

Origins and Implications of Autopoiesis

Preface to the Second Edition of De Máquinas y Seres Vivos

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> Context • In 1974, Humberto Maturana and Francisco Varela published *De Máquinas y Seres Vivos. Autopoiesis: La organización de lo vivo* in Santiago, Chile as a little book. A second edition of this publication was proposed in 1994, and the present document is a recent translation of Maturana's reflections "twenty years after." **> Problem** • The book clearly enunciates what it means to say that living systems are molecular autopoietic systems, and this Preface reflects on the shift of understanding from earlier notions of self-referred or auto-referred systems to the concept of autopoiesis. **> Implications** • The Preface describes the systemic quality that is human living and human sense-making. It marks what we can retrospectively see as the bridge between the explicitly biological studies of Maturana (and Varela), and the later, more anthropological and therapeutic work of Maturana with Gerda Verden-Zöller between 1989 and 1994 and, especially, with Ximena Dávila Yáñez since the year 1999. **> Results** • The underlying understanding implicit in this document outlines in great clarity the implications of Maturana's fundamental insights. It presents both a logical and passionately argued case for mutual respect, grounded in scientific findings in biology. The Preface is a clear vision of why Maturana's work has been so influential for reflexivity and constructivism. **> Key words** • Autopoiesis, constitution of the living, systemic, structural determinism, humanness.

Introduction by the translator: Translation, discourse, and languaging

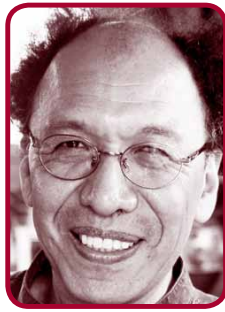
Alberto Paucar-Caceres and Roger Harnden came together for the purpose of translating Humberto Maturana's Preface of the second edition of *De Máquinas y Seres Vivos. Autopoiesis: La organización de lo vivo* from the original Spanish into English (Maturana 1994). One author is bilingual in Spanish and English; the other an expert on cybernetics, second order cybernetics, and the biology of cognition. Both have long been familiar with the ideas of Humberto Maturana and Francisco Varela. However, this has not been a straightforward translation task, and in this introduction we wish to briefly touch on some of the issues entailed.

We undertook this "labor of love" because we feel that the Preface is an important document in its own right, containing

fascinating original material. There are reflections by Maturana not readily available elsewhere – some biographical, some technical. We feel that the narrative evidences a turning point, both in the author's life and in his intellectual development. It can be seen as representing a transitional moment in which the early biological work on autopoiesis moved through a preoccupation with cognition and languaging towards the focus of the later work – the emergence of humanness through the biology of love. In other words, the paper acts as a bridge. It helps the reader construct a unified picture of the relevance of an original and important figure for biology and evolutionary theory and for understanding just what it is to be human. Its absence in English until now has resulted in a sometimes schizophrenic understanding of Maturana – confusion in the face of what might appear to be a disconcerting step-change from biology into something else, with no apparent coherence between the two.

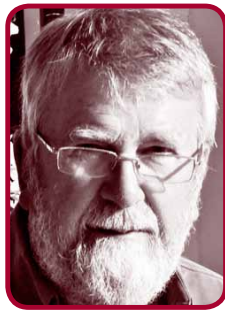
In undertaking this task our intention was to help address this somewhat fragmented understanding as much as to effect a simple "good" translation. Over the past thirty years there have been successful and unsuccessful translations of Maturana's texts. For the present task, we saw the opportunity to deepen insight into the coherence of an original and great thinker, not merely by a routine word-by-word translation from one language to another, but perhaps by helping nudge into the light the meaning of the complex and sometimes startling insights. This required a good deal of trust from the author, for which we are extremely grateful.

At several points we have added footnotes to comment on particular problematical issues or to point out what we think are interesting links to other bodies of knowledge. These footnotes are our own responsibility and stand outside the flow of the original Spanish preface, but we feel they may be of interest to the contemporary reader. We stress that these footnotes should not be tak-



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is an independent researcher and author, working from his home town of Blaenau Ffestiniog, North Wales. Both his personal interests and his professional activities have been driven by issues to do with the intimate relationship between the experience of personal identity and the human creative urge. He believes that the presently massive proliferation and global distribution of mobile web enabled devices has enormous implications for this virtuous cycle, with far-reaching implications for all sectors of human social interactivity. In particular, this is linked to an exponential increase in recursions of recurrent coordination of interactions.

en to reflect Maturana's views – they are our own personal comments from the sidelines, as it were.

We have rigorously and consistently attempted to be true to the author's conscious effort to mirror his scientific insights into the organization of life through a particular usage of style and syntax, best described as cyclical. Once again, we appreciate his willingness to allow us to relax occasionally the strict standards of literal translation at moments when we felt that the translation task itself was obscuring the core concepts and hindering their arising through the medium of the English language.

Octavio Paz said words to the effect that the task of expressing ideas in language is itself one of translation. In a different context, Maturana has frequently made the point that the primary functioning of language is due to its connotative rather than denotative nature. The key point is that the connotation never ends by finally "pointing" to an object. Language is endless translation and making sense in the course of the endless translations that accompany human behavioral interactions in their social and operational reality (human living). In this task, we have

certainly experienced the creative tension of riding the wave of the rich, mysterious, and sometimes ambiguous play of language itself. Indeed, we may not have been able to point to (to denote) any fixed objective reality, but we feel quietly confident that our translation conveys Maturana's deep insight that this "play" is not just one of language and living but is intrinsic to scientific insight into the biological dynamics of molecular life itself.

We are extremely conscious that in the re-creation process that every translation entails, the translator has a particular responsibility. After all, it is easy to fall into the wrong path and get the wrong message: "traduttori traditore" is the Italian saying recalled by Gabriel Garcia-Marquez. We firmly believe that we have avoided falling into that path and have conveyed the essence of Maturana's powerful thinking. The present document is Maturana's revision of our original translation.

We wish to thank Humberto Maturana for giving us the space to carry out this task in the way we wished, and we trust that we have indeed laid down the correct path in our walking of it.

Acknowledgment

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Reference

- Maturana H. R. (1994) Veinte años después. Prefacio de Humberto Maturana Romecín a la segunda edición. In: Maturana H. R. & Varela F. J. (1994) *De máquinas y seres vivos. Autopoiesis: La organización de lo vivo*. Second Edition. Editorial Universitaria, Santiago de Chile: 9–32.

Twenty Years After

Preface by Humberto Maturana

Romesín to the second edition of

De Máquinas y Seres Vivos

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Background

Francisco Varela and I wrote this book together. I have no doubt that if either of us had written it separately both content and style would have been very different. Under no circumstance can I claim to speak for him, whether about this book or about anything else. For this reason, in writing this new preface I will speak only for myself, presenting how certain ideas that arose in the writing of this book reflected aspects of my own life. I do not believe that it may be done honestly in any other way. Under these circumstances, when I say that Francisco was my student I do not pretend to diminish his stature or to subordinate his thinking to mine – I am just referencing the history of the ideas and our changing relationship. I am eighteen years older than Francisco, and in early life that age difference between a student and his teacher is enormous; however, it lessens or even disappears as the teacher's scientific life nears its end.

History

The original title of this book was *About Machines and Living Beings*. However, its topic is life organization, and I originally conceived the word “autopoiesis” precisely as an attempt to synthesize into one simple and evocative expression what seemed to me to be a critical factor in the constitutive dynamics of a living being. So the original title is not strictly speaking accurate, but it is not appropriate at this point to analyze the circumstances that determined it. However,

for this edition I would like to change it to reflect this central theme: *Autopoiesis: organization of the living*. What I would like to do in this new preface – over twenty years after the book was written – is describe and comment on how certain ideas, notions, and concepts arising in the course of my own life are reflected in this book.

