Biosemiotics (2016) 9:319–330
DOI 10.1007/s12304-016-9271-6

Levels or Domains of Life?

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Received: 11 November 2015 / Accepted: 15 August 2016 / Published online: 1 October 2016

Abstract In the case of living beings – the very concept of "level" of organization becomes obscure: it suggests a value-based assessment, assigning notions like "lower" and "higher" with rather vague criteria for constructing the ladder of perfection, complexity, importance, etc. We prefer therefore the term "domain", entities ranking equal. Domains may represent natural entities as well as purely human constructs developed in order to gain understanding of some facets of living things; living, evolved beings (e.g. viviparous animals, eukaryotic cells, etc.) as well as those abstract constructs, such as genotype and 'niche' which have been developed in the search for better understanding of such living things. Delimitation of such domains is sometimes a question of the dexterity of the researcher, and sometimes draws from the tradition in a given field. Such domains are not completely (canonically) translatable to each other. Rather, they interact by a process that we call here *reciprocal formation.* Life (including the biosphere and human cultures which are emergent within the frame of the biosphere) is unique among multi-domain systems. In contrast to purely physical systems, life is a semiotic system driven by the historical experience of lineages, interpreted and re-interpreted by the incessant turnover of both individuals and their communities. This paper provides cases of domain interrelations, and addresses two questions: (1) How do new qualities of inter-domain interaction emerge historically? (2) How do new domains (ways of understanding the world) emerge in evolution. Two approaches, physical and biosemiotic, are discussed as we seek to get a better understanding of the overarching tasks.

Keywords Domains · Emergence and evolution of dynamic systems · Life and biosphere

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Introduction

While this special issue is largely devoted to hierarchical systems in which well-established causal dependencies climb a ladder of lower to higher levels, we suggest a potential broadening of the conventional perspective. It may be fruitful to look to a system of non-hierarchical domains, mutually dependent not by emergence of phenomena from some lower levels, but on reciprocal forming of domains of a similar status. In a recent paper (Markoš 2014) we coin a definition of life as a semiotic category, and develop arguments in favor of such a definition – from the perspective of life-as-culture, and life-as-umwelt. A specific class of systems – those *that were born* – is seen as a keystone in the explanation of both the nature and evolution of life. The notion of being born will be central in this paper also and we take it to carry heavy weight. Things that were *born* come into the world inheriting processes, information, memory and experience from their parents. They did not arise de novo. Moreover, they are always born *into* an existing community (of their kin, lineage, ecosystem); hence individuals are – to different extents in different lineages – ushered into the rules of an existing community. Thus, the individual on one side and its community on the other present a paradigmatic example of two domains, both born from pre-existing individuals and/or communities, reciprocally influencing – forming in our wording – each other in the process of evolution. Other examples of such inter-domain interactions may be: the developing organism and its microbiome; the developing organism and its chromatin; the developing individual and its cultural/language/religious etc. milieu; host-parasite relationships; an individual organism in a population of its kin/species; an individual organism and the ecosystem it is born into, etc. Note that there is no relation of subordination between domains, neither is there a causal relation between some basic levels of description necessarily implying the properties of a derived "higher" domain.

The origins and evolution of complex dynamic systems have long presented a deep challenge to both popular and scientific thought. An important breakthrough in last century conceptualized many such systems in the context of non-equilibrium thermodynamics and demonstrated that they can emerge as a result of energy flows. Generally classified as 'dissipative structures', these emergent systems exist to channel – and dissipate – spare energy of the source in the most efficient way to a higher entropy state of their surroundings. Since then, there have been several attempts to reconceive *all* emergent systems in this thermodynamic context, including life in general and the human condition in particular (e.g. Prigogine and Stengers 1984; Deacon 2006, 2007). Such system should include phenomena as heterogenous as tornadoes, stars, growing snowflakes, biological species, ecosystems, or cultural, religious, or language communities. These approaches have not been definitively successful and important differences between life and non-life remain obscure. Below we argue that life – undoubtedly a complex dynamic system – represents a category different from physical dissipative systems.

