degree of complementarity of matter through structural coupling.

For example, culture, which is a highly organized organism, is made up of millions of microstates: each human being. Well-defined parameters of order determine the relations between each one of these microstates. The most critical parameter of order in the human being scale is the prohibition of incest, which in turn defines the type of family and symbolic reproduction within human communities. The higher the dominance that a parameter exerts over the rest, the higher the restrictions on the limits of interpretation of the world will be. The longer a setting exists, the longer the ideas of the world given by this parameter will continue throughout the centuries. This state will make it much more susceptible to enslaving other parameters of order while interacting with the medium from which it imports energy for its existence (Valle et al. 2016; Mora et al. 2017; Valle and Morales 2017; Valle 2017).

Yet, culture incorporates new parameter of order through its social institutions. Such are the modern states of equity between people, as gender and transgender relations between humans. Consequently, there are new forms in kinship structures and biological reproduction functions. These contemporary lifestyles have generated states crisis within older cultural structures. They are no longer compatible with the concrete systems from which they obtain energy for their existence. Systems opened to information—a type of open system— refer to systems whose dynamic and steady state are designed to react to information, not to entropy. They need a way to dissipate all the entropy produced in each small scale and this necessarily leads the entire system to complexification. Parameters of order increasingly become more structured so as to obtain major gains toward information equilibrium. Such is our hypothesis to assert that culture is a superorganism above human beings.

As of today it is necessary to test if this hypothesis is falsifiable and contributes to scientific knowledge (Popper 1957). Until the time of its verification comes, this idea will remain metaphysical and unfalsifiable. Nevertheless, at the turn of the past century, the concepts of atom and gene were abstract and unfalsifiable. Science has always dealt with the challenge of building concepts out of philosophic ideas, including metaphysical, unfalsifiable. The traditional way of doing so is through the scientific method. In such fashion, we have hypotheses and specific protocols to test any phenomena. Still, in other situations, there is no protocol to follow, nor mathematical formulas to help us, nor deductive systems to be applied. That is almost always the case for real open systems phenomena. In these situations, we only observe the results of something happening. The method cannot be deductive, and so, it is inductive. Inductively, scientists have the task of choosing one or another axiom, theorem, theory, or rule, which could be the possible answer for the perceived result. Furthermore, as Schrödinger noticed, the understanding of the complexity of life and culture via deductive systems is like trying to understand a work of art like the Sistine Chapel, Mexican muralism, or Renaissance architecture knowing only what the dots and lines are.

The choice between a research method, whether deductive or inductive, is related to an epistemological dilemma: the former corresponds to the vision of a universe of unilinear evolution, while the latter corresponds to an interconnected and adaptive world. For example, within theories of language, some assume that natural language has an internal evolution independent of environment. This is known as the deep structure of linguistic expressions. The changes occurring in grammar are justified as derivations of the development of grammar itself, as if it was a mechanism independent of humans. The most widespread theory of language under this perspective is the transformational generative grammar (TGG) by Noam Chomsky (1956). Other theories of language, like the Sapir-Whorf hypothesis, postulate that languages only exist as an effect of the community of speakers and that the environment has an essential role in their existence, conservation, and evolution. They presuppose that permanent contact with the context affects the development of language, as well as its adaptation. Consequently, environmental circumstances and needs, including social life, define the life cycle of a language (Carroll 1956). Different scientific disciplines posit similar ideas: the idea of unilinear evolution opposes the conception of interactive adaptation.

The systemic approach states that both research methods are adequate, the deductive method is appropriate to explain and know the life cycle and *life limits* of phenomena, while the inductive method is essential to conceive how the selection of processes of self-organization works for increments or reductions of complexity in a system, i.e. the *time limits*. In both cases, the concept of the variety of states in reality is fundamental to understand the limits of life and the limits of time. The real challenge of a philosophy of information and communication lies in finding the relationship between our biological reality and consciousness. Cybersemiotics and systemic-semiotics are based on similar questions and principles; both agree that only the framework of evolution could explain language and consciousness. However, the ordering of concepts and notions is not the same: cybersemiotics proposes an ecosystem model, in which the integration of biosemiotics and cognitive semiotics occurs through embodiment. Thus, cybersemiotics includes human consciousness in the theoretical foundations of the theory of evolution, using Peirce's semiotics and Luhmann's arguments on autopoiesis.

This new transdisciplinary work requires ontological foundations to sustain scientific discourses and verification on reality. In this sense, cybersemiotics as a second-order philosophy is best suited for problems that encompass Systems Thinking. Whereas system-semiotics, as a first-order philosophy, serves as the foundation of Systems Engineering. Under these considerations, coincidences and differences between both philosophies of science were briefly addressed. Open systems are a common ground, the nature of which is dynamic and depends on the laws of thermodynamics. Within these laws, the most interesting for semiotics are those related to the transformation of matter into energy and, in turn, into information, a process of transduction. Transduction is an effect of the interaction between systems that have significant differences in the variety of states between them: Prigogine's dissipative structures.

The next topic is Ashby's Law of Requisite Variety (1958), a key concept for understanding structural coupling and its role in the emergence of consciousness from a first-order philosophy. The motivations behind the exchange of the variety of states between systems have different explanations in cybersemiotics or systemic semiotics, as both approaches observe different aspects of reality. Hence, beyond opposing each other, they also complement one another. "The law of requisite variety says that R's capacity as a regulator cannot exceed its capacity as a channel for variety" (Ashby 1958, p. 86); variety embodies variety. This means that a system can only integrate the amount of variety of states the system has by itself. Consequently, if the number of external states is greater than the number of possible responses in the system, an internal redundancy within the system will occur. In a cybersemiotics ontology, this implies that we can only know what we already know. But if we want to understand and have more signs to deal with the world, more variety to our variety of inner states must be integrated.

According to our first-order philosophy, the recognizable variety at the microscopic level will always be less than the variety of states at the macroscopic level. One of the fundamental properties of human consciousness is the ability to increase the variety of the microcosm through learning. An open system, such as culture, moves far from equilibrium due to continuous and discontinuous disturbances in its variety of states of energy, matter and information. The mathematical concepts such as control configuration, control parameters, and parameters of order can be used to model external flows (Haken 2012). The exchange of variety in an open system shows compensatory changes between the parts of the system. Ashby (1958) proposed a model to correlate the response of a system to an exchange of variety. In this model, he represents the inputs as a set of disturbances with the variable d_i, which can be met by a set of responses, represented with the variable R_j. The outcomes of the system are the schematic idea of the possible new internal combination when external variety is larger than the internal; the variable to represent the set of possible outcomes is z_{ij}, as shown in Table 9.2.

Table 9.2 Binary matrix of disturbances and responses

		Response			
		R_1	R_2	R_3	…
Disturbances	d_1	z_{11}	z_{21}	z_{31}	…
	d_2	z_{12}	z_{22}	z_{32}	…
	d_3	z_{13}	z_{23}	z_{33}	…
	d_4	z_{14}	z_{24}	z_{34}	…
	…	…	…	…	…

The binary matrix constructed from the non-linear interactions between the disturbances (d) and responses (R) of the system. Source: Ashby (1958)

This is the case for living systems. Because of their thermodynamic conditions, living systems contain *being born* and *dying* as states of variety. But, what about the survival instinct? It is also a part of humans; the survival instinct is an absolute aim, which sole purpose is *to not die*. Due to our thermodynamic condition, it is impossible for almost any living system to absorb an *eternity* state of variety (except for the *Turritopsis Nutricula*). Therefore, a living system adapts to the array of events: *prolong life*, *postpone death*, *do not die* and *reproduce*. The survival instinct produces highly specialized strategies, medications, prostheses, lifestyles, and adaptation to extend a living being's existence. However, the Law of Requisite Variety suggests that every system must consume states of variety from other sources to reach equilibrium or achieve its objectives.

Let's imagine how the Law of Requisite Variety operates in a broader scale, such as the system of life. Life as a system would have a set of well-defined states and elements, what biologists call the *domains of life*: *eukarya*, *bacteria* and *archaea*. *Eukarya* contains the kingdoms of *plantae*, *fungi*, *animalia* and *protista*. The exact variety of Earth encompasses such domains, their kingdoms, and species. If certain species can prolong their existence, it is at the expense of other species losing that state of variety. The Law of Requisite Variety implies that extending the life of some species occurs at the price of absorbing states from other species, just as pharmaceutical penicillin needs live medium to grow (Kardos and Demain 2011). The solid-state fermentation media for penicillin culture contains corn steep liquor, lactose, and inert solid supports (Taşkın et al. 2009). It takes a considerable amount of resources and energy to transform matter in such media: land to cultivate corn to feed and raise livestock, so that it produces milk to extract the lactose; furthermore, the industrial transformation processes of all these products imply a long path toward producing high quality results. The extraction of these primary resources requires the modification of a space that contain a vast collection of biological entities; that is to say, other living systems necessarily perish so that another living system may adapt itself to a *prolong life* state. Thus, there cannot be more living states than the system itself as a whole; the only way is to absorb other forms of life variety with the same quality so as to prolong one form of life in particular.

