The Languages of Nature

(when nature writes to itself)

Cédric Gaucherel

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Preface

"If there's a book you really want to read, but it hasn't been written yet, then you must write it." — T. Morrison, 1988.

"Everything labors for everything…There are marvelous relations between beings and things... no thinker would dare to say that the perfume of the hawthorn is useless to the constellation" — V. Hugo, Les Misérables, 1862.

Charles Darwin's book *On the Origin of Species* is one of the most impressive science books ever written. It not only puts forward a revolutionary theory, it is also extremely well written and reveals the true depth of the author's thinking. As a young scientist, I was surprised, on reading the book for the first time, that Darwin described the origin of species as the "mystery of mysteries", as it has been called by one of our greatest philosophers. For me, the "mystery of mysteries" was that of the origin of life itself! Later in my career, I understood that all scientific subjects are worthy of interest; but that some are "perceived" as more appealing. In fact, all origin quests are fascinating, including the origin of Earth and the origin of the universe.

Some may wonder why a theoretical ecologist with a physics background should be "allowed" to explore biology and other topics in which he is no expert. For these readers, I cite the great physicist E. Schrödinger in his preface to *What is Life?* If we want to expound wide and universal theories, we have no choice but "venture to embark on a synthesis of facts and theories, albeit with second-hand and incomplete knowledge of some of them – and at the risk of making fools of ourselves." J. Lovelock also, the scientist who proposed the Gaia hypothesis to which I will return, expressed similar sentiments, which I will also share with my readers.

This book, written in 2014, concerns the study of life in all its forms and adopts a deliberately multidisciplinary approach. I intend to focus on life's specificities and to propose new explanations for most of them. It does not set out to propose a comprehensive theory of life. Rather, it plans to present a succession of hypotheses, embedded in a coherent and parsimonious framework. Because any understanding of life also involves the study of non-living objects, this book provides an in-depth analysis of phenomena that are described as "almost alive", such as ecosystems. I will explain why I think that ecosystems, my dominant field of expertise, provide a kind of *missing link* between live and inert forms. Obviously, the next step is to test these hypotheses – a process that some colleagues and I already started some time ago.

However, this book focuses heavily on ecology and environmental sciences, as these are the fields whence my ideas first emerged. This work is also my attempt to reveal the deep unity behind the apparently diverse themes of my research. Colleagues have often questioned me on this point and this book is my attempt at an answer. Sometimes chronologically, sometimes thematically, I will reveal here the gradual understanding that came to me, from pattern to process, from purely spatial to non-spatial processes, from applied to theoretical studies, and from (astro-)physical to (eco-)biological processes. The pieces of the puzzle progressively come together.

Some scientists have formulated similar hypotheses to mine, and I will cite their pioneering work wherever possible. Yet, to my knowledge, none has proposed the framework that I will begin to outline here: I am proposing *a linguistic view of life* (new and/or significant concepts will be written in italics throughout this book). I have listed here the preliminary results in an attempt to base this linguistic framework on more robust and rigorous ground, as well as their justifications. I will systematically mention those hypotheses for which we still have no clue and are awaiting a clear demonstration. In a sense, this book has an objective comparable to that of N. Chomsky's *Minimalist Program*: it suggests a program (in the sense of I. Lakatos), a research direction, associated with a conceptual and mathematical frameworks to guide the development of further understanding, rather than offering a stable theory and reliable predictions. This program is so vast that I will later refer to it as a *maximalist program*.

Nevertheless, the reader should be aware that some of the hypotheses proposed here might appear radical and divergent from the life sciences mainstream. I am not taking a huge risk: they are, after all, mere hypotheses. For example, we will explore the probable incompatibility between the linguistic view of life and the classical view of dynamical systems inspired by physics in understanding biological systems. The last chapter will explain in detail why a reinterpretation of living systems based on (formal) languages appears necessary to me. This too is a hypothesis and to demonstrate this necessity will possibly require a great deal of effort. Many of the propositions made here will therefore require an open mind and a certain indulgence from the reader.

The central hypothesis of this book could be described as follows: "*Drawing on natural (human) languages, we could benefit, in terms of understanding and possibly management, by searching for languages everywhere in the life sciences, and I suggest that these languages are interlinked in time by specific mechanisms.*" To explore this hypothesis, the book structure is based on five chapters: 1. The evolution of writing systems; 2. The information concept in life sciences; 3. The ubiquity of grammar and language; 4. The chronology of languages and origins of life; 5. Philosophical justifications. The details of each chapter are as follows:

1. Similar to Darwin in his seminal book, I will begin by outlining those concepts that are easiest for us to grasp, progressing toward less and less intuitive concepts. For this

reason, we will first study human writing systems and their possible evolution in depth, before looking for comparable writing systems in life sciences. A first link to the information concept and its articulation with the language concept will be outlined here.

2. After this context, I will then review the use and misuse of the information concept in life sciences, with a particular focus on biology and ecology. We will explore its useful properties and the drawbacks that led it to be banished of life sciences. For example, following on from our previous book with colleagues ("Information – the hidden side of life"), this chapter discusses the immateriality of information and other surprising related ideas. This chapter ends with a clear and testable definition of what, from my point of view, information really is.
3. We now have good reasons to believe that information is not appropriate to study life. I will therefore elaborate in this chapter on the need to handle *languages*. Languages have the huge advantage of providing a *grammar*, which has been defined, formalized and used in various sciences. I will thus show the ubiquity of the language concept in life sciences and insist on its formalizations, often leading to a deep control on our understanding of living systems. In-depth study of language properties enables their differences to be highlighted.
4. Once accepted, this ubiquity of language is quite surprising. I will propose some hypotheses for this observation; in particular, that languages together exhibit a *chronology* with varying properties in time over the long term. Here again, ecosystemic languages, rigorously formalized in the previous chapter, will serve as key examples of "almost-alive" systems. Differences with living system languages will be illustrated too.
5. At this stage, it seems to me essential to justify the linguistic framework proposed in this book. Why do languages perform so well in the life science systems tested? Why are they suited to this understanding role? It took me some time to understand that the role of *time* and of *historicity* of each living system plays a crucial role in this quest. I will therefore posit that languages are the appropriate (mathematical) tool for living systems because they develop and evolve in time!

Finally, this book is a personal mixture of well-established results and speculative intuitions. The reader should not be afraid by it and try to gain a bird's-eye view of the coherence of the whole. The reader will often be asked to accept in an unconventional situation, adopting a linguistic and computing science point of view, rather than a more traditional biological and/or mathematical point of view. They should then wonder whether these unusual propositions make sense or not. In case my propositions are unconvincing, the reader may easily return to the usual biological interpretation. If there is a small chance that they prove convincing, then I hope that the reader will join forces with mine to explore the linguistic view of nature. I sincerely hope that they will benefit by reading this book and thus discover a radically new and potentially fruitful understanding of life.