On Domains

"More or less anything we find in the scientific and philosophical discourse designated or recognized as a 'level' falls under the concept of causal domain. In scientific contexts causal domains and levels of description are typically shaped by collective knowledge”, argues Ivan M. Havel (2001,126). He defines such a domain as that sector of the world where “mutually coherent causal relations” can easily be defined and generalized into rules, structures, or laws. What, however, cannot be done, is an unequivocal (canonical) transposition of terms, relations, and explanations from one domain into another. In this respect, Havel’s perspective is close to the views of Ilya Prigogine and his school, when they compare different physical levels of description, and the meaning of time, entropy, etc. within and between such domains (Prigogine 1973; Prigogine and Stengers 1984); in other words, domains can neither be reduced onto one another nor deduced from one another. Moreover, the contours of domains often are not sharp. Hence, the interfaces at which domains interact represent areas of ambivalence, “negotiations”, emergence of novelties never observed before, even of new domains. Below we call such interactions (or changes of perspectives) *reciprocal forming*. Every system may provide a plethora of such mutually incompatible perspectives and it is important to note that the choice of particular pairs is made for the sake of manageability and clarity only. In the classic example of the whirlpool (the literature on which reaches back to Heraclites) one description works with terms like ordered movement of molecules and their mutual spatiotemporal patterns, whereas a second recognizes streamlines, rotational moment, the whorl’s pathway in the field, etc. Both descriptions non-trivially interpenetrate but neither can be derived from the other. Importantly, such systems are profoundly temporal in nature – they depend upon their history. We accept a fundamental incompatibility between such perspectives and decline to build hierarchical or supervenient relationships between them; thus, we will avoid talk of ‘levels, upward-downward’, etc. (others, like Dupré 1996, Cartwright 1999, have made similar commitments). Our approach is similar to views developed by Bruni and Giorgi (2015) on heterarchies and heterarchical embeddedness; we stress, however, the role of evolutionary memory and experience of lineages that are not “autistic” but belong to communities (“biospheres” in the wording of Kauffman) that bear their own baggage of evolutionary experience and memory.

Note the “collective knowledge” in the quote above: domains can be recognized as appearances on the background of nature, or created by the researcher in order to distinguish different features of the area of study. Havel argues that the term “level” or “hierarchy of levels” is “relative to the chosen ordering characteristic” (p. 127).

Life and Non-Life

The longstanding question of the emergence of life is apparently an example of clearly defined ‘lower’ and ‘higher’ levels. But discussions of this subtle issue sometimes gloss over the specific dynamical differences relevant in living versus non-living systems. We suggest three criteria for distinguishing between these classes of systems: functionality, way of coming into existence, and temporal development, with further triadic division that allows distinguishing life from other dynamic systems (cf. Markoš 2014).

Functionality

Deterministic Systems of Causal Mechanics Such system’s capacities, function, and properties are entirely predictable from first principles. Their mereological supervenience[1] (Kim 2002 ed; Kim et al. 2008 [1999]) is coherent and their dynamical equations are parametrically stable – the 'laws of physics' which guide them are immutable (or at least stable over time scales much longer than their characteristic dynamics). This category includes many of the basic examples of classical mechanics: balls rolling down inclined planes and pucks sliding across surfaces, e.g. It should be noted that membership in this category is not limited to those systems whose analysis is rooted in some putative 'lowest level' of microphysicality. As Mark Wilson (2010), Batterman and Rice (2014), and others have cogently observed, minimal models provide deep insight into their universality regardless of the fact that the primary objects in such models are not, themselves, microphysical. This approach is extraordinarily promising and has important implications for related study but is beyond the scope of this paper. We extend this category to include those deterministic systems described by Bedau (2008 [2003]) and others (see Bedau and Humphreys 2008) as 'weakly emergent'. Such dynamical systems behave lawfully but evince behaviors which are not predictable but which are comprehensibly derivative of a fixed causal base when studied a posteriori.