For example, the bacterium *Helicobacter pylori* lives in the stomach of primates. It has a spiral shape that serves to attach its body to the tissue that covers the inner lining of the stomach. It takes up to 7 days to incubate, and from 38 to 48 h to reach maturity. Its reproduction takes place after 55 hours, and its decline starts around the 66th hour. The last phase of its life is described by a change in its spiral shape, transitioning to a spherical shape. There are 35 known species of *H. Pylori*; some of them are related to pathologies of carcinogenesis in humans. Colonies of these bacteria thrive in a high acidity environment, as these bacteria present extreme adaptation to gastric mucosa; hence, it has undergone an acclimation to acid. Another characteristic of the *H. Pylori* is its resistance to antibiotics. When these bacteria feel threatened, the spiral shape transits to a spherical or coccoid state that allows the next generation to remain in incubation for 3–4 days, protecting them from antibiotics and accelerating their reproduction. Colonies of *H. Pylori* cultivated in labs have a diameter of 0.5 to 0.2 mm. When measured, the growth density permits us to determine the risk of ecological imbalance; i.e. human bacterial stomach infection (Boyanova et al. 2011). *Helicobacter pylori* will do anything possible to survive, remaining unconcerned about its ecological environment: its human host, culture, the deforestation required to produce antibiotics, nor human societies and technologies. It might even be thought of as a kind of predatory collective consciousness. Presented with the opportunity, colonies of *H. pylori* will not only propagate throughout the environment that surrounds them but will also do anything possible to expand themselves beyond their limited ecological space and colonize other environments. Despite the shortness of its life, its propagation capacity is rather impressive, the varying species of these bacterium and mutations have spread over the last 58,000 years to 50% of the world's human population (Linz et al. 2007; Atherton and Blaser 2009).

Still, one of life's main characteristics is that a change in one component produces a compensatory change in another. This property allows for the characterization of each set beyond its parts (Nelson and Cox 2015). Each compensatory change defines, in one way or another, what we consider a living being. Such is the case of the components of an organism at the scale of a cell colony, a tissue, an organ, a living being, a family, a community, a habitat, an ecosystem, or a planet. The variety of states definition expressed by the system is the systemic tool with which to study compensatory changes like these. Hence, the importance of the Law of Requisite Variety: it is a means to understand the unity and diversity of any entity whatsoever. Variety is a set of states of things in the world interconnected amongst themselves; in other words, it is the consequence of complex interconnection between states of reality.

In addition, we must not forget that another of life's qualities is its high degree of chemical complexity and microscopic structure which result from the intricate internal arrangements of a cell which, in turn, is made up of thousands of different molecules (Nelson and Cox 2015). This property is *heterogeneity*, which provides cells with a unique ability to interact selectively with other molecules. *Variety* is a property that habilitates the differentiation between elements within a set of parts. Whereas spatial variety is the differentiation between the spatial limits of a system, temporal variety refers to the compensatory changes through a succession of time. (Vallée and Ashby 1951; Grossmann and Watt 1992; François 2004). The enormous structural variety of each life system accounts for an array of structures connected within a system.

Why are we interested in knowing the variety of states of a system? The heterogeneity of what? The central interest of understanding the nature of diversity, in addition to the general aspects of the Law of Requisite Variety, is to clarify Ashby's principle suggesting that "Only variety can absorb variety" (Beer 1993:22), in order to distinguish the quality of variety and its degree of order. A sample of disordered letters might be as follows: {i r n a r d y a e t y t e s o i c v r a y e t v}. After ordering them by types, we can determine that it reads {v a r i e t y c a n d e s t r o y v a r i e t y}. The first sample with the 24 letters contains no information, but is rich in entropy; while, in the second sample, they carry no entropy, but are rich in information—especially for an English speaker. Both samples have the same structural variety, 24 letters, but there is something in their organic variety that differs. In the first one we get 24 entities without relation between them, while in the second sample, we find 24 entities related amongst each other. Three properties derive from the last: the combination of letters in words "variety", "can", "destroy" the relation between them, and the meaning in the English language. This type of variety is associated with the meaning of the parts and is found within the domains of semiosis. But a further level is required to understand "variety can destroy variety" as an essential part of the Law of Requisite Variety, it is meta-semiosis or the domain of cybersemiotics ontology. According to cybersemiotics ontology and Luhmann's principles, the first level of consciousness is the capability to distinguish between the identity and the difference of an open system (Luhmann 1995). This process occurs due to the Ashby's law.

The adaptation of a conscious system to a precise context or goal presumes the result of an evolutionary process in which absorption of a variety of meanings occurs (Baumeister 1986). Such is the case of individuals who adapt to the identity within their culture. All individuals' origin is birth, and their development goes on continuously for as long as they learn to identify the variety of states and limitations of their context. Context does not only mean the environment, but individual bodies as well. Throughout life, the limits of reality restrict the degrees of conscious maturity. In the process, individuals assimilate or reject symbols of diverse cultural content in a natural way (Ramachandran 2012). Symbols, icons or indexes that circulate through human interaction within a particular culture do so through time and space; not in an isolated or random manner, but from cultural interpretation rules that we understand as codes. While coding and decoding regulations is called *systems as a code* (S-code) or *semiotic systems* (Eco 1975, 2000), from a systemic approach, the process of semiosis expresses the exchanges and leveling of the variety of information.

This principle provides a general epistemological foundation for biosemiosis, zoosemiosis, and semiosis. In concrete closed systems, the increase of disordered variety is the measurement of uncertainty, which is necessary to know the behavior of any system. Dealing with "the level of uncertainty of a system depends on these elements of disorder" (Pask 1960, p. 116). In open systems, there are high techno-scientific research areas such as biosignaling to determine the uncertainty of biological systems. This discipline explains that cells need to communicate with each other to transduce energy in matter and replicate biological information. The increase of variety of states implies an increase of order in molecular interaction and more complexity in life structures (Nelson and Cox 2015). Meanwhile, in systems that are open to information, transducing matter into energy and reproducing social information requires messages, which are a form of super-organized order patterns. There are several areas of research to explain how information combines within social entities including linguistics, anthropology, history, sociology, psychiatry, neuropsychiatry and semiotics proper.

How do we absorb this variety of states? Information and order play special roles in this process. Human life is a living system which extends into information. Most social animals, like insects, bacteria, fungi, and mammals, modify their own body to adapt to the environment, and sometimes they modify the context and adapt it to their needs. But all of them come from a simple set of elements and rules, decentralized and dependent of the whole system. Indeed, human systems have centralized processes across social institutions. Centralized processes imply a huge intersubjective semiosis called "free will." The difference with other living systems is the manifestation of personality and capacity for personal decision-making. Intersubjective expression and semiosis could be unlimited if understood as part of imagination. An intersubjective idea can lead to a centralized process, like religion, language, economy, or social organization. Conducted by this idea, the systemic-semiotic approach proposes that the process of semiosis expresses the exchange of the variety of information across many scales: intersubjective, private, collective, public, centralized and decentralized.

One of the most significant contributions from the sciences of language is the idea that language is an entity that only has life within a collection of social interactions. For example, the word "stadium" and the word "ballpoint pen" have meaning according to an agreement between the members of a linguistic community. They have learned and replicated tacitly to name the individual experiences that make up the social existence of a stadium and a ballpoint pen. It would appear as if semiosis, at the scale of a particular culture, is something more than a simple process of interaction and exchange of information. From the systemic perspective, a thing is not a single thing, but many things; this depends on the scale of observation, operation and temporality. However, understanding the variation of information states of semiosis is always done from the perspective of culture. Within society, we can observe the organization and disorganization of ideas. Positive entropy dissipates within social relations, while an intricate network of individual, collective, public and private relations motivates negative entropy or disorder in information structures. Thus, researching about the Law of Requisite Variety in semiosis has the aim of formalizing the interaction inside conscious systems, composed by a network of networks of semiotic systems, necessarily interconnected across biological, physical, and social scales which generate order (Luhmann 1998).

Summarizing, the system-semiotics approach has a methodological and applied purpose; while the purpose of the cybersemiotics ontology is to constitute transdisciplinary and general semiotics. In cybersemiotics, the theory of information, communication, meaning, language and the production of signs are gathered within an evolutive framework. In both frameworks, coevolution and adaptation of conscious subjects employ semiosis. Semiosis corresponds to the operations of consciousness which organize the variety of states of reality in the form of pure, complicated, precious, sophisticated, or accidental thoughts. In the last century, Umberto Eco opened a discussion to determine if semiotics is a discipline or a field of research. In response to this problem, he divided the program of semiotics into two parts: general semiotics and particular semiotics. General semiotics encompasses information theories, communication theories, the theory of meaning and of signs in general. Particular semiotics is related to special applications for modeling a semiosis process, such that it occurs in a methodological and applicative order.