In 1960 I returned to Chile after a period of six years abroad. I had obtained a doctorate in biology at Harvard University in 1958. Ostensibly I returned to Chile in order to honor a previous commitment with the University of Chile, but intimately I chose to return because I wanted to give back something of what my country had given to me as I grew up in it. On returning, I was accepted as a second assistant to Gabriel Gasic, who held the Chair of Biology at the Medical School. After a long conversation with Gasic, I convinced him to let me teach a series of lectures on the origin and organization of living beings as a part of his biology course in first year medicine. He granted me five or six sessions, towards the end of the academic year, and I had the privilege of being able to deliver these with freedom to include the content I wanted to include.

At the time I thought my whole life had more than adequately prepared me for those classes. After all, I had studied medicine, biology, anatomy, and genetics; I had tackled anthropology, archaeology, and paleontology; I had interests in ethnology and mythology; and I had undertaken detailed investigations in specific areas of biology (such as anatomy, neurobiology, and taxonomy) during my ten years as a student in Chile and abroad. Indeed, I had already

been interested in the phenomenon of life as a high school student when Gustavo Hoecker kindly accepted me as an apprentice in his laboratory at the beginning of my first year of medicine studies in 1948.

At the end of the last session of the series of lectures, one of the students asked me: “Sir, you say that life originated on land more or less three thousand five hundred million of years ago. Please tell me what actually happened when life originated ... what happened at the beginning of life so that you can say now that life began then?” As soon as I heard the question I knew I did not have an answer: I had prepared myself to answer it, certainly, but found I could not do so – in fact I had not myself reflected on the issue in the terms in which the question had been formulated. “What actually originated and has been conserved up to now from when living beings appeared on Earth?” was the question I heard. Indubitably I flushed – not just once but several times – and finally I answered: “I do not know, but if you come next year I will offer you an answer.” I had one year to find it.

We do not always accept the questions that we accept, even when we say that we do. To accept a question consists of immersing oneself in the search for the answer that answers it. Furthermore, the question specifies the answer that it admits. So the first thing that I did was to reformulate the question for myself in a complete manner: “What began when living beings began on Earth and has been conserved ever since?” Or, in other words: “What kind of system is a living system?”

In 1960 this was a question without an answer. Biologists simply did not seriously consider it. They skirted it by saying that much more knowledge was required; or they would simply list the properties or characteristics of a living being, proposing a list that necessarily remained indeterminate in the absence of some independent characterization of living that would permit one to say when the list was complete. Notable scientists such as Alexander Oparin and John Haldane, who had devoted their attention and experimental work to the question of life, had not proposed anything that could be considered an adequate characterization of the living. Other scientists, such as Ludwig von Bertalanffy, adopting a systemic ap-

proach in the quest for understanding living beings as totalities, spoke of an organismic vision, apparently thinking that to understand living beings it was central to attend to their constitution as open systems and to the way they processed energy.

I thought differently. I thought that what was central to explaining and understanding living systems was to attend to their condition of being discrete, autonomous entities that live their life as independent unities. In fact, I thought (as I still do) that the most significant thing about biology as a science is the fact that the biologist deals with discrete and autonomous entities that in their individual operation generate general phenomena that are valid to all the members of the class of living beings: what is central in biology is what happens in the living of living beings as individualities. At the same time, I think that the most important thing in physics as a science is that the physicist deals with general laws and not with the particularities of the entities that, being subordinated to them, make the functioning of those laws apparent through their relations and interactions: what is central in physics are the general laws that define what is possible and what is not possible in the relations and interactions of entities in general, without caring for their possible individuality.

It is in relation to all that I have just said that I thought, and still think, that the main task of a biologist is to explain and understand living beings as systems in which both what happens to them in the intimacy of their inner operation as autonomous beings, and what happens to them in their interactions as totalities with other unities, arises and takes place in them and with them through the individual realization of their living as autonomous entities. It was with this thinking that I dedicated myself in my reflections and lectures to the double task of answering the student's question about the origin of living beings on Earth and of revealing the configuration of the internal processes that result in the arising and operation of a living system as autonomous entity in the relational space in which it exists as a totality.

As far as I knew, nobody else had asked these questions in the way I was asking them, perhaps because nobody was fully willing to address the implications arising

from accepting that all biological phenomena occur through the realization of the living of the living being itself. Besides, there was something else motivating and driving my enquiry.

At the age of twenty (ten years previously), I had been ill with pulmonary tuberculosis. I was a patient in a sanatorium in the Andes and under strict instructions to remain absolutely at rest. However, I was secretly reading the great book by Julian Huxley, *Evolution: A modern synthesis* (1942). In this book, Huxley argues that the notion of evolutionary progress is valid as it refers to the historical process of increasing independence of living beings from the environment. And he says that we human beings are the culmination of this historical process as we are the organisms that are the most independent from the environment in which we live.

I found myself thinking differently from Huxley as I reflected on the purpose of life and the meaning of living in the long intimacy of my inaction. My answer then, as it is now, was that life had no meaning outside of itself, no sense besides its actual occurring in living. So, I thought: the sense of the life of a fly is to live "fly" – to do the fly things that make a fly a fly; the sense of the life of a dog is to live dogging – to do the dog things that make a dog a "dog;" and the sense of the life of a human being is living humanness, to do the human things that make a human being be a "human being." Differing from Huxley, I thought that living beings existed without purpose, without any value reference to anything outside themselves. Lying passively in repose for a year in a hospital in Santiago first, and for another year in the sanatorium in the mountains, these reflections led me to recognize and accept that any sense that my life might have was my own task and my own responsibility. However, they also led me to see that living systems were autonomous beings and that their autonomy rested in the fact that all the aspects of their operation as living beings had to do with themselves, with the realization of themselves as living beings, and that this operation could not be said to come from any external or internal purpose but was the result of their manner of constitution. Purpose, aim, and progress, I thought, are human notions that had to do

with humanness, with human living. And, of course, I asked myself what it was to be a human being, what was peculiar to humanness so that I might live accordingly and be human in the same way that a fly lives as a fly "flying." My conclusion was that human beings were self-conscious, intelligent, sensitive, and capable of understanding their own living and the living of other living beings, and that I wanted to live as such.

It was from this background of reflections that from 1960 onwards I began to direct my thoughts to finding a way of speaking about living beings that captured their dynamic constitution as discrete autonomous systems, as systems in which all that happens with them in their operating as discrete units (entities) – both in their relational (external) and in their internal (constitutive) dynamics – refers to themselves alone, and occurs as a continuous, unbroken realization of a process that results in themselves as such dynamic entities. That is, my reflections led me to think that all that happens to living beings takes place in them as though they operate as self-referring entities.

With the above in mind, my task as a biologist became one of describing the inner operation of living beings that results in their existing as spontaneous discrete autonomous entities that produce themselves through their own operation. At that time this was not an easy task and my colleagues did not understand what I wanted to do, perhaps because I did not then know how to say what I wanted to say, or because I still did not have the conceptual clarity to do it or to express my understanding in a way that revealed the operation of the processes that resulted in the living of living beings.

After receiving a PhD from Harvard University, I worked during 1958 and 1959 in the Department of Electrical Engineering of the Massachusetts Institute of Technology (MIT) in the neurophysiology laboratory of Jerome Lettvin. Within that department there was also an artificial intelligence laboratory. Every day, walking past that laboratory (without entering), I used to overhear fragments of the conversation of outstanding researchers in the robotics of that time, describing what they were doing in their attempt to model biological phenomena. Marvin Minsky was one of them.