Cybernetic Systems This category of system carries with it some sort of programmatic set of instructions that controls its behavior. Such programs and codes represents an extraphysical[2] behavioral determinant, which contextualizes and controls the system's response to and interaction with the physical world. Importantly, programming is not inferable from first principles (physical laws, e.g.). However, while it is artifactual: once written (or stable on long time scales), it both constrains and enables behavior, becoming effectively an adjunct to the determination of 'natural' laws, present from some alpha point in the system's history.

Evolutionary Dynamic Systems We will distinguish two types of evolutionary systems which share the same essential characteristic. Evolutionary dynamic systems proceed through time in unpredictable ways and *retain* historical information which, in turn, conditions their dynamics going forward. In contrast to cybernetic systems whose code is fixed, historicity imbues into evolutionary systems rules and responses which change gradually. Both 'dissipative systems' and informational, semiotic systems can be placed into this category. Whereas dissipative systems, as emerging de novo, have no evolutionary memory, semiotic systems work with experience and memory of their lineage or community; they recognize signs and extract their meaning. Evolutionary semiotic systems must continually reprocess the meanings of these signs as context changes and in response to both experience and memory.

[1] The concept of *supervenience* is common in both analytical philosophy and theoretical biology; e.g., Deacon 2006, 2007; McLaughlin 2008 [1997]; Chalmers 2008 [1996]). It can be summarized by the slogan "two things cannot differ in quality without differing in intrinsic nature".

[2] We use the term extraphysical here to clarify the fact that there are determinants which do not conform to nor are derivable from the first principles of some microphysics.

Coming into Existence

Artificial Systems The simplest dynamical systems are those whose function proceeds mechanistically. Susceptible to the time-worn clockwork analogy, many life-sustaining processes can be modeled to fit into this category (e.g. metabolism, genetic processes, etc). Artifacts in this context, then, are robust mechanistic systems whose durability is much longer than the characteristic time of their dynamical processes. It is important to stress that durability here is a subjective notion – if a dynamical process undergoes many working cycles with unchanged parameters, they can be said to be durable even if, over much longer time scales, parametric change occurs. There is, of course, the danger of imputing to such systems a 'creator' but this is by no means necessary. In fact, self-organization frequently leads to durable constructs which then become subsystems in life. However, they are not a defining characteristic of life, merely the necessary building blocks upon which it is based.

Repeated Emergence "from Nothing" Flames, vortices and snowflakes emerge spontaneously in the presence of certain circumscribed energy flows. Typically initiated by some sort of dynamical catastrophe, they maintain themselves by canalizing energy flows which are exogenous. The simplest of such structures are ubiquitous and easily classified yet their details are frequently *sui generis*. The clichéd example of the dissimilarity of snowflakes is testament to the fact that, in typical terrestrial atmospheric conditions, snowflakes form in a macroscopically highly-constrained way, yet their microstructure (representing a record of their dynamic formation) is extremely variable. Heraclites' whirlpool, similarly, is immediately recognizable as such despite the fact that it is not composed of any single set of water 'particles'. Its history leaves no trace on its constituents nor on its macrostructure. Again, in the prevailing environmental context of terrestrial surface water, such whirlpools are highly stereotypical.

Systems in this category require an environment of energy flow (disequilibrium) and spring from some singular, catastrophic symmetry breaking. Once instantiated, they persist as long as a correct range of disequilibrium is maintained. Key, however, to such systems is the fact that they perish and reemerge with no history. Their parts might retain organizational relationships as a result of the system dynamics (e.g. ice crystals and clays) or (as in fluid vortices) cycle through or depart entirely from the system. We identify a crucial limitation to such systems that, upon 'death' – occasioned by the elimination of the environmental flux necessary for endurance – they shed their history. And, each time they recur, they do so de novo. Hence, each vortex is fundamentally like every other. It is, on that scale, ahistorical.