In a systemic perspective, cybersemiotics is a transdisciplinary and general semiotics. Systems-semiotics, on the other hand, is a meta-methodological approach and a particular semiotics of Systems Research. Cybersemiotics and systemic-semiotics are complementary. However, their analyses and syntheses of reality are different: cybersemiotics is a purely philosophical framework and systemic-semiotics is a more practical-theoretical framework; notwithstanding, both share common theoretical reference frames and similar semiotic principles. Cybersemiotics agrees with Luhmann (1995) on the networks that connect semiotic systems and meaning. The systemic-semiotics approach goes further to propose that semiosis organizes ideas in the form of semantic networks which help to dissipate entropy through an intricate arrangement of individual and collective relationships. In both cases, their research objects are open systems and share systemic problems, like dissipative structures of semiosis in open systems, but while cybersemiotics applies Luhmann's triple autopoiesis to solve them, systemic-semiotics proposes the Law of Requisite Variety to understand the evolution of semiosis. In the next section, I will describe in detail a systemic-semiotic proposal to formalize cultural phenomena and the nature of the differences when compared to cybersemiotics.

9.4 The Organization of Thought Through Network Theory

A conscious system is a network of semiotic system networks, of necessity interconnected through semiosis. Therefore, the systemic-semiotics hypothesis posits that the conscious unity is based on semiosis, and it is possible to formalize it through complex networks and their theoretic representations. In this way, the evolution and adaptation of cognitive subjects is carried out by semiosis, because: (A) semiosis covers the operations of consciousness which organize pure, complicated, refined, sophisticated, accidental etc. thoughts; (B) these systems are understood as networks of semiotic system networks, necessarily interconnected through semiosis; and (C) therefore, the systemic-semiotics posits semiosis as the unit of analysis for consciousness.

Cybersemiotics ontology has another hypothesis: "[t]he becoming aware brings into being the descriptions that lead us to postulate self, environment, etc. When becoming becomes aware and begins to make the distinction between one self, the others, and the environment, an ontology will necessarily be produced as a prerequisite for the production of meaning in language communication. The concept ontology does not refer to a final and unchangeable, true picture of the world or reality" (Brier 2013, p. 247). Cybersemiotics principle is that to become aware of oneself it is necessary to go through evolutionary stages. First, it is necessary to recognize the variety of different states that surround us. The second is to recognize the array of collective representations to interact with reality, built on from a variety of known states. To this extent, the state of the evolution of an anthill, a pack of wolves, an octopus, and a human being could be considered as within this stage. The third evolutionary stage consists of expressive and personal representations of reality. Cybersemiotics calls them ontologies. This philosophical position is the basis of any evolutionary semiotics; as is the case of systemic-semiotics. The "first overview of the cybersemiotic idea and to explain how the integration of semiotics and system theory offers a more plausible model of evolution that can explain the emergence of mind" (Brier 2013, p. 221–222). Yet, for cybersemiotics, the evolution of consciousness can only be explained by the embodiment of *language games* in humans and *sign games* in other species (Brier 2009).

A semiotics approach, using the tools of complexity sciences, enables the observation of the emergence of patterns and allows for them to be formalized. Ethnographic work has shown these cultural patterns, but the reasons for the emergence of new properties has remained unknown. Social institutions like rituals are characterized as a set of different states of things, people, and activities. They collectively constitute a complex communication model with features susceptible to being observed through a graph or network model. These network models could formalize the compensatory changes and continuities within society. However, from our point of view, society is not a network. Graphs and networks are merely the tools for scientific observation and representation of cultural properties. For this reason, the consciousness unity that we are considering is not language, but semiosis. Through network representations, we can observe its probabilistic evolution and their changes in meaning. For example, when a sign enters into the circuit of digital networks, its meaning is disaggregated and converted into something else, until it finally moves away completely from its original semiosis. The transition from original to final semiosis has nothing to do with the generative models of language, word classes, or syntactic structures; nor is it related to modular or role and reference semantics.

The systemic-semiotics method characterizes social institutions as *regular networks*, *local structures*, or *regular lattices*, or as Strogatz (Watts and Strogatz 1998; Strogatz 2001) did with the social web. The interaction of human groups in shared social spaces, such as markets, public squares and cemeteries, allows for the structuration of a type of connection among individuals, not necessarily related kinship, in *random long-range connections*—as Barrat and Weigt (2000) described on *small-world networks*—, resulting in moderately unexpected highly random behaviors where the diffusion process is the most critical behavior to research. The combined use of these two types of networks *regular* and *random long-range*, to model dynamic self-organizing systems is called *small-world networks* (Watts and Strogatz 1998). Network models require particular gathering of data, to be able to explain the emergence of a new pattern during fieldwork; that is, the point where the structure of a local network of signs establishes long-range connections to unify several local networks with specific grouping nodes (i.e., markets, churches, cemeteries and public places). *Non-random local networks* or *local networks* are the primary components, these are better illustrated by kinship structures or families. New entities emerge as a result of the contact of people and objects within the network hubs, which enables the observation of the network's behavior during the consolidation of meanings. In this way, when a network hub approaches its critical point, from the point of view of social science, phenomena are closer to the climax of the social interaction like rituals. The speed of time between an exchange of signs, people and objects increases exponentially as we approach the peak moment of the ritual (Valle et al. 2016; Mora et al. 2017; Valle and Morales 2017; Valle 2017).

From a simpler perspective, the process of transmitting information from one point to another is *communication*, but from a cybersemiotics ontology perspective, the process where a message arrives from one location to other and somebody understands it is the *communication of meaning*. Using a systemic-semiotics approach, meaning can occur in public, private, individual or collective spheres. Its evolutionary purpose is to create the necessary conditions for interaction and the transformation of sense and the matter of signs at different scales of semiotic organization. Luhmann's conception of communication is related to the theory of sign production, which Eco includes as part of his "Program of General Semiotics" (Eco 1975, 1976). For Luhmann, there is a first level of communication which allows for identifying the identity and difference of an open system. At this level, there is a differentiation between the aim, the channel of delivery, and the unit of action of the system. The second level refers to social systems which are constituted through actions. In this way, communication is always a self-referential process, since its purpose will always be to disaggregate the identity and the difference of the system (self-consciousness,) and can only do so as a social system. Consequently, communication involves an act of understanding and as the relation transmitter–receiver supports a change of their original semiosis. The act of communicating involves a variation in the original semiosis of the communicator as well as in the final semiosis of the interpreter. For the theory of socio-communication, sociocultural evolution generates a subproduct: communication. Therefore, the dimensions of meaning are reflected in objects that preserve memory, such as in the case of oral tradition, the first prehistoric ideograms, and writing systems.

For Luhmann (1995), the difference between information and an act of communication is that information disincorporates autopoiesis from consciousness in its need to acquire structure, while communication makes both coincide as a unity called communicative sign:

> Translated into our conceptual language "expression" means nothing more than the autopoiesis of consciousness, and "sense" or "meaning" means the need to acquire structure for this in the form of an intentional relation. Accordingly, there are signs with expressional value and signs without it, and there are expressions that use signs and those that do not […] *Only in communication do expressional value and utilization of signs inevitably coincide*. In communicative speech, all expressions function as signs. (Luhmann 1995, p. 145–146).

Then, for cybersemiotics, the unity of communication is consciousness across meaning. Instead, for systemic-semiotics, the unity of consciousness is semiosis. For semioticians like Charo Lacalle (2001) and Eric Landowski (1981), the concepts of *public* and *private sphere* place the medium of communication as an interface that regulates the traffic between individual semiosis. The methodological objective of these categories is "to measure the degree of visibility of the subject in the communicative processes" (Lacalle 2001, p. 23). Currently, in communication outlets hosted in social network's websites, the degrees of visibility of individuals are self-evident, whereas, over the XX century and the beginning of this century, the visibility of individuals as a concept was an empirical topic not yet comprehended. From a systemic approach, we can distinguish several scales in which "empirical individuals communicate, and systems of meaning make communication processes possible" (Eco 2000, p. 424). Provisionally, we can divide the visibility of interactions as scales of semiotic organization: culture, society, community, and kinship, which we will explain below.