However, the more I listened to them the more I felt that what they were doing was not imitating or modeling biological phenomena, but that what they were doing was modeling or imitating how what the living systems did appeared to them in their domain of observation. It was through being aware of such confusion that in the biological lectures I gave in the Medical School I always spoke in a manner such that my description of the processes that happened in them showed the way in which those processes constituted the living system as autonomous beings. I did not want to make the mistake that I thought was being made by those scientists working in artificial intelligence at MIT.

Avoiding this error was not easy because the biological discourse of that time was a functional and propositional discourse. Biologists were talking about biological phenomena as if such phenomena were made visible in talking about the function that they were supposed to fulfill, and as if the description of such function would reveal the relational processes that gave origin to them. I thought that it was not adequate to talk of biological phenomena in functional terms, not even metaphorically, because such a manner of talking conceptually obscured the actual operations that constituted the biological phenomenon that one wanted to understand. In order to avoid such concealment, I began to distinguish between what I was saying as an observer, according to what I saw as I looked at the living system in its operation as a totality, from what I was saying had to be taking place in its internal dynamics when it was operating as a totality.

To do this I began to describe, I thought adequately and without confusing them, the two operational domains in which the existence of a living being takes place, namely: a) the domain of interactions in which it exists as it operates as a totality; and b) the domain of operation of its components as these give rise to it as a totality through their interactions with no reference to the totality to which they give rise. It is in its operation in these two non-intersecting but complementary domains that the living being realizes its living as a relational totality. I wanted to describe the operation of the components of the living beings exclusively in local non-functional or non-purposive terms. In other

words, I wanted to show how a living being arises as a totality in a domain different from the domain of operation of its components as a simple spontaneous consequence of their operation when they concatenate in some particular form. That is, I wanted to describe the particular manner of spontaneous concatenation of the operation of the components of a living system that make it a living system, and I thought that to demonstrate that I had indeed done so, I had to show that all biological phenomena arise from that manner of operation when the adequate historical conditions are given.

Accordingly, as I was thinking that the autonomy of living beings as I indicated above was an indirect expression of the concatenation of processes that constituted them as discrete entities, I began to talk about living beings as *self-referring systems*. That is, I began to speak of living beings as systems in which all that they do makes sense only in relation to themselves. And at the same time I began to differentiate living systems from systems that we human beings produce, systems in which, by design, all that happens to them makes sense only in relation to some product or something that is different from themselves, systems that I began to call *allo-referring systems*.

However, talking about living beings as *self-referring systems* was not satisfactory to me because the notion of "self-reference" subordinates the dynamics of the components of a system to the totality that results from their operation, which was the very thing that I wanted to avoid when I talked about the local relations of the components of a living being, showing that the living being in its existence as a totality was a spontaneous result of that manner of operation. Indeed, I was aware that talking about living systems in terms of self-reference obscured the fact that I had not yet identified the operational dynamics that made a living being a self-referring entity.

Then, at the beginning of 1964, while I was talking with my friend Guillermo Contreras, a microbiologist, about whether or not it was possible that information could flow from the cytoplasm toward the nucleus (at that time we still did not know about retroviruses), and as I wrote on the blackboard how DNA participates in the synthesis of proteins and how the proteins participate

in the synthesis of DNA – drawing a picture that showed the productive circular relation that existed among them – I suddenly realized that that circularity was the molecular productive dynamics constitutive of living beings.

That is, at that point I realized that what defined and in fact constituted living beings as autonomous entities that result in self-referring as a simple consequence of their operation was that they were discrete entities that existed as such in the continuous realization and conservation of the circular production of all of their components in such a way that all that occurred with them occurred in the realization and conservation of that closed circular productive activity. In this reflection I also realized that it is not the flow of matter and energy as a flow of matter and energy, and not any particular component as a component with special properties that defines and constitutes a living being as a living being.

A living being consists of and occurs as a continuous dynamic realization of a network of molecular transformations and productions such that all the molecules transformed or produced in that network recursively participate in it in a way such that through their interactions they: a) generate the network of transformations and productions that produced them; b) give rise to the borders and extension of the network as part of its operation as a network in a way such that it closes upon itself, constituting a discrete molecular entity with dynamic borders that separate it operationally from the molecular medium that contained it; and c) at the same time operate as borders of the network that admit a flow of molecules that are incorporated and become components of it and a flow of molecules that leave the network and stop being components in it as they become part of the medium.

To put it in another way, I became aware that the living being is not a collection of molecules but is a molecular dynamics; a network of processes that occurs as a discrete singular autonomous entity as a result of the operation of the different classes of molecules that compose and realize it; a closed network of interactions and relations of different classes of molecules that produces molecules of the same different kinds that produced them; a closed

molecular dynamics that specifies its borders and extension. Moreover, it is to this network of productions of components that closes upon itself, because the components that it produces through their interactions (recursively) generate the same network of productions of components that produced them as a dynamic entity that determines its own borders and extension in the midst of a continuous flow through it of elements that become or stop being its components according to whether they participate or stop participating in it, that we refer to when we speak of *autopoiesis* in this book. Furthermore, what we also say in this book is that *a living being is in fact a molecular autopoietic system*, and that the molecular condition is central to its constitution because it determines the domain of operational relations in which it exists as a self-producing composite entity. If there were autopoietic systems that were not molecular autopoietic systems, that is, if there were closed networks of production of non-molecular elements that satisfy the relational dynamics of autopoiesis, they would exist in a different domain than living systems, yet, since such a system would have characteristics completely different than those of a living systems it would not be a living system.¹ I have insisted on this not out of being repetitive but because it seems to me that the most difficult thing in relation to living beings is to understand and accept that: a) a living being is a particular relational molecular dynamics (molecular autopoiesis), not an assembly or collection of molecules of a particular kind; b) living is the continuous realization of that particular relational molecular (autopoietic) dynamics in a configuration of dynamic relations that

1 | Author's note: A culture occurs as a network of conversations; see Maturana & Verden-Zöller (1993). If a culture were to become a closed network of conversations as an *autopoietic system of conversation* it would not be a living system, and the human beings in it would become subordinated to the conservation of the conversations that constitute the culture (that culture) or be eliminated from it as they reflect and begin to generate conversation that do not belong to it. In a culture that operates as an autopoietic network of conversations, human beings as reflective self-conscious beings that may choose whether they want or do not want to be part of it cannot exist.

is conserved in a continuous flux of molecules through it; and c) to the extent that living is and occurs as a molecular dynamics, one cannot say that a living being has autopoiesis or uses autopoiesis to live – living beings are molecular autopoietic systems and molecular autopoiesis constitutes them as autonomous living beings. In 1965, I referred to this way of being autonomous of living beings, speaking of a *circular organization of transformations and of molecular productions*, claiming that a living being is and exists as a discrete molecular dynamic system in the continuous realization and conservation of such organization. As I did this I also became aware that my description of the living being as a system of circular organization was adequate because it in fact permitted me to show, in agreement with what I have already said above, how all biological phenomena take place and arise in the life of a living being as a system that exists realizing itself in a dynamics of continuous self-production. I spoke of this for the first time in a section about the organization of living in an article that I called “Neurophysiology of Cognition,” presented in March 1969 as part of an anthropology congress in Chicago whose theme was “cognition as a human phenomenon” (see Maturana 1970b). A year later I addressed the same theme as part of a more extensive article, the title of which was “Biology of Cognition,” first published as “Report N° 9.0 of the Biological Computer Laboratory” at the University of Illinois in 1970 (Maturana 1970a).