Systems that Are Born of a Lineage of Similar Systems These systems are distinctive because they come into existence as inheritors of the dynamical history of their predecessors. Not simply by dint of their locus in environmental context or their dynamic initialization, they have deep history – a historical memory that is long by comparison to the characteristic time of both the dynamics and the system's lifetime. Such systems include cultures, nations, languages, religions, styles, fashion, and also species and communities of living beings. Of course an argument by reduction requires that there is a moment of inception for any such system. But we are concerned with function within appropriate time scales. With respect to the life cycle of individuals alive in a lineage, that origin point is vanishingly far in the past. The emergence de novo has by now been overwritten many, many times by evolutionary and aggregative change, each occurring in the context of life, not outside of it. So it is reasonable (except in that one ancient case) to always ask origin questions in reference to progeneration.

Systems of this kind evince a uniqueness distinct from the variability of simple dissipative systems because of the large amount of accumulated variation embedded in their existence. Because of the long time evolution of the group of systems (its lineage), reductive analysis fails epistemologically. Such failure is familiar in chaos theory, for example, and is a well-understood barrier to application of many powerful scientific tools. There remain a posteriori analyses which we will consider subsequently.

It is also characteristic of such systems that they form in populations. In such a population, each individual is a 'particle' of the community, born and dying in a continuing context of collective history. Each individual may be more or less individuated but none is indifferent, none is entirely passive like the inert interchangeable parts of classical micro-physics. In such systems it is frequently the case that the coming-into-being of such individuals ramifies upon the meta-dynamics of the collective, further complicating and individuating the collective experience and the historical memory it carries forward.

Dissipative systems have often been considered as physical analogies for life e.g. growth of crystal as an analogy of ontogeny; or systems of self-sustaining reactions (see Prigogine and Stengers 1984; Turing 1952). It will be an important task in this paper to clarify the distinctions between these two classes of systems (i.e. dissipative structures, and systems with genealogy). What they have in common is that the collection of individuals and the individuals themselves are both dynamic systems. They reciprocally potentiate, they re-form one another and modulate each other's dynamical unfolding. The most common approach to such coupled systems is to take one perspective as viewing an organized movement of particles, and *at the same time* an organized behavior at the "level" of the whole. The system is, from the very beginning, describable by both perspectives. As will be shown below, reciprocal formation becomes the key concept in *born*, living systems.

Behavior in Time

Systems in Equilibrium and/or Quasi-Equilibrium Few real physical systems reach true equilibrium states but many achieve long-term near-equilibrium behavior. In the simplest case, a ball resting in a valley, equilibrium is static and stable. With little promise of time evolution, however, such systems do not evoke much interest. Slightly more interesting is a steady-state condition like that of a bucket of water at constant temperature. Here, there is considerable dynamic activity on the molecular level but the lack of an energy gradient precludes the emergence of any dissipative structure. Macroscopically, the water remains inert and microscopically its activity is stochastic. More complicated forms of equilibrium include looping behaviors and even some strange attractors whose activity, while unpredictable on one scale, remains bounded on a large scale. None of these behaviors allows for historical evolution on long time scales and, hence, no reciprocal formation is possible.

Deterministic and Quasi-Deterministic Time Evolution As with systems at equilibrium, those which unfold according to entirely deterministic equations of motion do not acquire information and are not modulated by their experience. Hence, they lack the capacity to reformulate subordinate systems and what history they have is part and parcel of their initial (and constant) deterministic rules for time development. Even in systems which introduce noise or other stochastic factors but which retain the structure of immutable dynamical equations, no historical information is obtained through the flow of time and, again, reciprocal formation is impossible.

There are some remarkable dissipative systems in this category including the famous B-Z reaction (Zhabotinsky and Zaikin 1973), in which two mutually catalytic compounds are allowed to interact in an environment of free energy. The resulting pattern formation has been studied extensively and remains a paragon of physical emergence. However, like its simpler cousin, the whirlpool, the B-Z process ceases when the energy gradient is exhausted and there is no lasting historical information passed on either to its parts or its inheritors. Similar issues arise in reaction-diffusion processes (Turing 1952) and even in stellar nucleosynthesis but again, the 'particles' in question remain indifferent to the course of events of the collective system and have no history. Each is doomed to restart its dynamics from scratch every time.