Culture refers to those interactions that correspond to the set of values and standards of a social system. These values and norms act as parameters of collective order and include beliefs (religious, aesthetic, ethical, and philosophical), legal systems, political ideologies, technical practices, prevailing economic attitudes, etc. Culture polarizes strongly almost all individuals in the system, through reciprocal conditioning of behavior, which in turn, "generates the behavior and attitudes necessary to maintain global coherence, efficiency, and, in some extreme cases, ensure their survival" (François 2004, p. 145). Figure 9.4 is an example of the interactions in the cultural scale. It is a descriptive diagram of language. This type of representation is called a "sociotechnical system" by Van Gigch (1988). This example corresponds to the organization of systems, suprasystems, and subsystems in which a

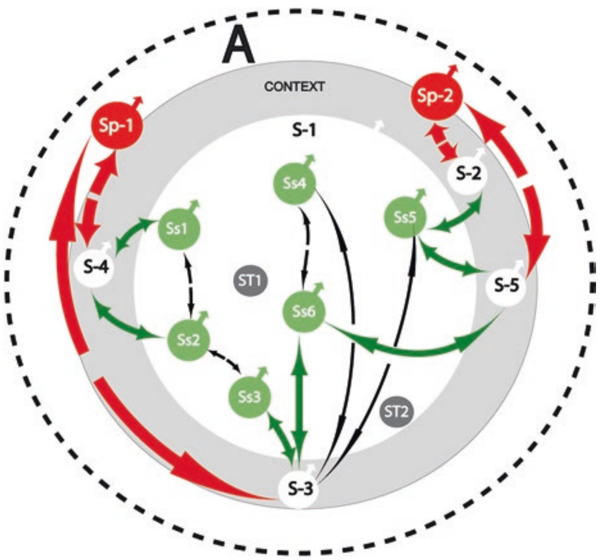

Fig. 9.4 Descriptive diagram of an open socio-technical system
Reading keys: A = Environment. Sp = Suprasystem. Sp1 = Secondary model or verbal language. Sp2 = Primary model or temporal space language. S = System: S1 = Scriptures. S2 = Mathematical language. S3 = Languages with high phonological processes. S4 = Languages with high syntactic processes. S5 = Other systems (i.e. aesthetics). Ss = Subsystem Ss1 = Mixed writing. Ss2 = phonological writing. Ss3 = syllabic writing, Ss4 = morphemic writing. Ss5 = lexical writing. Ss6 = semantic writing. ST = Technical systems (i.e. writing instruments and media). ST1 = Analogue tools, ST2 = Digital tools. (Source: Valle 2015, p. 255)

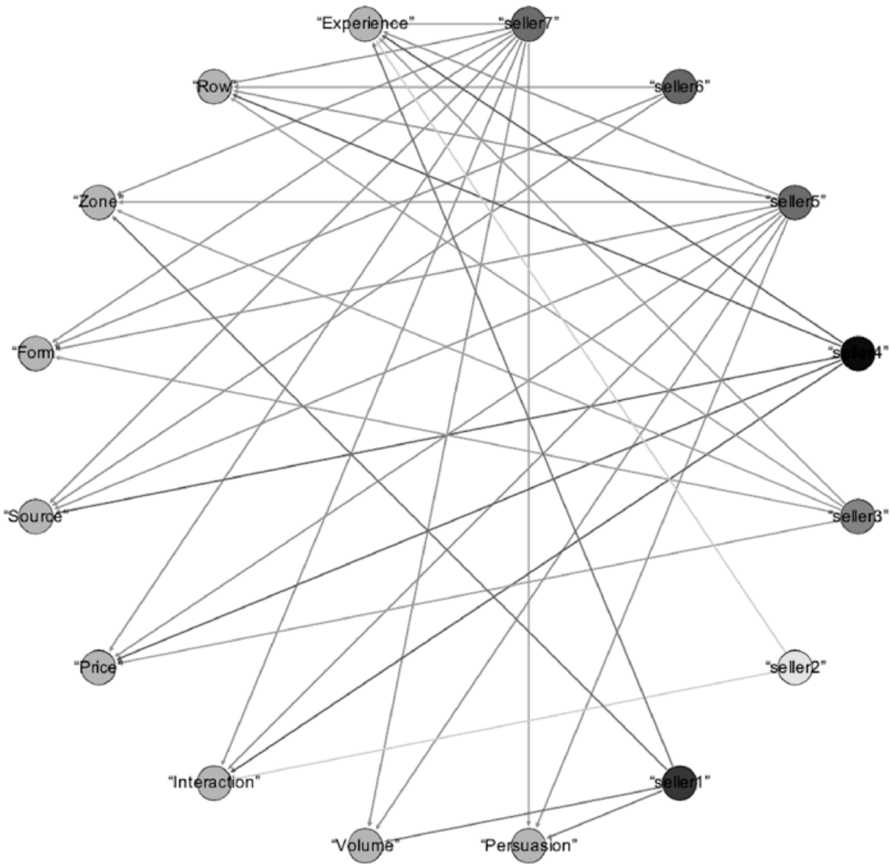

Fig. 9.5 Network model representing a system of economic beliefs in a commercial exchange Nodes represent the purchase-sale experience. Dots are the position of the stands, the origin of the products, the form and placement of the product on the stand. The parameters of order are purchase-sale interactions, the volume of merchandise, sales persuasion, price, and raw materials. Vendors are labeled from 1 to 7. The nodes of this network correspond to the parameters of order the potential buyers use as reference to choose a commodity in seven positions in a rural market or *tianguis*. (Source: Based on Mora et al. (2017)).

social institution like language operates, as well as codependences and relevant points of interaction which can be observed (Valle 2015).

Society involves the interaction of human systems using parameters of order, as shown in Figs. 9.4 and 9.5. Keynon De Greene (1994) explains the use of order parameters as follows: when applied to complex living systems, the establishment of order describes evolutionary limits and warnings for the survival of the system. The parameter order belongs to a macroscopic, emergent collective field, in which critical points of an infinite number of micro-level interactions occur. The parameter of order expresses the stochastic generation of new structural change, as well as the deterministic maintenance of the established situation or its structural constancy.

The appearance of the parameter of order represents a significant loss for the degrees of freedom at the micro-level, so that the micro-level behavior follows the parameter of order. Languages, theories, religions, political belief systems, economic belief systems, as well as scientific and social belief systems, such as the Newtonian paradigm, are exemplary parameters of order (Greene 1994).

Community, in this sense, is a type of interaction between empirical individuals that share frames of reference, similar epistemologies and the realization of similar tests to ascertain reality in a way that mutually validates their knowledge (Holzner 1968). Communities are about "the structure made of interconnected individuals who live in similar environmental conditions" (Thayer 1972, p. 122). Individual members do not "necessarily have to be identical, even if they are all of the same general types. They may very well perform different functions" (François 2004, p. 100). J. G. Miller's theory of living systems places communities as interconnected organizations which, in turn, combine with societies (Miller 1965, 1978, 1986, 1990). Thus, communities consist of a group of two or more individuals who share an identity and a common purpose, and who are committed to the joint creation of meaning through interaction (François 2004). An example of this form of organization is shown in Figs. 9.6 and 9.7.

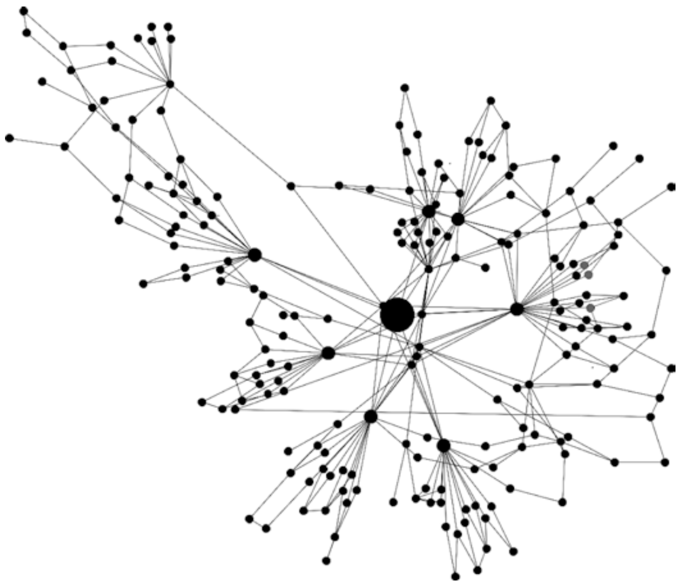

Fig. 9.6 Structure of the interaction during the Day of the Dead ritual at a cemetery in Mexico City, 2013

The nodes represent families and tombs from a single lineage; the links correspond to the interactions between them based on affinity and consanguinity relations. The most significant node represents the cemetery entrance. There is a higher concentration of individuals in that space due to the location of stalls selling flowers, candles, food, dishes, etc. (Source: Valle et al. (2016))

Fig. 9.7 Directed (left) and undirected (right) graphs of a local kinship network in Tlahuac, Mexico City municipality Source: Valle et al. (2016)

Kinship is the smallest but most the smallest and more variable, yet stable type of interaction interaction unit within a community. This type of organization regulates two types of relations, according to classic theory: consanguinity and affinity relations (Morgan 1871). However, approaches like Dziebel's (2006) and Fortes's (1949) from a systemic perspective, consider kinship as a regular or egocentric network, asserting the origin node, and focused on a single family member called *ego* (Wasseman 1994). Thus, kinship relationships in a virtual or physical community are the basis of cultural networks study, as shown in Fig. 9.8.