The book that the reader has in his or her hands, initially published in Spanish under the title *De Máquinas y Seres Vivos* (*About Machines and Living Beings*), is an expanded version of the section on the organization of living beings in the article “Biology of Cognition” that I have just mentioned. This book that the reader is reading was written as a result of a conversation I had with Francisco Varela in 1970 when he returned to Santiago from the USA after receiving his Ph.D. from Harvard University. Francisco argued that if what I was proposing was an account of biological phenomena, and if that was all that was needed to completely characterize living beings as autonomous systems, it should be possible to propose a mathematical formalization of their circular organization. Francisco Varela was a distinguished math-

ematical thinker; I am not. For this reason I insisted that before attempting such a formalization, we had to have a complete description of the phenomenon or the system that we intended to formalize.² We agreed to do this, and the result was this book.

The word “autopoiesis”

Francisco Varela first arrived at my laboratory in April 1966, sent by Juan de Dios Vidal Correa after he was accepted as a student for the biology degree in the Faculty of Sciences at the University of Chile. At the end of 1967, Francisco was accepted by Harvard University to undertake a Doctorate in Biology. Upon the completion of his doctorate he returned to Chile. Since he had previously been my pupil I knew in depth his abilities and accomplishments and I recommended and supported him so that he could be accepted as an independent researcher in the Faculty of Sciences of the University of Chile. This happened by the end of 1970.

To insist on what I said above: I think that any formalization is necessarily secondary to the conceptual and operational understanding of what one wants to formalize, otherwise the formalism can become divorced from experience. Francisco agreed and we started working on what finally turned out to be the present book. It was a process in which I would write and then we would discuss the issues. Although this was always an interesting process, it was never simple, and sometimes it was painful. Soon it became obvious to me that we needed a word to describe the organization of the living that was more evocative than the expression “circular organization” that I had been using since the beginning of 1965.

One day I was visiting a friend, José María Bulnes, a philosopher. While he was talking to me about the dilemma of the gentleman Quejana (later, Don Quixote de

2 | Author's note: One formalizes what one thinks, so what is fundamental to any formalization is the understanding that one claims to have of the phenomenon that one wants to formalize. This is why the first and necessary operation in any process of formalization is the abstraction of the operational and relational coherences that will constitute its fundaments.

la Mancha) in deciding whether to follow the path of arms – the path of praxis – or the path of the arts – the path of poiesis³ – it occurred to me that I might create a new word, *autopoiesis*, as the correct expression to capture and convey what I was connoting in talking of the circularity of the organization of the living. José María did not invent or suggest the word *autopoiesis* and could not have done so because he had no need of it; I invented and proposed it. Nonetheless I am grateful to Jose for the conversation that we had, and also to his wife, Verónica, who suggested an alternative word, “autopraxis,”⁴ which I rejected because in certain aspects it seemed a limiting word. The following day I proposed the word to Francisco, who liked it, and from then on we began speaking of autopoiesis in referring to the organization of living beings.

Initially I thought that I could use the word autopoiesis exclusively to denote the organization of living beings. Yet, I soon realized that it was not adequate to do so because, in principle at least, one could imagine that such an organization could be realized in many different domains with different kinds of non-molecular components

giving rise to different kinds of systems that would not be living systems. Living systems are molecular autopoietic systems. For this reason, it seemed to me that it was necessary to be specific in each case regarding the properties of the components of the system that one might be talking about and that one may be willing to think may be autopoietic, because it is the properties of the components that determines in each system its domain of existence as a composite unity.⁵

For this reason, in later publications such as *The Tree of Knowledge*, which I also wrote with Francisco Varela, I stress that we living beings are molecular autopoietic systems, emphasizing that what defines us as the particular kind of autopoietic systems that we are is that we are molecular autopoietic systems that exist and live as human beings. In summary, what we purported to do in this little book, and what I still claim that we do, is to show how the systems that we distinguish as living beings in the biological world are molecular autopoietic systems and that all biological phenomena are a result of either the operation of molecular autopoietic systems or the historic contingencies of their operating as such. Therefore we claim in this book that being a living being and being a molecular autopoietic system are the same.

From the time of the first publication of this book, questions have been asked about the possible existence of autopoietic systems in domains other than the molecular domain. This question cannot be answered lightly. It is certainly possible to distinguish between living systems and autopoietic systems of different orders according to the domain in which the autopoiesis takes place. In such a distinction, the cells are first order molecular autopoietic systems in that they exist directly as molecular autopoietic systems; we organisms are second order auto-

poietic system in that we are autopoietic systems made up of cellular aggregates. When considering the case of a beehive, a colony, a family or some other social system as an aggregate of organisms, it could be possible to talk of third order autopoietic systems. Yet, in these latter cases, the third order autopoiesis arises as a result of an aggregation of independent organisms and is not a defining or intrinsic feature of the beehive, the colony, the family, or the social system as the particular kind of system that each one of them is. By highlighting or emphasizing the autopoietic character of such third order systems, when their autopoiesis is in fact something circumstantial related to their components rather than something intrinsic that defines them as the kind of systems that they are as a beehive, colony, family, or social system, we obscure the precise quality that defines each of them as the distinct kind of system that each of them is. For instance, even though social systems are autopoietic systems of the third order through being systems composed of organisms, that which defines them as what they are as *social systems* is not the autopoiesis of their components, but is the configuration of relations that these hold between them as individual organisms through their interactions: a configuration of relations that we connote in our everyday distinctions by calling such systems “social systems.” Nevertheless, what we must neither overlook nor forget is that whatever happens in these higher order autopoietic systems is realized through the *autopoiesis* of their components.

In making the distinctions above about different orders of autopoiesis, it is important to bear in mind that there may well be autopoietic systems of a higher order that are at the same time autopoietic systems of the first order in their own right. For instance, this might be the case for many multicellular organisms if the transcellular and intracellular molecular processes that realize them constitute a first order molecular autopoietic network that intersects with the realization of the molecular autopoiesis of the cells that compose them. If this were the case, those organisms would exist as autopoietic wholes in two simultaneous but different phenomenal domains, and would be subject in their realization as such to the simultaneous conservation of two autopoietic

3| Translators’ note: This refers to Don Quixote, Part 1, Ch. 33, and also to Part 2, Ch. 6. In these two chapters, Don Quixote states that there are two ways of achieving honest promotion: the way of “arms” and the ways of the “arts.” For Don Quixote, both are equally fulfilling, whether the “practical” (*praxis*) or the “intellectual” (*poiesis*). Thus is written: “There are two ways... by which men can go and achieve honor and richness: one is that of the arts; the other of arms. I have more of arms than arts, being born inclined to arms under the influence of the planet Mars” (Part 2, Ch. 6). It has been said that Cervantes, being an old soldier himself, had to choose arms for his hero. See also Jorge Luis Borges’s short story, “Pierre Menard, the author of Don Quixote” (originally published in Spanish in 1939).

4| Translators’ note: “The word *autopraxis*, as suggested by Verónica, would have not been adequate because that word would have referred to the actual happening of the molecular processes. But since my intention was to say that the living occurred as the continuous result of those processes, I considered that the word *autopoiesis* expressed that and was the adequate word.” (Maturana in personal conversation with Alberto Paucar-Caceres, Sardinia, May 2011)

5| Author’s note: The central feature of autopoiesis is that it is the actual interactions of the components of the system that produce components of the same kind, and it is only in the molecular domain that this happens: molecules interacting with molecules give rise to molecules. So living systems exist as spontaneous autopoietic autonomous entities in the only operational domain in which autopoiesis can in fact take place spontaneously, namely, in the molecular domain.

dynamics: the conservation of the first order molecular autopoiesis of their cellular components, and the first order systemic molecular autopoiesis of their realization as organisms as they operate as totalities. Something similar would happen with social systems if these were also first order molecular autopoietic systems, which in my opinion they are certainly not. Neither are social systems autopoietic systems in some other domain different from the molecular one. Finally, it is not possible for social systems to be first order autopoietic systems in a communication space, as the distinguished sociologist Niklas Luhmann proposes, because in such a space the components of the alleged autopoietic system would be communications rather than the living beings, which would give rise to such communications as a manner of living together and that constitute it as the system that we call social in daily life. I think that all that one can say in relation to a system of human relations and autopoiesis is that what most resembles an autopoietic system is what we distinguish when we consider a culture in its constitution as a closed network of conversations.