History History, then, is the key discriminator. Particles or, better, individuals that are born into the system and die again are not interchangeable: their uniqueness is rooted in the fact that their memory and experience reaches far into the past. Importantly, that same historicity implies that they can reflexively process changes as time moves forward. We might say that this means that they can also 'interpret' their present situation, and 'organize' their future.

Here semiotic processes enter the stage, and with them emancipation from reductive scientific models. Each semiotic 'particle' carries with it some interpretive baggage – to borrow a term from genetics, its *phenotype* is the whole set of its functionalities as it is instantiated in historical context.

Darwin's emphasis on descent was consonant with our attention to this issue. In the *Origins of species* he writes: "[T]he natural system is founded on descent with modification;[…] that community of descent is the hidden bond which naturalists have been unconsciously seeking, and not some unknown plan of creation, or the enunciation of general propositions." (2009, p. 369) Our task below will be to arrive at a basic understanding of reciprocal formation in evolutionary biology. Particles may be represented, e.g., by cells born to a context of multicellular bodies or consortia; or multicellular beings born into the community of their species, ecosystems, or culture. We will concentrate on systems that are products of evolution in the biosphere on our planet. (To our knowledge, the closest approach to ours is the concept of biospheres by Kauffman 2000.)

Born into the Living World

Nucleic acids,– besides being carriers of information, can be copied with great accuracy. The resemblance of such durable natural signs to human alphabetic script, combined with the fact that DNA (a 'text' written in that script) is an information storage system, resulted in a conviction that the genetic script represents the basic level controlling all other features of living beings (Monod 1976; Dawkins 1982; Jakobson 1971). This deterministic paradigm, together with the technical feasibility of obtaining long strings of nucleic acids and/or proteins and deciphering their sequences, enabled scientific investigation to yield exceptional insights into the workings of the processes of life, and this approach has come to dominate biological study. Recently, advances in parallel epigenetic models (e.g. Gilbert and Epel 2009) indicate that important other modes of information storage probably augment the storage capacity of nuclear DNA sequences, offering an exciting expansion of our understanding of the 'texts' of life.

But the attention paid to genetics comes at a cost. We have become increasingly accustomed to cybernetic metaphors imagining 'scripts', 'blueprints', and 'programs' at the heart of life. Missing in these constructions is the essential role of the 'reader' of these texts. We hold that it is the unique characteristic of living, born, things to carry with them an interpretive, process-based capacity which is fundamentally separate from (and essential to the expression of) the information stored in the texts. The cellular structure is a vibrant, active ecosystem in which ongoing processes balance and regulate elaborate chains of information deployment. Structures as diverse as membrane channels, organelles, nuclei and cytoplasmic transport all act dynamically and continually. In fact, their action has been continuous since some ancient time in the far distant past, varying, responding to endogenous and exogenous factors, and remembering in a very different way than do the codes of text more commonly attended to.

Beyond the cell, where first-order genetic expression is most evident, multicellular living organisms likewise have continuity, relationality and interaction. Throughout the processes of ontogeny, parental influence is profound in many larger organism, imbuing formative processes in the newly-born. Sometimes maligned as neo-Lamarckian, such influences are certainly harder to study and subject to dangerous misattribution. But they are, nonetheless, evident. Feed-forward information from parental organisms and from communities of organisms to newborn, formative, and even adult individuals is ubiquitous. This has never been in doubt. The crux of the anti-Lamarck critique has been that such information is not *durable* in the same way that genetic coding is. That critique rests on a specific, genetic understanding of heritability in which phenotypic characteristics are uniquely and completely determined by genetics (as, for example Dawkins 1982). What it leaves out is the *active and ongoing* set of processes that continue and provide the context within which that genetic information is deployed (or read).