Using the network models in Figs. 9.4, 9.5, 9.6 and 9.7 and the definitions of each type of interaction as a scale of semiotic organization, it follows that through public and private actions, the collective as well as the individual co-occur at different scales: culture, society, community, and family, as shown in Fig. 9.8. Lacalle (2001) and Landowski (1981) establish that an individual has a degree of visibility throughout the communicative processes, which can be understood applying sociosemiotic concepts like *public* and *private*. In this sense, a social network operates with public or private individuals and public or private collectives of individuals under different modalities, as shown below. Table 9.3 illustrates the visibility of an individual through Lacalle (2001) and Landowski (1981) sociosemiotic concepts, adding social network representations which correspond to different scales of semiotic organization.

Figure 9.8 is intended to clarify how the *isomorphism of interaction* operates across different communication interfaces and impacts the communication process, as outlined in said figure and in Fig. 9.4. Isomorphisms from the biologic scale towards the social scale correspond to the *interaction* from real networks in the "Graphic representation" column versus the social network website in the first column. Signs circulate across different scales of the network; therefore, they do not

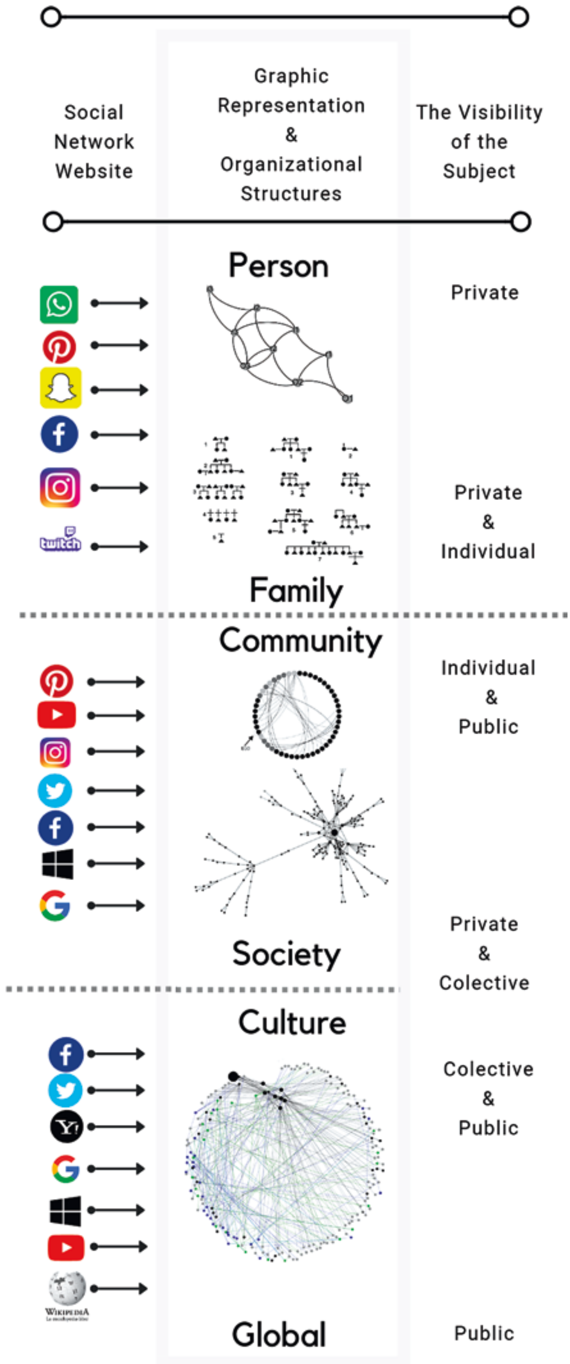

Fig. 9.8 The isomorphism of interaction and its homomorphisms
Note that the social network website Facebook operates across all scales, and consequently, the intimacy, privacy and anonymity of individuals are exposed. For this reason, other social network website where intimacy is not at risk have become more popular among young people. (Source: Elaborated from Valle (2017))

Table 9.3 Visibility of an individual throughout visual communicative processes

Empirical individual	Sociosemiotic concept	Communicative process	Social network website
Individual	Private	Private diaries	Facebook, Snapchat, Twitch, WhatsApp
	Public	Public figure	Twitter, Instagram, Facebook, Tumblr, Flickr
Collective	Private	Community intimacy, closed user groups	Chat services: WhatsApp, Skype, Facebook, Pinterest, Twitch, Rabbit, Ustream.tv, Go Meeting, Bluejeans
	Public	Public opinions Expert opinions Amateur opinions	YouTube, Facebook, Flickr, Blogs, Tumblr, News, Rabbit, Ustream.tv

Source: Elaborated from Lacalle (2001, p. 23)

have the same communication level or share similar interactions, resulting in sign meaning not being the same as in their original semiosis. The homomorphisms[7] of interaction are individual–private, individual–public, collective–private, and collective–public, all of which determine the type of semiosis and the visibility of individuals. Interaction occurs within culture, society, community and family, that is, regular networks within semiotic organization. Figure 9.8 also illustrates the qualitative aspects referring to the nodes and their meanings (Figs. 9.4, 9.5, 9.6 and 9.7), and quantitative features such as nodes of influence involving objects, persons or signs as well as their degree of connectivity. The behavior of interactions is represented as an isomorphism of interaction network along with its homomorphisms.

Cybersemiotics advances that interactions are necessarily evolutionary, which is also congruent with the systemic-semiotics approach. Within the types of interaction described above, social systems are integrated and constituted. In human communication, an expression serves as evidence of autopoiesis of consciousness. The changes of connectivity across networks are proof of the need to structure communication in the form of intentional relationships with entities beyond the self.

9.5 Discussion

The process of semiosis involves many aspects that have their basis in signification theory propositions: signs undergo transformations, and transformations occur under certain conditions. Open systems always exhibit periods of growth, relative

[7] According to Vallée (1990), the multidisciplinary or transdisciplinary character of systems theory has, as its fundamental purpose, the finding of the structural isomorphisms between systems which belong to different disciplines or between representations of the same order. Wiener (1954) refers to such isomorphisms as mere homomorphisms in his cybernetics work. The search for this type of isomorphism, or proper homomorphism, has led to the concept of a model which allows for the representation of a category of systems.

stability, and decay; that is, transformations of different qualities. Those transformations are understood as their *life cycle* (Boulding 1952). Throughout the process of consolidation of meaning, several life cycles occur, and in these the evolution of signs into other signs by acquisition of meaning becomes clear, either at an individual or collective dimension. For systemic-semiotics, a directive guiding principle is the signs transduction—or semiosis—and the general rules of their transformations. In such a way, systemics and semiotics complement each other through the principles and models of the Systems Research paradigm.

Cybersemiotics developed the concept of *sign games*, which are a type of semiotic secondness which produces meaning for all living systems, as opposed to natural language or language games, and based on Luhmann's paradigm of triple autopoiesis (Brier 2013). We use we use past experiences manipulating linguistic signs to communicate our ideas on a daily basis (Peirce 1974). We also use other types of signs to convey meanings which are more complex than linguistic signs, such as clothing, tools, or body modifications (Barthes 2015); these are what, in Brier (2013), are called *sign games*. Therefore, personal taste for objects and words define us when facing a cultural community, both subtly and forcefully. However, taste is not an element of logic which can be characterized merely by its enunciation, the conformation of signs requires a given form and matter, and which depend on historical and cultural contexts. A context of choice or of fashion is a space of statistical equiprobability which, for Eco's general semiotics, is confined to a given code.

From a systemic approach, a code is a specific set of signals and interconnection rules to conform a communication system capable of transmitting messages. Hence, semiotics and the theory of codes are needed to describe the structure of the semiotic function, and the global possibilities of coding and decoding. These principles correspond to the operation domain of signs transduction, while the region of the organization corresponds to the theory of production of signs or languages (Eco 1975). Louis Hjelmslev (1987) considers that the structure of the sign system is not different from the language structures described by linguistics. Languages, in a linguistic sense, are unrestricted languages, thus, they consist of the elements and rules sufficient to provide meaning to anything. However, other forms of communication, such as theories and mathematics, are designed to represent things and objects in a certain way and under certain conditions, as shown in Fig. 9.9.

In restricted logical languages, it is possible to determine the validity of their axioms through recursive functions in their axiom system, whenever they are well defined. An example is the development of the deduction theorem (Tarski 1994). Nonetheless, if languages do not have these kinds of logical deductive properties, they are unrestricted, like most natural languages of culture. In the terminology of propositional logic, linguistic expressions correspond to cultural languages such as natural languages, three-dimensional languages, like American Sign Language, and visual, culinary, olfactory, proxemic, and materials languages. Against all theoretical predictions, from the perspective of variety organizing domain, restricted languages have properties identical to those of unrestricted languages (Tarski 1944, 1994).

