Epilogue

**BOUNDEDNESS AND SELF-ORGANIZED SEMANTICS IN A NUTSHELL**

This book started by posing the question why a great amount of both non-intelligent and intelligent complex systems share the same properties and what makes a system to respond in an intelligent way. What we have learnt from the book is that a range of common properties of both intelligent and non-intelligent systems is necessary for sustaining the stability of a system. Further, the stability is developed through hierarchical self-organization which, to the most surprise, takes a new role: the role of implement of a semantic-like response. These premises, as we have seen, define an operational protocol that allows developing a systematic general theory about transformation of a system of constituents into a system of specifiable agents which respond to external stimuli in an intelligent-like manner. The proposed approach develops both the physics and the information theory and puts the relation between them on novel grounds by establishing the foundation for realization of a functional circuit capable to autonomous organization of information in a hierarchy of semantic structures along with its autonomous comprehending and autonomous creating of information.

The book has demonstrated that the key advantages of this strategy are:

- The boundedness sets the homeostasis to be a property of each hierarchical level starting with the quantum-mechanical one. Alongside, it makes available its characteristics to take metric-free forms which provides covariance of their robustness to small perturbations (provides their independence from the choice of a reference frame).
- The exclusive property of boundedness to appear both as a grounding principle for every given hierarchical level and as an emergent property at the next one opens the door to versatility and scalability of the hierarchical order through its non-extensive super-structuring.
- The general way of ‘building’ a hierarchy is through morphogenesis considered in the setting of the developed by us concept of boundedness. Its major advantage is that it provides a sustainable evolution of a ‘kind’ by means of diversifying its mutations.
- The semantics appears as an autonomous property of self-organization contrary to the traditional information theory where the process of distinguishing of a message from a random sequence is subject to an “external mind.”
- The information is organized in semantic order in a non-extensive manner. The effect of that non-extensivity is best illustrated by the rate of its extent – it is justified by the availability the next and the previous unit (letter, word, sentence…) to be “foreseen” on the grounds of the knowledge about the current unit only, i.e. such circuit performs as an “Oracle.” To compare, according to the
traditional information theory each letter can follow or precede any other one from the alphabet and thus it is impossible not only “foreseeing” the next letter, but it is impossible to judge \textit{a priori} whether a given sequence is a message (i.e. it comprises information) or it is a random sequence of symbols.

- The boundedness sets an exclusive two-fold representation of a semantic unit: as a specific sequence of letters and as performance of a specific “engine.” The latter renders a novel approach to the causality that acts in the hierarchical order - the functional irreversibility of any Carnot engine (in one direction works as a heat machine and in the opposite it performs as a refrigerator) provides a way of implementing logical irreversibility as a generic property of any semantic unit.
- The exclusive two-fold representation of a semantic unit: as a specific sequence of letters and as performance of a specific engine serves as grounds for building a multi-layer hierarchy of semantic structures. It is established that in this setting the semantics admits both non-extensivity, permutation sensitivity, and Zipf’s law. This approach proves the governing role the Second Law plays in the operation of the “engines.” Yet, the fundamental breakthrough is that the Second Law is considered as putting ban over any realization of \textit{Perpetuum mobile} at the expense of releasing it from the requirement for maximization of the entropy. In turn, the latter renders the widest ubiquity of the Second Law: it adds to its realm the entire variety of complex systems including systems that exhibit different forms of macroscopic self-organization (e.g. pattern formation and morphology), i.e. systems whose common property is violation of the entropy maximization as condition for thermodynamical equilibrium.
- The information is defined in a metric-free form, irrational numbers included, the major property of which is the robustness to small perturbations. This opens the door to “abstract” way of defining objects: both “red” and “green” apple belong to the set of “apples,” yet “red” and “green” are metric properties while “apple” is an invariant for the entire class of “apples” that possesses metric-free property.