To the extent that it is the organization that defines the class identity of a system and the structure that realizes it as a particular case of the class defined by that organization (Maturana 1975; Maturana & Varela 1984), systems only exist in the structural dynamics that realize their organization. It is because of this that the operation of distinction that brings forth a system or connotes it with a name while pointing to the structure that realizes it both implies the organization that defines its class identity and that this is realized in that structure. The different words we use in daily life evoke different operations that we realize in our languaging living, and because they reveal the coherence of our relational living in our operation as human beings they are never arbitrary or trivial. It is for this reason that in everyday living in English we use different words to talk about living beings and social systems, indicating that we do not connote the same system when we use one word or another. In doing so we are also indicating that when we talk about living systems or social systems we are talking about different classes of systems because each class is defined by a different organization:

the living systems by molecular autopoiesis and the social systems by the configuration of living together that we connote when we speak of them. Thus, if what makes a living being a living being is that it is a molecular autopoietic system, and if what makes a social system a social system is a manner of living together of a group of organisms, it cannot by any means be the same thing to talk about a living system and a social system, even if the realization of the social system occurs through the realization of the living of the organism that integrates it.

Perhaps what is most difficult for us to understand is that the structural intersection of systems is the realization of two or more different systems by means of the same structure or through the same structural components. In such a structural intersection, the different organizations of the different systems that intersect do not intersect, they remain distinct constituting different systems that exist as different totalities in different operational domains. There are no intersections of organizations; nor could there be, because the distinction implies the organization of what is distinguished, and the organization implied in the distinction only arises in the operation of distinction. That is, the different organizations that we imply with the different words we use remain independent and distinguishable from each other in spite of the intersection of their different structural realizations. The class identity of a system is specified by its organization and not by the structure that realizes it as a particular entity.

Since the organization of a system is not directly distinguishable but is implied in the act of distinction that brings forth a particular entity as a structural totality, and since systems interact through their structure, individual systems can only be discriminated and recognized by particular features of their structural realization. No doubt we know this from our daily living, because we know that we can realize different identities, whether simultaneously or successively, in the same bodyhood. But if in addition we are not aware that the words that we use imply the organization of that which we distinguish, we remain blind to the fact that it is not possible to ascribe any arbitrary organization that comes to our minds to a system that we distinguish because the system dis-

tinguished arises in its distinction with an organization implicit in it that is specified by the operation of distinction. Not seeing this has led to an indiscriminate use of the word *autopoiesis*. Finally, it is necessary to understand that the organization implied by an operation of distinction is not arbitrary. This is because of the structural determinism of the observer who can in every instant only distinguish what his or her structural configuration and the structural configuration of the circumstances of the medium permit,

An artificial case

As Varela and I were completing the book, the idea of making a computational model emerged. What I wanted was to use the computer to generate processes equivalent to molecular processes in such a way that if one left them to operate without any reference to a totality in an exclusive relational dynamic of contiguity, the result would be a network of processes that would constitute an autopoietic system.

We talked a lot about this possibility until one particular day, in November 1971, I arrived at the laboratory in the morning with a drawing, which I still have, that represented a dynamic of particles in the form of a small set of "chemical reactions of synthesis and of lysis" such that if they were taking place at the adequate rhythms (e.g., at an adequate temperature), would generate, as a spontaneous result that was not included as an aspect of the design of the "molecular" processes, an autopoietic unity in a two-dimensional space, such as the screen of a computer. What we had to make was a program in order for the computer to generate those particles and their interactions and transformations in a graphic space. If we were able to do this at adequate rhythms, I said, autopoietic units would spontaneously arise in that two-dimensional space.

Given that I did not know how to program, Francisco, with another friend, Ricardo Uribe Berenguer, was to take charge of the task, and we decided, at Francisco's request, that he would be named the first author when the results were published (Varela, Maturana & Uribe 1974).

The dynamic of reactions that I proposed was the following:

Let there be particles A, B, and M, and let them operate in the following manner:

- 1 | $2B + A \rightarrow M + A$
- 2 | $M + M \rightarrow MM$
 $MM + M \rightarrow MMM$
- 3 | $M \rightarrow 2B$
- 4 | The chain MMMMM ... is permeable to B.
- 5 | The chain of Ms is flexible and movable, and it can close on itself.

When the program was allowed to run it gave rise spontaneously to an autopoietic unity in the graphical space of the computer screen. My purpose with this model was to present a generative relation that spontaneously gave rise to an autopoietic unity as something new in a space quite different from the domain of operation of the interacting components. At the same time I wanted to show that an autopoietic unity was only the result of the spontaneous organization of a set of elements in a particular composite unity as a consequence of the operation of their properties, while none of those properties would permit an observer to deduce what would occur. Any novelty appearing as the result of a generative dynamic would arise as a historic novelty and would be intrinsically new (see Figure 1).

The present

I consider that any phenomenon whose realization entails the realization of the living of at least one living being is a biological phenomenon. Thus, the synthesis of a polypeptide chain that occurs in a laboratory with the participation of ribosomes in a test tube outside of a cell's context is a chemical phenomenon and not a biological one, whereas if the same synthesis occurs during the dynamic of cellular metabolism, it is a biological phenomenon, a situation usually recognized when talking about biochemistry. At the same time, since I claim that molecular autopoiesis characterizes and fully realizes the living, I consider that every phenomenon that implies the realization of the autopoiesis of at least one living being is a biological phenomenon. This book arose with the purpose of showing how all biological phenomena result, either directly or indirectly, as a consequence of different historical contingencies in the realization of

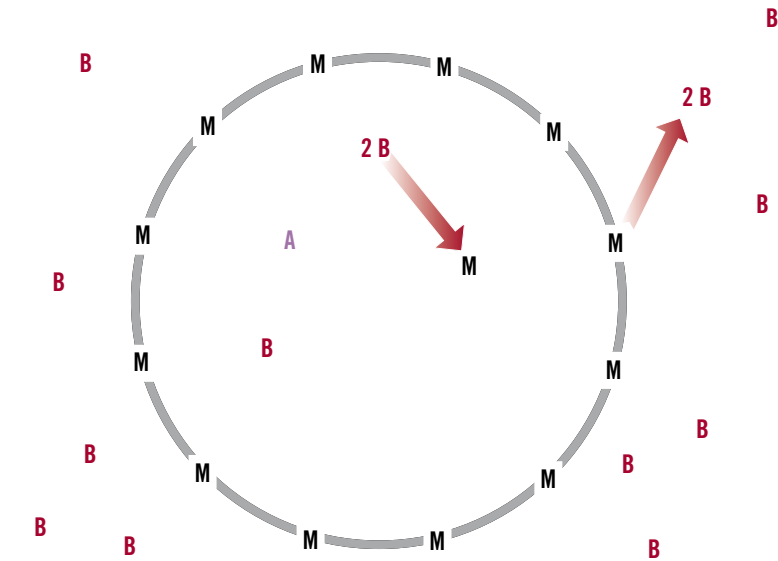


Figure 1: A schematic representation of the autopoietic dynamic entity arising in the graphic space generated by the computer.

the *autopoiesis* of at least one living being. I think that this book fulfills that aim and that the expansion of biological understanding that has been produced since its initial publication confirms and does not refute this claim but confirms it instead.