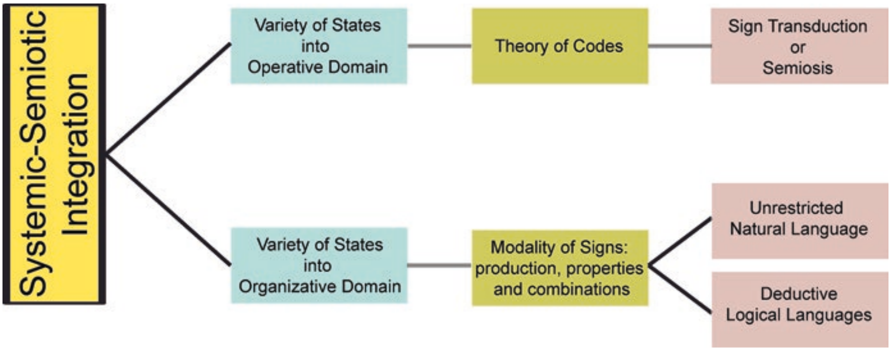

Fig. 9.9 Systemic-semiotics integration

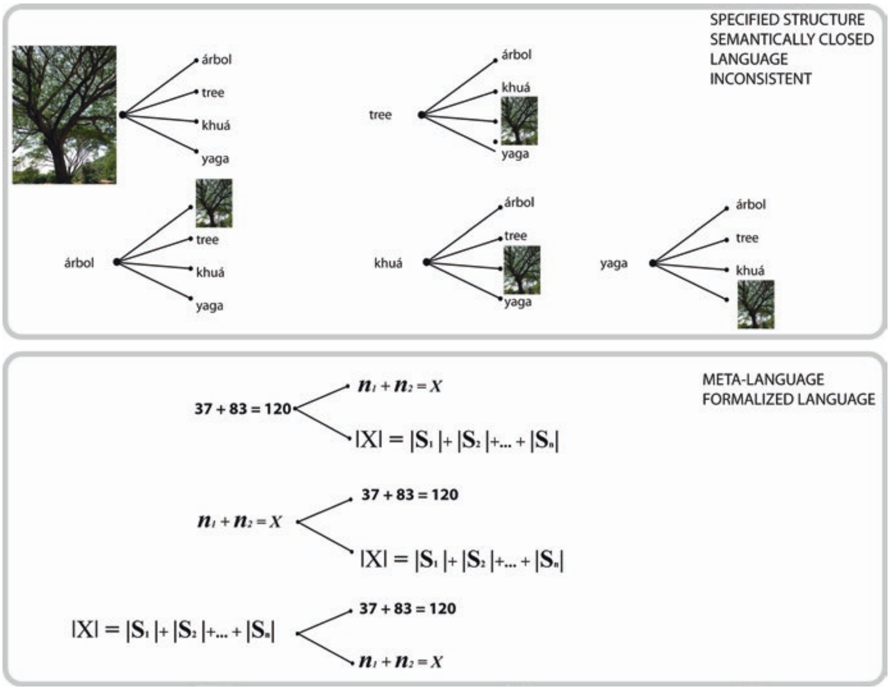

Fig. 9.10 Metalanguage external to the object–language
Source: Author

For example, every linguistic expression, such as 'árbol' in Spanish, can be translated into Otomi, English, or Zapotec, and vice-versa, as shown in Fig. 9.10. However, to read a mathematical formula, you need to have knowledge of logical structures inherent to the syntax rules of the deductive system. Specified languages are the languages that belong to the class of deductive systems; those with formalized primitive terms, rules of definition and rules of inference (Tarski 1944).

Linguistic languages have their words, laws of specification, and reasoning, and closed-semantic definitions. This last term is relevant because the idea of *true* meaning depends on who makes the enunciation and where (historically). Figure 9.10 represents the relations between the expression of a semantically closed language (above) and a formal language (below). The first has a combinatorial metalanguage and a hierarchy of communication. The object-language occupies the position of the initial node (the root node from which the branches in the trees scheme extend). The internal structure in both examples holds the relation between an initial and a final node, whose combinatorial principle is equal to the combination factor. In both cases, the directed graphs schematize the relations of semiosis through metalanguages. The cybersemiotics approach does not consider metalanguage as an analytical concept, which is logical since metalanguage analysis is a reductionist method.

The complexity of metalanguages lies in the fact that their function within an object-language is the interpretation of semiosis regarding the social, cultural and historical experience of the interpretant. In some way, it carries psychological aspects which are always difficult to formalize. In certain formal languages, open semantics prevails only for highly abstract and general properties, and this in turn, makes open semantics only applicable to defined objects and processes (i.e., a square, a circumference, a line, a point, or arithmetic operations, etc.) There is no closed-semantics of sociocultural-historical order and, therefore, metalanguages are not required to reach necessary conclusions. In fact, in a deductive system, there is not semantics *per se*, since its axioms and concepts have the property of being applied to many types of objects, regardless of their categories, material, or formal qualities. Thus, its internal design supersedes the combinations of its defined terms, with the intervention of its rules of definition and inference. By contrast, in closed-semantic systems, to define the combinations of terms, historical temporality intervenes. Hence, those linguistic languages are, from the characterization of logic, semantically closed and inconsistent, and always require a metalanguage to clarify the ambiguities of their signs (Tarski 1944). Cybersemiotics faces this problem when it does address language from linguistics and characterizes language games as a linguistic problem.

However, when we investigate language from a cultural perspective, as a set of semiotic systems, it involves two behaviors: the maintenance of meanings, and their transformation-adaptation. The maintenance and actualization of definitions occur through self-reference, as posited by cybersemiotics and Luhmann's theory. While the transformations happen according to autopoiesis. The combination of both processes renews the logical limits of the semiotic system, giving force and identity to the autonomy of the object–language regarding other metalanguages inherent to culture. Then, the most critical property of the semiotic system (S-code) is the capacity to absorb the variety of external states, new things, external elements to the self-referential system, and the autopoietic processes from which they emerge. In this way, if a system is designed to capture a large variety of states, it has a more prominent adaptability and capacity to deal more effectively with the natural tendency to entropy: the higher the information as a measure of order, the higher the influential capacity of a semiotic system (S-code) has to be to encode the variety of states of the world through messages, and the better chances it will have to adapt and assimilate external disturbances in the form of conscious systems. In this way, theoretically speaking, culture is a conscious superorganism. Based on these considerations, cybersemiotics and the systemic-semiotics approaches cannot be part of the program of general semiotics for Semiotic Research, described so painstakingly by Umberto Eco, nor are they part of particular semiotics in linguistics.

The systemic-semiotics method described here is not the only possibility for the formalization of culture, nor the most accurate path that semiotics should follow in its dialogue with transdisciplinarity. Yet, its purpose is to integrate the diversity of principles and theoretical perspectives of semiotics to express, through formal models, the process of acquisition of meaning. The constitution of a quantitative semiotics of sorts is not of a mathematical order, as the reader might verify throughout the last section. However, the fundamental ideas of these sections have their basis on the "Methodology of Deductive Sciences" by Alfred Tarski, who shared a common logical-semiotic knowledge with Roman Jakobson and Louis Hjelmslev. Nor is this a framework which announces axiomatic semiotics proposals to be tested or constituted as rules, laws and theorems. It is a systemic-based methodology for the recognition of behavior patterns across different varieties of states of semiosis. In this sense, a quantitative semiotics is a particular semiotics for transdisciplinary Systems Research. One of its methods is quantitative and it pursues concrete results in order to identify the extent to which our scientific tools allow us to make the processes of signification measurable. The path we follow in this text starts from the epistemic aspects of the system as well as the concepts of variety which, in our opinion, are fundamental in furthering the development of a systemic formalization of semiosis. On the other hand, cybersemiotics is an ontological basis and guidance for our ideas and scientific intuitions about the grounds of evolutionary consciousness. It is a general semiotics for transdisciplinary Systems Research.

Systems Research is divided in three categories: Systems Thinking, Systems Science and Systems Engineering. The cybersemiotic approach is an ontological foundation of Systems Thinking, and its aim is the research of consciousness. Consequently, the hypothesis is that the unity of semiosis is consciousness and language. The systemic-semiotic approach is a basis for Systems Engineering, and its aim is to learn about semiosis and the governing principles of human intelligibility. Accordingly, the hypothesis is that the unity of consciousness analysis is semiosis evolution. Eco's *A Theory of Semiotics* (1976) has been a very important intellectual tool for the logical and semiotic foundation of several multi-disciplines that were born during the twentieth century. The concepts and definitions brought together in this work are the basis of developments in many disciplines. However, Systems Research has managed to define a common object of study for transdisciplinary semiotics: open systems.

The cybersemiotics approach enables an understanding of social systems and culture as socio-communication (instead of following Eco's theory of sign production). And systemic-semiotic tools, like quantitative semiotic methods, allow us to identify the probabilistic evolution of meaning (disregarding Eco's theory of codes). The former can be sustained in a pure philosophical dimension, whereas the latter is necessarily classified as methodological application. Naturally, the definitions of information, entropy, open system and semiosis as units of systemic-semiotic analysis are not exclusive to this approach; it is only a methodological support. Moreover, the formalization of graphs and networks is an attempt to show the enormous capacity of abstraction within the relational properties between entities. We take these epistemic concepts from the work of Peirce, Euler and Listing; however, along with Listing, and in the philosophical work of Peirce, we find the first characterizations for a formal language of signs as monadic, dyadic, triadic, and poliadic relations, which Peirce called *existential graphs*.

