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Biological Organization and Information

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Short Abstract: A novel concept of information modeled on biological phenomena is introduced. Its definition assumes that all biological entities are whole-part organizations. This concept depends on observers, signals, an interpreter and a perception hypothesis. Information is conveyed by organizations, composed from hierarchies and associations, and doesn't presuppose a sender.

Long Abstract:
Biological phenomena has characteristics that arguably cannot be described by physics and chemistry alone. Moreover, most magnificent biological discoveries of the last century relate to either structure or organization in biological entities; subjects not easily handled by existing theories. The systemic integration of cell parts into wholes and the integration of cells into organisms call for interconnecting and synchronization procedures. While existing information concepts, modeled elsewhere, have been largely used to explain biological integration and evolution, they are far from being adequate and unconditionally accepted [3].

The information concept I wish to introduce is modeled on biological phenomena and grounded on (biological) organization and its mathematical model, whole-part graphs [1]. It assumes that the inherent organization of biological entities can be mathematically depicted as a whole-part structure, and that any signal reaching sensorial parts of a biological entity provokes, at least temporally, a change on its organization. This concept is not restricted to living organisms but has characteristics that may be of great biological relevance. A biological entity is anything intervening in a biological process, form molecules onward. Whole-part graphs are a crossing of associations and hierarchies, or encapsulations; enchainments and graphs being simple forms of them. Molecules are organizations were chemical bonds are associations and identification of a molecule or group of molecules as a (functional) unity relates to hierarchization or encapsulation. A signal is any perturbation in the environment background that is localized in time or space. Signals may travel, reaching isolated biological entities. Any isolated biological entity has a topologically identifiable part (region) that separates "inside" from "outside". This region may contain sensory parts that when reached by environment signals translate them into internal signals, themselves perturbations in the entities' interior "background". This is the basic picture. The definition rests on the following phenomenological hypothesis — A signal reaching a sensorial apparatus of a biological entity (B) and transmitted into it provokes a (localized) change in its organization. Moreover, if another, equivalent, signal reaches the same entity it will tend to provoke the same organization change, and may be thus recognized by (B) (perception). This local change can either be a electric or structural reorganization in nervous systems or changes in a cell's transcription regulation complex and activation patterns. It represents or models the signal which is mapped onto it, and may become stable or permanent. This mapping is, though, not one-to-one, even if the signal is organized. It is important at this

point to recall that organizations, even perennial are not still entities, having a temporal component. This temporality results from the dynamical character of biological organizations. Which has two main sources: processes – sequences of organizations coherently immersed in space-time – and natural movements of the organization's counterparts while embodied by out-of-equilibrium physico-chemical systems.

Information: Given a signal (?), a biological organization (I) reached by (?), and at least another organization (B) perceiving both, (B) says that (?) is an information for (I) if (I) changes with respect to its model within (?); that is, if (?) perceives changes in (I), after its contact or interaction with (?). Although non quantified, such definition is indeed mathematical and can be described through whole-part graphs and their immersion in physical space. Perception is not objectively observable, except possibly when the interpreter is also an observer. However, this definition establishes information and its interpretation as a ground interaction between organizations and the environment, since no sender is presupposed. Also among organizations, since signals may be organizations (molecules and patterned perturbations) and may originate from organizations (senders). Moreover, by subsuming a sender (I´) in this picture and constraining signals to be prefixed and finite in number, a channel between (I – I´) may be constructed and the usual information definitions seen to coincide with the above in this constrained setting. Their usual measures are also recovered.

Otherwise, the present definition and setup allows for constructing dynamical models, and hopefully theories, for evolving organizations grounded on information exchange; extending, thus, our present possibilities for understanding information in biology. For instance, it allows for formalizing the two information levels explicitly left out of Shannon's communication theory [4] by considering how perception is affected by and affects the internal organization of I (context), and to handle temporal aspects of perceptions and information (kinetic and teleological aspects). Moreover, this definition provides an immediate formalization of ubiquitous terms related to information, like data, knowledge and learning. Information and organization are dual, in a manner similarly to energy and momenta configurations, and context dependent as well. Contrary to configurations, though, organizations are not sets. They may be part of another organization, have voids components where other organization may attach becoming part of it and an intrinsic complexity measure [2] that provides means for comparing them. This leads to a much richer structure in the mathematical space of organizations and to new possibilities in describing and studying biological phenomena, yet to be explored.

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[3] J.G. Roederer – Information and its Role in Nature. Springer, Berlin, 2005.
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