

Education for Sustainability: Lessons from Living Systems Governance.

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Abstract

What is a living system? How to define a living system? Can we get a definition which is independent not only of the dimensional and time scales, but also of the system structure, its level of organization and its degree of evolution? My first paradigm is “*the gauge invariance of living systems*”: whatever the living system it can be defined by 7 functional capabilities [1]. These properties define what is a level of organization, independently of the system complexity. How do new blueprints of living systems emerge? Every living system can be defined as an endophysiotope (endo: internal, tope: space-time, physio: of functioning) integrated into an ecoexotope of survival (exo: external, tope: space-time, eco: of inhabitation). The ecoexotope is providing a capacity of hosting (or carrying capacity) while, to survive, the endophysiotope needs to express a capacity to be hosted in adequacy [2].

Living systems are not only embedded and juxtaposed into more complex ones but they are also embedding previous less complex ones, which are juxtaposed, in an iterated way, a fractal manner, just like Matryoshka dolls are. My second paradigm is “*each jumping step from a previous blueprint to a new one is the merging into an Association for the Reciprocal and Mutual Sharing of Advantages and DisAdvantages*”, an ARMSADA [2]. What is an ARMSADA? For more than hundred years, symbiosis has been defined as an association for mutual benefits. That it is not what it is! It is an ARMSADA! Whatever the actors and the interactions into a system -as a Whole-, “*there are never advantages without disadvantages*“. All that is an advantage for a partner is a disadvantage for another one! If there are some benefits they are only for the Whole. Whatever the kind of structure, type of functioning and level of organization, of both the partners and the Whole, all living systems (bacteria, cells, multi-cell organisms, ecosystems...) are ARMSADAs [3]. With only these 2 paradigms we can trace a periodic table of classification of living systems according to their organization levels. These 2 paradigms are falsifiable and fruitful. The ARMSADA paradigm allowed assumptions that has been proved in AIDS and cancer curation research [4]. It could be a keystone principle both for higher education [5], new research trends [6] and ethical governance [7].

Whatever the system complexity [3], it always runs through 2 phases: -a larval phase, which is a growth phase (a phase of persistence and resilience), and “*if the self of the system survives long enough to attain a mass threshold*”, -an adult phase, which is the reproduction phase, during which “*the system, itself, survives its self*“. Indeed the describing parameter is not time: the governing parameter is the mass. Mass growth is determining time duration. If we represent in a log-log plot the relationship between the Volume of the system in its Adult phase V_A and its time of generation (e.g. the duration of the growth phase needed to gain the reproductive capacity) t_g , we get a line with a 3/2 slope. A power law is thus linking together all the interconnected systems of systems of our Universe as a Whole: $V_A = C.t_g^{3/2}$. Indeed, every sub-system we get from the whole Universe system obeys the same power law. And, if we iterate the graph, again with the same kind of log-log plotting, we observe that our Universe is a subsystem of a hyper-universe in which it is embedded and probably juxtaposed with other Universes. This power law is the fractal law of functioning of all living beings, whatever is their complexity [8]. But what does mean a 3/2 exponent power law?

Into a living system all actors are in interaction, not only within a same level of organization, but also between different levels. The endophysiotope of a i level (the cell level for example) is embedding endophysiotoxes of $i-j$ levels (the $i-1$ bacterial level for example), for which it is the ecoexotope of survival, and it is juxtaposed to other endophysiotoxes of different levels ($i-1$ bacterial level, i cell level, $i+1$ multi-cell organisms level) with which it is embedded into a $i+k$ level endophysiotope (the $i+2$ ecosystem level for example) which is its ecoexotope of survival. So, into the network of interactions, we do not know which is the first cause, because each cause can generate an effect that can result into either another effect (a positive or negative or modulating one), which is a new cause, or return to the same cause (positive feedback), directly or indirectly. That is *the systemic “constructal” law: “interaction is construction, construction is interaction”*. Many power laws have been evidenced in the functioning of living systems. $V_A = C.t_g^{3/2}$ is the same as $V_A^{2/3} = k.t_g$. What does that mean? If we look at the physical dimensional scales, $V_A^2 = C.t_g^3$ is the same as $D^2 = K.t_g$, e.g. the global flows of matter and energy exchanges are at a constant speed K at the surface interfaces within a system and between adjacent systems. The living system power law of governance $V_A^{2/3} = k.t_g$ is expressed as a similar 2/3 power law as is the Brownian motion (the basic physical phenomenon of our Universe), even if we don't know why. And 2/3 (or 3/2) power laws are known for many processes at different biochemical and biophysical scales (like the 3rd Kepler's law). Life emerged and evolved from basic physical processes through laws of holistic governance [8] that can now be modeled [5, 6].

Every ARMSADA is a “E PLURIBUS UNUM”, “Unity through diversity”, association, which survives “*in varietate concordia*” [1, 2]. ARMSADAs are not win-win associations. They are long lasting, in a “*meden agan*” holistic way, as long as the partners are supporting their Whole, as long as the advantages and disadvantages are mutually and reciprocally shared [3, 5]. They emerged in emergency situations when all the partners lose simultaneously the capacity to kill the other ones. Their growth is long lasting as long as it is supportable by every partner and supportable for every partner [7]. Every living species, sooner or later, must pass the exam of entering an ARMSADA; it has to pass it again and again..., if it fails one time it is eradicated. Only will survive ARMSADAs.

Key words: ARMSADA <http://armsada.eu>, gauge invariance, holistic governance, living systems, power law, systemic constructal law.

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