The possible formalization of culture and the development of a true artificial consciousness necessarily requires the laws of mechanics and a precise description of the ontological processes which enable the emergence of life and consciousness, and which prove for a fact that it is essential to return to philosophy, except that this type of philosophy must be transdisciplinary, as does its field of research.

References

Arieti, S. E. (1969). Toward a unifying theory of cognition. In *General systems theory and psychiatry* (pp. 193–209). Boston: Litle Brown and Company.

Ashby, W. R. (1958). Requisite variety and its implications for the control of complex systems. *Cybernetica, 1*(2), 83–99.

Ashby, R. (1961). *An introduction to cybernetics*. London: Chapman & Hall Ltd.

Atherton, J., & Blaser, M. (2009). Coadaptation of helicobacter pylori and humans: Ancient history, modern implications. *The Journal of Clinical Investigation, 119*(9), 2475–2487.

Barrat, A., & Weigt, M. (2000). On the properties of small-world network models. *The European Physical Journal B-Condensed Matter and Complex Systems, 13*(3), 547–560.

Barthes, R. (2015). *Le bruissement de la langue. Essais critiques 4*. Le Seuil.

Bateson, G. (1972). Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology. Chicago: University Of Chicago Press.

Baumeister, R. F. (1986). *Identity: Cultural change and the struggle for self*. New York: Oxford University Press.

Beer, S. (1968). *Decision and control*. New York: J. Wiley.

Beer, S. (1985). *Diagnosing the system for organizations*. London/New York: Wiley.

Beer, S. (1993). *Designing Freedom*. Toronto: House of Anansi.

Berg, J. (2017). Science, big and small. *Science Magazine, 358*(6370), 1505.

Bertalanffy, L. v. (1956). General systems theory. In *Yearbook of the society for the Advancement of General System Theory* (pp. 1–10).

Blauberg, I., Sandovsky, V., & Yudin, E. (1977). *Systems theory: Philosophical and methodological problems*. Moscow: Progress Publishers.

Bohm, D., & Peat, D. (1987). *Science, order and creativity*. New York: Bantam Books.

Boscovich, R. (1758). *Philosophiae naturalis theoria.* Appendix de anima et Deo.

Boulding, K. E. (1952). Implications for general economics of more realistic theories of the firm. *The American Economic Review, 42*(2), 35–44.

Boyanova, L., Mitov, I., & Vladimirov, B. (2011). *Helicobacter pylori*. Norfolk: Caister Academic Press.

Brier, S. (2003). Information seen as part of the development of living intelligence: The five-leveled Cybersemiotic Framework for fis. *Entropy, 5*, 88–99.

Brier, S. (2008). *Cybersemiotics. Why information is not enough*. Toronto: University of Toronto Press.

Brier, S. (2009). Levels of Cybersemiotics: Possible ontologies of signification. *Cognitive Semiotics, 4*, 28–63.

Brier, S. (2013). Cybersemiotics: A new foundation for transdisciplinary theory of information, cognition, meaningful communication and the interaction between nature and culture. *Integral Review, 9*(2), 220–263.

Carroll, J. (Ed.). (1956). *Language, thought, and reality: Selected writings of Benjamin Lee Whorf*. Cambridge, MA: Technology Press of Massachusetts Institute of Technology.

Caws, P. (1968). Science and systems: On the unity and diversity of scientific theory. *Society of General Systems Research, 13*, 3–12.

Checkland, P. (2000). Soft systems methodology: A thirty year retrospective. *Systems Research and Behavioral Science, 17*(S1), S11–S58.

Chomsky, N. (1956). Three models for the description of language. IRE Transactions on information theory, 2(3), 113–124.

Dakin, R., Fellows, T. K., & Altshuler, D. L. (2016). Visual guidance of forward flight in hummingbirds reveals control based on image features instead of pattern velocity. *Proceedings of the National Academy of Sciences, 113*(31), 8849–8854.

De Rosnay, J. (1975). *Le macroscope. Vers une vision globale*. Paris: Edition du Seuil.

Dziebel, G. (2006). *The genius of kinship*. New York: Youngstown.

Eco, U. (1975). *Trattato di semiotica generale*. Milano: Bompiani.

Eco, U. (1976). *A theory of semiotics*. London: Macmillan.

Eco, U. (2000). *Tratado de semiótica general*. Barcelona: Lumen.

Fischer, R. (1991). A neurological re-interpretation and verification of Boscovich covariance (1758). *Cybernetica, 34*, 2.

Fortes, M. (1949). *The web of kinship among the Tallensi*. London/New York: International African Institute and Oxford University Press.

François, C. (Ed.). (2004). *International encyclopedia of systems and cybernetics*. München: Walter de Gruyter.

Friggeri, A., Adamic, L., Eckles, D., & Cheng, J. (2014). *Rumor Cascades*. Association for the Advancement of Artificial Intelligence.

Glasersfeld, E. (1976). Cybernetics and cognitive development. *American Society for Cybernetics, Cybernetics Forum, 8*(3/4), 115–120.

Glasersfeld, E. (1988). *The construction of knowledge*. Seraside: Intersystems Publisher.

Goguen, J., & Varela, F. (1979). Systems and distinctions; duality and complementarity. *International Journal of General System, 5*(1), 31–43.

Greene, K. (1994). Can systems dynamics be theoretically improved and, if so, does it matter practically? *Systems Research, 11*, 3.

Grossmann, W., & Watt, K. (1992). Viability and sustainability of civilizations, corporations, institutions and ecological systems. *Systems Research and Behavioral Science, 9*(1), 1–41.

Guddemi, P. (2000). Autopoiesis, semeiosis, and co-coupling: A relational language for describing communication and adaptation. *Cybernetics & Human Knowing, 7*(2–3), 127–145.

Haken, H. (2012). Complexity and complexity theories: Do these concepts make sense? In J. Portugali, H. Meyer, E. Stolk, & E. Tan (Eds.), *Complexity theories of cities have come of age. An overview with implications to urban planning and design* (pp. 7–20). Heidelberg/Dordrecht/London/New York: Springer.

Haken, H. (2013). *Synergetics: Introduction and advanced topics*. Stuttgart: Springer Science & Business Media.

Hjelmslev, L. (1943). Prolegomena to a theory of language, Francis J. Whitfield (trans.). Copenaghen: Ejnar Munksgaard.

Hjelmslev, L. (1987). *Ensayos lingüísticos*. Madrid: Gredos.

Hoeschele, M., & Fitch, W. (2016). Phonological perception by birds: Budgerigars can perceive lexical stress. *Animal Cognition, 19*(3), 643–654.

Holzner, B. (1968). *Reality construction in society*. Cambridge, MA: Schenkman.

Dewey, J. (1980). Art as experience: New York: G.P. Putnam's Sons.

Kardos, N., & Demain, A. (2011). Penicillin: The medicine with the greatest impact on therapeutic outcomes. *Applied Microbiology and Biotechnology, 92*(4), 677.

Kargl, W. (1991). *andlung und Ordnung im Strafrecht.: Grundlagen einer kognitiven Handlungs- und Straftheorie*. Berlin: Duncker and Humboldt.

Klinkenberg, J. (1996). *Précis de sémiotique générale*. Paris: De Boeck & Larcier.

Klir, G. (1991). *Facets of systems science*. New York: Plenum Press.

Kotarbinski, T. (1995). The methodology skills: Concepts and issues. In A. Collen & W. Gasparski (Eds.), *Design and systems: General applications of methodology*. London: Transactions Publishers.

Kuenen, L., & Gilbert, C. (2014). Visual ground pattern modulates flight speed of male Oriental fruit moth Grapholita molesta. *Physiological Entomology, 39*(4), 271–279.

Kuenen, L., Gilbert, C., & Siegel, J. (2014). Flying slower: Floor pattern object size affects orthokinetic responses during moth flight to sex pheromone. *Journal of Insect Behavior, 27*(5), 581–592.

Kuhn, T. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Lacalle, C. (2001). *El espectador televisivo. Los programas de entretenimiento*. Barcelona: GEDISA.

Landowski, E. (1981). Jeux optiques. *Actes Sémiotiques. Documents, III* (22).

Laszlo, E. (1987). *Evolution: The grand synthesis*. Boston: New Science Library/Shambhala Publications.

Linz, B., Balloux, F., Moodley, Y., Manica, A., Liu, H., Roumagnac, P., Falush, D., Stamer, C., Prugnolle, F., van der Merwe, S., Yamaoka, Y., Graham, D., Perez-Trallero, E., Wadstrom, T., Suerbaum, S., & Achtman, M. (2007). An African origin for the intimate association between humans and Helicobacter pylori. *Nature, 445*(7130), 915.