Perhaps the most illuminating aspect of this theory of the living (autopoiesis) lies in the fact that it shows that the living being is a systemic entity even when its realization is of a molecular character. This theory reveals that no molecule or class of molecules determines by itself any aspect or feature of the operation of a living being as such, and this is because all the characteristics of the living being occur in the dynamic of the realization of its *autopoiesis*.

In effect, a phenomenon is systemic if it occurs as a result of the operation of the components of a system while they realize the relations that constitute it as such under circumstances in which none of them determines by itself the characteristics of the system even though its presence is strictly necessary. Thus, the ordering of amino acids in the synthesis of a protein according to a particular sequence determined by the sequence of nucleotides present in a partic-

ular strand of DNA is a systemic phenomenon because in order to occur it requires the dynamics of protein synthesis that takes place as a constitutive part of the cellular autopoiesis, and the sole presence of DNA is not sufficient. By claiming that all that happens with living beings occurs in a systemic dynamics I do not pretend to say something that has never been said before. What I claim is that when we do not fully accept in our reflections the systemic character of the cellular phenomena, we do not speak adequately about living beings and we generate a deceptive reductionist discourse, as is the case in the notion of genetic determinism, which clearly hides the systemic character of the generation of phenotypical features.

The understanding that the theory of *autopoiesis* makes possible the systemic character of all the phenomena that entail the realization of the living of a living system permits us to explain the origin of living beings on Earth, or anywhere in the cosmos, as the spontaneous arising of a living being as a discrete entity at the instant that the molecular autopoietic dynamics take place as a systemic phenomenon. In the same way, the theory of *autopoiesis* permits us to un-

derstand the phenomenon of inheritance as a systemic phenomenon of conservation of the living being/medium relational unity as its reproduction happens as a fracture (of the living being/medium relational unity) that occurs with conservation of its organization. And all this in a process that allows us to see that the reproductive conservation of the organization of a living being and of its relation with the medium does not depend on any particular molecule or class of molecules, even though they might seem at first glance to be central to the structural realization of the living being (Maturana 1980; Maturana & Mpodozis 1992).

The theory of autopoiesis also permits us to understand the phenomena of cellular symbiosis, and of the formation of multi-cellular systems, as spontaneous phenomena of systemic conservation of a new organization when some aggregate of cells or organisms gives origin to some configuration of preferred relations that separates them as a totality from a medium that contains them. Anyhow, by understanding that the phenomenon of living is the molecular autopoietic dynamics, we can understand that: a) the flow of the history of living beings courses as a spontaneous process of conservation of old lineages and the generation of new ones through the systemic reproductive conservation of different manners of living (or ontogenic phenotypes) in an ontogenic and phylogenic natural drift; b) new lineages arise as epigenetic variation conserved through systemic reproduction of a particular organism/medium relation in a systemic and not molecular hereditary process; and c) what we usually connote when we talk about natural selection is a result of the differential conservation through systemic reproduction of the variations that occur in the diversification of lineages, and not their generative mechanism (Maturana & Mpodozis 1992).

Structural determinism

We living beings are structurally determined systems and, as such, all that happens to us arises in us as a structural change determined in each instant according to our structure at that instant. Science only operates with structurally determined systems,

and in both science and daily life we treat any situation that seems to us to violate structural determinism as an expression of a mistake or a fraud or as a miracle. The notion of structural determinism, however, does not arise as an ontological supposition nor as an explanatory principle, but it arises as an act of poetic synthesis as an abstraction of the regularities of an observer's experience. Therefore, it has validity in each case only in respect to the domain of the regularities wherein it arises. For this reason, the different domains of the experiential coherences that the observer lives constitute different domains of structural determinism, each one defined by the experiential coherences that are proper to it and define it.

There are two additional notions that we must not confuse with structural determinism when speaking about a structurally determined system, namely: predictability and predeterminism.

Predictability

The fact that a system is structurally determined does not mean that an observer may be able to predict the future structural changes that may occur in it. Given that a prediction is an attempt to treat some particular situation as a structurally determined system in order to be able to compute its structural changes, the observer must first know the structure of the system that he or she is considering in order to then be capable of predicting or computing its structural changes. Accordingly, when an observer claims that a system is predictable or not predictable, what he or she is actually doing is connoting what he or she thinks is his/her knowledge or ignorance of the structure of the system that he or she is characterizing in that manner. All scientific understanding is founded on an implicit or explicit recognition that our explanations always deal with structurally determined systems, in whatever may be the domain of explanation we choose, in such a way that if the system does not fulfill the criteria of structural determinism we expect, we either assume there has been an error or else that we had insufficient knowledge.

In addition, we are not always able to identify the structure of a system in the moment that we wish to compute its future

structural changes, either because we do not have full access to it, or because in our attempt to know it we destroy it, or because the structural dynamics of the system is such that it recursively changes as we interact with it as we attempt to describe it. In such cases, every time that we look for regularities in it, we find that its structure is no longer the same because it responds in unexpected ways. Living beings are precisely systems of this kind.

Predeterminism

The notion of predeterminism makes reference to the supposed possibility that the initial state of a structurally determined system may specify through its own structure its future states regardless of unexpected contingencies. This indeed can never happen to a structurally determined system because the course of its history in the field of interactions in which it exists is, and can only be, an epigenesis precisely because it arises in the interactions.

For the same reason I think that in the strict sense there is no genetic determinism, and it is not possible to say in a manner that makes sense in the operational dynamics of the organism that the phenotype is an expression of the genotype. The phenotype arises in an epigenesis. In a similar way, inheritance as a reproductive conservation of a manner of living or ontogenic phenotype is a systemic phenomenon and not a molecular one, as I mentioned above. The epigenetic character of systemic operation in general, and in particular of the natural course of the living of any living system, excludes any predetermination. In the same way, the constitution of a lineage in the reproductive conservation of an ontogenic phenotype (or manner of living, or particular epigenetic configuration, or particular living system/medium relational unity) is a systemic phenomenon.

And, finally, the constitution of a lineage, and therefore the reproductive conservation of any biological identity, and in particular speciation, is also a systemic phenomenon and not a phenomenon determined by a molecular genetic process. Belief in the possibility of a predeterministic dynamic in systems obscures the comprehension of epigenetic phenomena (Maturana & Mpodozis 1992).

Spontaneity versus purposefulness

There is nothing more difficult than to understand and accept the spontaneity of biological phenomena in a culture like ours, oriented to explaining everything related to living in terms of goal-seeking or purposefulness. Thus, we usually do not see that molecular processes are spontaneous, whatever the place or circumstance in which they occur, including the metabolic cellular processes that involve the participation of so-called “high energy molecules,” such as ATP (adenosine triphosphate).

Molecular processes occur in each moment as a result of the structural properties of molecules and not because something external to them is directing or guiding them. Also, it might frequently be difficult to accept that any given system, whatever it may be, arises in the moment when a particular set of elements begins to conserve a dynamic of interactions and relations that give origin to an operational cleavage that separates a subset of elements that become the system from other elements that remain excluded and that thus become its surrounding medium. The dynamics of interactions and relations that, as it is conserved as a relational configuration between elements separate a collection of elements from others, giving origin to a system, becomes the organization of the system, and elements and relations that realize that organization in an operational unity that arises as such as a singular entity dynamically separable from other elements that constitute its medium become its structure. That is, the observer sees that when a system arises, the medium also arises as that domain of operational complementarity in which the system operates as a discrete entity as long as its organization is conserved.