Kauffman (2000) and others (Markoš et al. 2009) propose a model in which autonomous agents do 'care'. They actively participate in their environment and, by common effort, steer the biosphere toward one of many adjacent possible states. Anthropomorphizing such activity, one can re-envision life and evolutionary processes as 'negotiations' in which parts 'work' and 'care' (or are 'selfish', for example, or seek novelty). The semiotic content of this sort of construct is unmistakable and suggests expanding the notion of semiosis past its traditional application to humans and even 'lower' organisms. In fact, following such researchers as Kull et al. (2009) we find it productive to expand upon Uexkull's idea (e.g. 2001; von Uexküll 2010), the *umwelt*, and bring it to bear on the problem of the essentially active and engaged characteristic of life.

In this way, genuine novelty can arise: the community sharing the *umwelt*, i.e. a model of the world that is complete, gets an inkling that something exists beyond its original world. At this moment, in the words of Lotman (2009), such novelty gets tentatively *semiotized* and inserted into the *umwelt* – a re-interpretation, re-modeling of the whole *umwelt* will take place. Such promontories leaning out of the community's *umwelt* often lead to overlaps between two or more *umwelten* (of populations, species, dwellers in the ecosystem, etc.) that had developed – up to this point – in parallel, without mutually influencing each other. Yet they share a common past, because all forms of life sprang from common ground. They share a genetic code, many metabolic pathways, cellular structures and intercellular communications, basic ontogenetic pathways, and behavior (e.g. mimics in different human cultures), so elementary mutual understanding is always present. However, a great majority of other relations had been – during the independent evolution of given lineages – strongly modified by "usage" in different contexts. As they each reach outward, a jarring mutual reinterpretation must take place when they come into contact.

The above approach suggests a provisional definition of life which, even when stripped to its essentials, is already self-referential. We might hold, for example, that life consists of systems which are born into a community, are semiotic, and have a history. But the entire notion of being 'born into', the key point generally left unremarked upon in contemporary analyses, implies history and semiosis. And the word 'semiosis' in this usage automatically presupposes both 'birth into' and evolutionary (historically responsive) change. To a living being there is no such thing as objective history, there is only the incessant interpretation and embedding of experience into the *umwelt*. The phenotype, that paragon of species' definition, is nothing more than a manifestation of this process, a physical statement of the way – in fact the only way – that particular life exists in the world.

Of course, such a definition by no means excludes the dependence of life on mechanical parts and subunits. Biology has fruitfully explored cybernetic (code-controlled) and mechanical structures for centuries and that exploration has marked a profound rationalization of the science. But that rationalization has come largely at the expense of ignoring the semiotic processes requisite for life itself. Until now, the attempts to define a biosemiotic science of life (e.g. Barbieri 2003; Deacon 1997, 2013) remain incomplete in the face of incessant attempts to reduce Darwinian evolution to forms that can be thrust into reductionist science (e.g. Conway Morris 2003).

The unceasing, reciprocal formation of meaning within the community depends upon knowledge of contexts, common experience and tuning, common "shortcuts" (myth, religion, heuristics, ideology, fashion), all enabling the community to act economically and meaningfully in most of situations. None of this can be taught ex cathedra – such static coding would only provide momentary, and fleeting, membership in the community. The essence of life springs from cohabitation, from long-term reciprocal re-forming: "*Narrative is a steadfastly human form of semiosis.* […] N*arrative not only describes events but actually, in its enunciation, does things. Moreover, its doing may occur at a deeper level than previously believed.*" (Cobley 2014, 212 & 219) The *narrative world*, then, is constructed through nuances of messages, statements, references, metaphors and analogies, rituals, stories, ideologies, etc. These structure an endless number of virtual *small worlds* of our everyday lives, as well as lives of our communities. And these small worlds constantly overlap, intermesh and reciprocally form into the great, hazy narrative world *umwelt*. In its most general form, a narrative is a story that takes place in a small (or possible) world (Eco 1994, articles in Allén ed. 1988, Dolezel 1998). It embraces only a negligible part of the real world, and the narrator (or writer) must necessarily assume that the receiver is acquainted with the world of a given culture as such and will understand the story anyway. The receiver will construe his/her own world (virtual umwelt) to stage the story in, and in some way understands it. Such an understanding by the individual may subsequently – via further unfolding – (re)form the understanding of the whole community, by fine-tuning its understanding of the world. It follows that even the real world is – for an individual – a mere possible world taken for the physical reality he lives in (e.g. contributions to Allén 1988). Myths, for example, are narrative structures that have canalized human communities for tenths of thousands years (Rappaport 2010).