Luhmann, N. (1995). *Social systems*. Stanford: Stanford University Press.

Luhmann, N. (1998). *Sistemas sociales: lineamientos para una teoría general*. Barcelona: Anthropos Editorial.

Martin, J., Bendz, J., Chroust, G., Hybertson, D., Lawson, H., Martin, R., et al. (2012, April). *Team 4: Towards a common language for systems praxis IFSR conversation– April* 2012. November 9, 2017. Retrieved from Systems Praxis Org.: http://systemspraxis.org/syssciwg/SysPraxisRpt2012.pdf

Maturana, H. (2002). Autopoiesis, structural coupling and cognition. *International Society for the Systems Sciences*. November 3, 2017. Retrieved from (DRAFT): http://www.isss.org/maturana.htm.

McWhinney, W. (1997). Praxis: Beyond theory and practice. *Cybernetics and Human Knowing, 4*(2–3), 79–97.

Miller, J. (1965). Living systems: Basic concepts. *Behavioral Science, 10*.

Miller, J. (1978). *Living Systems*. New York: Mac Graw Hill.

Miller, J. (1986). Can systems theory generates testable hypothesis? *Systems Reseacrh, 3*, 2.

Miller, J. (1990). Introduction: The nature of living systems. *Behavioral Science, 35*(3).

Mitchell, M. (2009). *Complexity: A guided tour*. Oxford: Oxford University Press.

Mora, T., Román, J., & Gallardo, E. (2017). Trade networks in objects for the traditional day of the dead offering at Ozumba Tianguis. In E. Bailey (oord.), *Rituals: Past, present and future perspectives* (pp. 19–40). New York: Nova publishers.

Morgan, L. (1871). *Systems of consanguinity and affinity of the human family*. Washington, DC: Smithsonian Institution.

Morin, E. (1972). Le retour de l'événement. *Communications, 18*(1), 6–20.

Nelson, D., & Cox, M. (2015). *Lehninger. Principios de Bioquímica–6ª Edición*. Barcelona: OMEGA.

Pask, G. (1960). The natural history of Networks. In M. Yovits & S. Cameron (Eds.), *Self-organizing systems*. New York: Pergamon Press.

Pask, G. (1968). *An approach to cybernetics*. London: Hutchinson.
Peirce, C. S. (1931). The Collected Papers of CS Peirce, 8 vols. Harvard University Press, 58.
Peirce, C. (1974). *Collected papers of Charles Sanders Peirce, volume 1–VI*. Cambridge, MA: Belknap Press of Harvard University Press.
Peirce, C. (2012). *Obra filosófica reunida Tomo II (1893–1913)*. México: Fondo de Cultura Económica.
Popper, K. (1957). *The poverty of historicism*. London/New York: Routledge.
Prigogine, I. (1978). Time, structure, and fluctuations. *Science*, 777–785.
Prigogine, I. (1980). From Being to Becoming: Time and Complexity in the Physical Sciences. San Francisco: W. H. Freeman & Co.
Prigogine, I. (1993). Tan Solo una Ilusión?. Barcelona: Tusquets.
Prigogine, I., & Nicolis, G. (1967). On symmetry-breaking instabilities in dissipative systems. *The Journal of Chemical Physics, 46*(9), 3542–3550.
Prigogine, I., & Nicolis, G. (1971). Biological order, structure and instabilities. *Quaterly Review of Biophysics, 4*(2–3), 107–148.
Ramachandran, V. (2012). *The tell-tale brain: A neuroscientist's quest for what makes us human*. New York: WW Norton & Company.
Rosenblueth, A., Wiener, N., & Bigelow, J. (1943). Behavior, purpose and teleology. *Philosophy of Science, 10*(1), 18–24.
Saussure, F. (2011). *Course in general linguistics*. New York: Columbia University Press.
Sebeok, T. (1991). A sign is just a sign (p. 33). Bloomington: Indiana University Press.
Schneider, E., & Sagan, D. (2008). *La termodinámica de la vida: Física, cosmología, ecología y evolución*. Barcelona: Tusquets Edits.
Schrödinger, E. (1992). *What is life?: With mind and matter and autobiographical sketches*. Cambridge: Cambridge, University Press.
Serway, R., & Jewett, J. (2014). *Física para ciencias e ingeniería* (Vol. 1). México: Cengage Learning.
Shannon, C. (1948). A mathematical theory of communication. *Bell Systems Technical Journal, 27, 623*(656), 379–423.
Shannon, C. (1949). Communication theory of secrecy systems. *Bell Systems Technical Journal, 28*, 656–715.
Sillitto, H. (2012). *Integrating systems science, systems thinking and systems engineering: Understanding the differences and exploiting the synergies (Draft)*. Rome: INCOSE International Symposium.
Singer, J., Sillitto, H., Bendz, J., Chroust, G., Hybertson, D., et al. (2012). The systems praxis framework. In *Systems and science at crossroads – Sixteenth IFSR conversation', SEA-SR-32* (pp. 89–90).
Spierings, M., Hubert, J., & Honing, H. (2016). Can birds perceive rhythmic patterns? A review and experiments on a songbird and a parrot species. *Frontiers in Psychology, 2016*(7).
Strogatz, H. (2001, March). Exploring complex networks. *Nature, 410,* 268–275.. Macmillan Publishers.
Sun, E., Rosenn, I., Marlow, C., & Lento, T. (2009). Gesundheit! Modeling contagion through facebook news feed. *AAAI, Conference on Weblogs and Social Media.*
Tarski, A. (1944). The semantic conception of truth: And the foundations of semantics. *Philosophy and Phenomenological Research, 4*(3), 341–376.
Tarski, A. (1994). *Introduction to logic and to the methodology of the deductive sciences*. (No. 24). Oxford University Press on Demand.
Taşkın, E., Eltem, R., & Soyak, E. (2009). Enhancement of solid state fermentation for production of penicillin G on sugar beet pulp. *BioResources, 5*(1), 268–275.
Thayer, L. (1972). Communication systems. In E. Laszlo (Ed.), *The relevance of general systems theory*. New York: Braziller.
Valle, B. (2015). *Metodología Sistémica para desciframiento de Códices*. Ciudad de México: Instito Politécnico Nacional.

Valle, B. (2017). Lo individual y lo colectivo en las tic. Isomorfismos con el pasado y perspectivas de la era digital. *Revista Iberoamericana de Comunicación*, 103–152.
Valle, B., & Morales, O. (2017). Networks in modern rituals: An ethnographic method for quantitative semiotics. In E. Bailey (coord.), *Rituals: Past, Present and Future Perspectives* (pp. 41–60). New York: Nova Publishers.
Valle, B., Morales, O., & Badillo, I. (2016). *Networks and meaning in the day of the dead ritual*. Saarbrücken: LAP.
Valle Canales, B. L., Murillo Sandoval, S. L., Badillo Piña, I., Peón Escalante, I., Morales Matamoros, O., & Tejeida Padilla, R. (2015). Esbozo de la semiótica con perspectiva sistémica. Comunicación y sociedad, (24), 215–242.
Vallée, R. (1987). Sur les "eléments propres" de H. von Foerster. *Rev. Internat. Systémique, 1*, 1.
Vallée, R. (1990). Sur quelques concepts de la théorie des systèmes. *La systémique en tant que nouvelle forme de connaussance Symp. Écrit, nr. 2,*. Inst. de la Méthode, Bienne.
Vallée, R., & Ashby, R. (1951). Statistical machinery. *Thales, 7*, 1–8.
Van Gigch, J. (1988). Designing the order inquiring system II. The contemporary computer. *Systems Research, 5*(3).
Vidales, C. (2017). Building communication theory from Cybersemiotics. *Cybernetics and Human Knowing, 24*(1), 9–32.
Wasseman, S. (1994). *Social network analysis. Methods and applications*. Champaign, University of Illinois, Urbana-Champaign.
Watts, D., & Strogatz, H. (1998, June). Collective dynamics of 'small-world' networks. *Nature, 393*, 440–442.. Macmillan Publishers.
Weinberg, G. (1975). An introduction to general systems thinking (Vol. 304). New York: Wiley.
Werner, J., & Buse, M. (1988). Temperature profiles with respect to inhomogeneity and geometry of the human body. *Journal of Applied Physiology, 65*(3), 1110–1118.
West, G. (2017). *Scale: The universal Laws of growth, innovation, sustainability, and the pace of life in organisms, cities, economies, and companies*. New York: Penguin Press.
Wiener, N. (1954). *The human use of human beings: Cybernetics and society*. Boston: Houghton Mifflin.
Wilber, K. (2001). *Sex, ecology, spirituality: The spirit of evolution*. Boston: Shambhala Publications.
Young, J. (1974). *A model of the brain*. Oxford: Oxford University Press.
Young, J. (1978). *Programs of the brain*. Oxford: Oxford University Press.