The dynamics of the spontaneous arising of a system and its medium constitutes for the observer the arising of order from chaos since he or she cannot predict the appearance of a system because he or she cannot see the structural coherence from where it arises.⁶

6 | Translators' note: To us, the word “chaos” in this context appears problematic in the English-speaking rendering. On the other hand, this has echoes with texts such as Carl Jung's “Septem Sermones ad Mortuos” (1966), so we have left

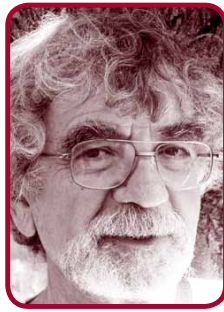
Accordingly, everything arises from chaos to the extent that something becomes in the beginning of the conservation of an organization that did not pre-exist the moment in which it appeared and could not be deduced from the domain of operational coherence in which “new” had relational sense for the observer. When we speak of historical phenomena we speak of experiences of our present that we live as arising from chaos because the present is only understood *a-posteriori* in relation to the past, and we do so proposing a generative process as an explanatory relation that would relate two non-intersecting domains, conserving structural determinism.

In other words, the notions of order and chaos are two aspects of the explanatory commentaries that an observer makes about what happens in the spontaneous systemic dynamics of the constitution of a system in a structurally determined domain that is presently unknown to him or her, and not two intrinsic conditions of what an observer could wish to call “the natural world.” In reflecting on what happens in the spontaneous dynamics of the constitution of systems, what an observer sees is that in distinguishing a system, three domains of order become apparent: (1) the domain of the structural coherences of the distinguished system; (2) the domain of the structural coherence of that which arises as the medium in his or her distinction of the system; and (3) the domain of the relational dynamics of the system and the medium. In addition, for the observer who beholds the domain from where a system arises, and beholds it from the perspective of the operational coherences of the operation of the system as a totality without being able to describe it, that domain is, strictly speaking, chaotic: that is, from the perspective of the operation of a system that arises in a manner in which

it as the original Spanish suggests. We hope the intended meaning is clear from the context, and it is in line with the author's previous suggestion as to the quality of structural determinism being a “poetic synthesis.” We ourselves are entirely happy with the evocative implication (which resonates, in a somewhat different context, with, for example, the words of Ilya Prigogine and Isabelle Stengers: “Order out of Chaos,” 1984). We are not suggesting these meanings map across on to each other – rather that they suggests the sense of episteme (Foucault 1970).

an observer is not able to predict its arising, the domain from where it arises previous to its appearance, is the chaos itself. Only afterwards, if the observer becomes capable of proposing a generative mechanism, is the chaos not chaos any more. What is perhaps surprising and seduces observers to think that there needs to be intentionality or purposeful processes in relation to the living being is the relation of the operational coherence of the living being with its circumstance in a behavioural dynamics that seems to occur as if the living being were intentionally adapting to an independently changing medium.

I think that I must insist here that the fact that the notion of chaos should arise from the inability of an observer to predict or visualize the appearing of a particular system from a domain of structural determinism that he or she cannot describe but this does not mean that the organization of the system that arises in a distinction depends arbitrarily on the actions or desires of the observer. Without doubt what an observer distinguishes depends on what he or she does, and there is no doubt that what he or she distinguishes is associated with the operation of distinction that he or she does, but the observer distinguishes only what can be distinguished in the space of structural coherences that arises in the coherence of his or her experience. But there is yet something more. The spontaneous organization of a system as this arises in the conservation of a particular configuration of relations in a collection of elements that creates a cleavage with respect to the medium that arises with it has, among others, two basic consequences: the first is the arising of a new relational or phenomenal domain that did not exist before, in which the entity or system that arises as a unity defined by the organization that is conserved from then on, has properties in its operation as a totality that are not the properties of its component elements. Such a relational or phenomenal domain cannot be deduced from the previously existing properties of the components because the phenomenal domain arises with the composition of the system. The second consequence of the cleavage of a system and the medium is the arising of a sequential asymmetry in the flow of the happenings because each situation arises as a spontaneous composition of what was before, in which new relational or phenomenal domains ap-



HUMBERTO MATURANA ROMESÍN

Born in Chile in 1928, Humberto Maturana Romesín was interested in animals and plants from childhood and wanted to be a biologist to investigate life that dies. A long period of reflection, reading Frederic Nietzsche and Julian Huxley, occurred during three years of complete bed rest. Beginning medicine in 1950, in 1958 he received a Ph.D. in Biology from Harvard University. His main contributions in biology related to showing that living beings are molecular autopoietic systems, and that if one follows the consequences of the fact that living beings do not distinguish in their experience between perception and illusion, one can show that: language as a biological phenomenon occurs as a flow of living together in coordinations of coordinations of consensual behaviors; and cognition as a biological phenomenon occurs when an organism operates adequately to the circumstances of its living, conserving its autopoiesis as a consequence of the operational-relational coherences with its niche that are proper to it in the present of its living as a feature of the history of evolutionary structural drift to which it belongs. At least this is what he claims in the present moment.

pear, which the observer distinguishes when he or she speaks of history and time. Time arises in an observer's explaining of the distinction of the asymmetry in the happening of his or her experience in a situation that he or she distinguishes as reversible, because by doing such a thing the observer must distinguish his/her own experiential asymmetry in the before and after. Both time and historicity are explanatory propositions of the asymmetry in the happening of the experience of the observer, in which she or he connotes its intrinsic irreversibility.⁷ That is, the observer proposes the notion of time by distinguishing the historicity of his/her experience, and it is from that historicity that an observer can generate a reference from which things can be described in a way that suggests that there might be temporal reversibility in cyclic phenomena, even when the experiential happening of the observer as it takes place in an epigenetic dynamics is intrinsically irreversible and unidirectional. The processes that we describe as cyclical are only descriptive projections that the observer abstracts from the unidirectional flowing where they belong.

Let us now consider the issue of purposefulness. The spontaneity of the arising of systems denies any dimension of intention or purpose in their constitution or in their operation. Notions such as purpose or intention belong to the domain of reflections of

the observer as commentaries that he or she makes when comparing and explaining his/her distinctions and experiences in the different moments of his/her observing. Anyone who does not accept the fundamental spontaneity of molecular processes cannot accept the spontaneity of the operational coherences that take place between a living being and the medium that are proper to the realization of its living. According to structural determinism, once a system arises, its becoming necessarily consists in a history of recurrent interactions with the elements of a medium that arises with it and contains it.

Moreover, such a history of recurrent interactions between the system and medium necessarily courses as a structural co-drift. Both the structure of the system and the structure of the medium necessarily change together in spontaneous congruence and complementarity as long as the system conserves both its organization and its operational coherence with the medium that allows it to conserve its organization. This happens in a dynamics of operational complementarity in which an observer sees the system sliding in the medium following the only path that it can follow in the conservation of its organization, in a process in which the structures of the system and medium change together congruently until the system disintegrates.⁸

In the story of living beings on Earth, this dynamics has taken place since sequential reproduction appeared, giving origin to the

generation, conservation, and diversification of different lineages as the dynamics that has given origin to all the manners of living that we see on earth today. And it has taken place in a continuous interlacing of structural transformations in which the different classes of living beings begin to happen as a part of the medium of others.

We, as current living beings, constitute the present of the spontaneous historical dynamics of the generation and conservation of the reproduction of autopoietic systems on Earth that, once arisen, initiated an operationally coherent coexistence among the distinct living beings that arise in part from local causal phenomena but primarily from historical coherences. In fact, terrestrial living beings exhibit, and must have exhibited at every moment in their historical co-drifting as a biosphere, an operational coherence with each other and with the abiotic medium of a historical character that cannot but appear incomprehensible for the observer that looks for local causal connections in the attempt to not fall into the trap of using goal-seeking, purposeful, explanatory arguments.