Newborns of all kinds are born not only with data banks (their genetic and other biological information) but with epigenetic, systematic knowledge enabling them to parse those data. The running systems of the newborn's cells, for example, are part and parcel of its maternal cells, the machinery and interrelations are direct descendants of those working in all of the generations past. This is a central point in our argument. All of the processes necessary to *understand*, the relationships which undergird the unfolding growth and life of an organism, are appropriated from its lineage. They do not re-emerge de novo but are intact aspects of the historical *umwelt* of its species. Cellular dynamics offers a simple example of this point. Living cells are vastly complicated systems, often likened to cities in their intricacy and complexity. But cells do not come newly into the world. They are always born from other cells. But in the cellular case, the word 'born' implies an immediate unity with its parent. Cells reproduce by dividing or blebbing off parts of themselves. So the offspring, in this case, begins as a part of the parent. The elaborate plumbing and wiring of the cityscape, the complex running of parcels back and forth, the power plants and data banks all *continue* to exist. Of course, the growing cell then often changes, sometimes quite radically but it does so on the basis of a continued existence. Continuity and inheritance, consist of functional parsing of those processes. Interpretation and action rest, first and foremost on that capacity to successfully do so – to *read*. A cell, then, already has what the philosopher's straw man, an extraterrestrial alien lacks, an in-built readership – it inherits the capacity to know its world because it participates in the *umwelt* of its lineage.

One can bootstrap this argument to the domain of human cultures and observe that narrative worlds and 'objective reality' are deeply different. On one side are terms, signals, unchanging relations of 'objective reality'. On the other are things as they seem, signs, and meanings. The first can be defined (in principle) with accuracy, the second can be understood through reciprocal formatting. In the first, identical things can exist (triangles, letters, numbers), in the second similarity reigns – but the quality and extent of such similarity must be recognized and specified, it is not independent on the observer. The first represent the ideoscopic way of knowledge, the way of ideas; the second is the cenoscopic, the way of signs (Deely 2009). Cenoscopic experience is part of human nature, we accumulate (come by) it from birth (even conception); whereas ideoscopic knowledge is the codified product of individual and collective exploration and discovery. While this grows and changes over time, in any moment it takes a static form that, then, must be *taught* to members of the community (e.g. Newton's laws).

Ideoscopic knowledge is, in principle, available to everybody in an *identical form*, in its entirety, transferable between individuals intersubjectively, independently of their personal experience.

Objects and their relations represent the results of our efforts, whereas things of the real world exist independently, on their own. By reducing things to objects we abstract away most of their properties; highlighting a few which can then be retrospectively recognized, transferred and manipulated. Such a transformation, no matter how framed in terms, numbers, algebraic and logical formulas, must eventually float over into the narrative world to have an impact on our lived world. We must grasp the meaning of what was calculated, invented. This semiotic step breaks the logical chains that bound 'objective reality' to its course and returns it to the fluid world of reciprocal formatting. The *meaning* of any knowledge is *always* the output of a process of explanation taking place in the narrative world. The narrative – be it a fiction or a scientific treatise – feeds back on our view of reality, it creates the world it refers to, by the fact of such referring (e.g. Cohn 1999; Auerbach 2013 [1946], Eco 1994). Heidegger (1995, 2013) stresses the fact that humans incessantly build up their world and *appropriate* it (*Ereignis*).) But this particular semiotic step must be kept at bay until the last. It cannot contaminate the analytic process without stripping away the essence of the ideoscopic experience. The formula, say, F = m.a, is fully in the world of objective reality, only at the very end it must be *told,* explained by means that are not parts of science (i.e. how we feel when we experience forces or what we see when objects accelerate).