The analysis I have made of the spontaneous dynamics of the constitution of systems, and what I have said about the co-drifting of living beings in their historical course as a part of the biosphere, shows that no additional argument is necessary for explaining the coherence of living that we see between living beings, even when their individual evolutionary histories appear to be totally independent of each other.⁹ The

7| Translators' note: Both Warren McCulloch and Maturana demonstrated the intrinsic cyclical dynamics of the nervous system in sense-making. Both (as, more explicitly, did Gregory Bateson) also suggested the cyclical nature of any meaningful behavioral interaction.

8| Translators' note: The process being described here is similar to what we understand by the phrase "structural coupling" used in other places.

9| Translators' note: This is a strong endorsement of other thinkers who have variously point-

operational coherences that arise in the encounter of living beings can be understood either as mere coincidences between systems that happen to share both evolutionary and ontogenic independent histories in the domain in which they encounter, or they are the result of their co-participation in a common historical process, in a manner similar to that in which the dynamic coherences of opposing points in a wave front are the result of a historical process initiated in the origin of the wave.

Thus, it is not necessary to imagine a causal connection to explain how the cytoplasmic contents of a lettuce cell result in its being nutritious to us, just as it is not necessary to explain how we are able to establish loving relations with dolphins. I have insisted on this point here because I consider that it is necessary to be fully aware of the fact that living beings are historical entities participating in a historical present in continuous transformation in order to understand what we show in this book when we say that we living beings are molecular autopoietic systems, and what we say when we say that living takes place in the realization of the molecular autopoiesis. However, it is also necessary to understand that living beings exist in the continuous resulting present of historical dynamics so that we may not be tempted to use the present as an argument to explain its origin.

Final Reflection

To me this book has not lost its validity;¹⁰ perhaps what has happened is the opposite. The book is difficult, and much of what is said in it is unexpected, but it says what it intends to say. There are no second thoughts or intentions in it. As I wrote it I did not attempt to say or do anything different from what it says or does: (1) that living beings and the living take place in the realization of discrete molecular autopoietic systems; (2)

ed out the co-evolutionary nature of life on Earth.

10| Translators' note: Remember that this was written in 1994, not the present. However, we are confident that the same applies today in 2011, particularly in the context of issues to do with the planet, climate change, and sustainable development.

that autopoietic molecular dynamics occurs as a spontaneous phenomenon in which all of the molecular processes occur in a local structural determination without any reference to the totality that they constitute; and, (3) that biological phenomena, as phenomena that arise in the realization of living, occur and have occurred in the contingencies of the historical realization of the molecular autopoiesis, in the discrete units that living beings are. Yet perhaps what results most unexpectedly is that in the spontaneous history of living should have arisen spontaneously also the observer, explaining, and this book itself, all as mere contingencies of the evolutionary course of transformation of the manner of living followed by the lineages of living beings. This preface is not the place to talk more about the nature of this historical process. I have many publications on the theme of cognition and language, and I have given origin to what has been called "the biological theory of knowledge," published for the first time in two articles, one of them titled "Neurophysiology of Cognition" (Maturana 1970b), the other titled "Biology of Cognition" (Maturana 1970a).

On a final note, it is proper to indicate that although Francisco and I wrote this book and another, titled *The Tree of Knowledge* together, after that our lives followed different paths.¹¹ What has been has been. On many occasions we spent great moments together and on other occasions it was not so, but I want to thank him here, in this preface, for the manner on which my life may have been enriched in that dynamic of enchantment and disenchantment that we lived together while we were writing this book and as we were doing all the things that we did together, first when he was my pupil, and then when we worked as colleagues in the Faculty of Sciences in the University of Chile.

Lastly

Why or for what do I wish to explain the living and the living being? We modern human beings live in conflict; we have lost confidence in the transcendental notions

11| Translators' note: Francisco Varela died tragically young after a long illness, in May 2001.

that previously enabled us to give sense to our human life under the form of different religious inspirations, and what remains with us now, namely science and technology, does not provide us with the spiritual sense that we need to live. There is frustration and anger in young people, who are trying to determine what to do in the face of a world that we, their elders, have taken along the path of destruction.

What to do? I think that knowledge accompanied by reflections that make us aware of the possible consequences of both our doings and our desires make us responsible for what we do because we become aware that we can always act according to whether we want or do not want those consequences. At the same time that knowledge and those reflections make us free because they make us aware of what we know and what we desire, allowing us to decide whether we want or do not want to live the consequences of our responsibility for what we do.¹²

Although we living beings are structurally determined systems, we human beings, as living beings that live in language existing in the recursive flow of living together in consensual coordinations of consensual coordinations of behaviors, generate the world that we live as a way of living together that arises at each moment according to how we are in that moment as reflective living beings that live in languaging. For that reason, knowing or not knowing how we are as living beings is not a neutral matter; and it is not the same thing to know or not know how we live being free. Also it is not the same thing to know or not know that we are free in reflection, and to know or not know that reflection permits us to come out of any trap, and, in fact, reflection permits us to transcend the structural determinism of our bodyhood in the responsible behavior that arises in choosing what one wants or does not want. It is through the responsibil-

12| Translators' note: We strongly feel that the issues raised in this preface of 1994 are highly relevant to the debate on sustainable development and globalization. Maturana's insights can provide the foundations for a new paradigm to tackle proactively such issues through transcending the limits and filters imposed by traditional institutional processes and systems and pointing to a whole philosophy of inclusion.

ity and freedom that reflection and knowledge make possible what I want, and that is what, in my view, gives sense to this book beyond its validity as an explanatory proposition of the living and of living beings.¹³ This has been my first inner motive to write this book.

We living beings exist in two domains: in the domain of our physiology, where our body dynamics takes place; and in the domain of our relations with the medium where our living as organisms take place as the kind of beings that we are. Although different and not intersecting, these two domains modulate each other generatively in such a way that what happens in one changes according to what happens in the other. It is in the domain of the relation with another living being in language where the human living occurs, and it is in the domain of the relation with another where responsibility and freedom as manners of living take place as manners of living together. But it is also there that emotions take place as different manners of relational behavior with others, and it is there, where in the end exists the human soul, that the frustration and the irritation of youth occurs. We have wanted to replace love with knowledge as a guide for our daily living, both in our relations with other human beings and with nature as a whole, and we have made a mistake. Love and knowledge are not alternatives: love is our fundament and knowledge is an instrument.

Furthermore, love is the fundament of our human living, not as a virtue but as the emotion that grounds the human social phenomena, and has made and continues to make possible humanness as such, in the lineage of bipedal primates to which we belong (Maturana & Verden-Zöller 1993).

When love is denied in the attempt to give a rational fundament for all our relations and actions, we dehumanize ourselves, becoming blind both to ourselves and to the other. In this blindness we have lost in our daily living the vision that allows us to see the harmony of the natural world to which we belong, and we are almost unable to experience the aesthetic and poetic conception

that treats the natural world, the biosphere in its fundamental historical harmony, as the kingdom of God, and we live fighting with it. My awareness of all of this has been my second inner motive in the search for understanding living beings and the living, in the desire to recover the unity of body and soul in human daily living that the understanding of our biological nature makes possible through our consciousness of our responsibility as living beings that are free to live in whatever world that they wish because they can be aware of the consequences of what they choose.

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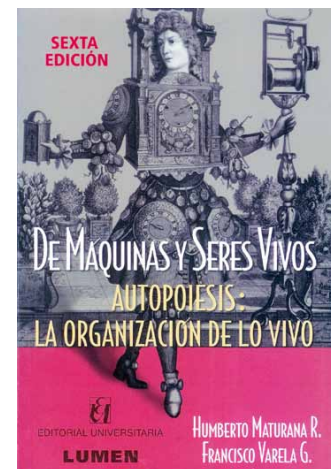
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¹³ Translators' note: We are reminded of the words of Richard Lovelace: "Stone walls do not a prison make, Nor iron bars a cage..."