In cultural study, semiosis is widely accepted and the nuances of subjective realities and intersubjectivity embraced. But biologists, as heirs of modernity and its science, continue to be fully in the thrall of a simplistic notion of objectivity. We generally fail to acknowledge that each organism must engage in an interpretive process throughout its coming-into-being and in its role as member of and carrier for community identity. We suggest that attention to this reciprocality will enhance and deepen our science of life.

Acknowledgments Supported by the Templeton Foundation and by the Czech Science Foundation 13-24275S (AM).

References

Allén, S. (Ed.) (1988). *Possible worlds in humanities, arts and sciences. Proc Nobel Symp 65* de Gruyter: Berlin-New York.

Auerbach, E. (2013 [1946]). *Mimesis: The representation of reality in Western literature*. Princeton University Press.

Barbieri, M. (2003). *The organic codes. An introduction to semantic biology*. Cambridge, UK: Cambridge University Press.

Batterman, R., & Rice, C. (2014). Minimal Model Explanations. *Philosophy of Science 81*(3), 349–376. doi: 10.1086/676677.

Bedau, M. A. (2008 [2003]). Downward causation and autonomy in weak emergence. In B. MA & P. Humphreys (Eds.), *Emergence. Contemporary readings in philosophy and science* (pp. 155–188). .Cambridge, MA: MIT Press.

Bedau, M. A., & Humphreys, P. (Eds.) (2008). *Emergence. Contemporary readings in philosophy and science*. Cambridge, MA: MIT Press.

Bruni, L. E., & Giorgi, F. (2015). Towards a heterarchical approach to biology and cognition. *Progress in Biophysics & Molecular Biology 119*, 481–492.

Cartwright, N. (1999). The dappled word. A study of the boundaries of science. Cambridge University Press
Chalmers, D. (2008 [1996]). Supervenience. In B. MA & P. Humphreys (Eds.), *Emergence. Contemporary readings in philosophy and science* (pp. 411–425). Cambridge, MA:: MIT Press.
Cobley, P. (2014). *Narrative*. London: Routledge.
Cohn, D. (1999). *The distinction of fiction*. Baltimore: Johns Hopkins UP.
Conway Morris, S. (2003). *Life's solution. Inevitable humans in a lonely universe*. Cambridge, UK: Cambridge University Press.
Darwin, C. (2009). *On the origin of species by means of natural selection, or Preservation of the favoured races in the struggle for life* (6th ed.). Cambridge, UK: Cambridge University Press.
Dawkins, R. (1982). *The Extended Phenotype* (2nd ed.). Freeman & Co..
Deacon, T. W. (1997). *The symbolic species*. *The co-evolution of language and the brain*: Norton.
Deacon, T. W. (2006). Emergence: The hole and the wheel's hub. In P. Clayton & P. Davies (Eds.), *Re-emergence of emergence* (Vol. 2006, pp. 111–150). Oxford: Oxford University Press.
Deacon, T. W. (2007). Three levels of emergent phenomena. In N. Murphy & &. S. WR (Eds.), *Evolution and emergence. Systems, organisms, persons* (pp. 88–100). Oxford: OUP.
Deacon, T. W. (2013). *Incomplete nature*. *How mind emerged from matter*: Norton.
Deely, J. (2009). Purely objective reality. Berlin: Mouton de Gruyter.
Dolezel, L. (1998). *Heterocosmica. Fiction and possible worlds*. Baltimore: Johns Hopkins University Press.
Dupré, J. (1996). *The disorder of things*. *Metaphysical foundations of the disunity of science*: Harvard University Press.
Eco, U. (1994). *The limits of interpretation*. Bloomington: Indiana University Press.
Gilbert, S. F., & Epel, D. (2009). *Ecological developmental biology: Integrating epigenetics, medicine, and evolution*. Sunderland, Ma: Sinauer.
Havel, I. M. (2001). Causal Domains and Emergent Rationality. In B. Brogaard & B. Smith (Eds.), *Rationality and Irrationality, Vienna: öbv* (Vol. 2001, pp. 119–141).
Heidegger, M. (1995). *The fundamental concepts of metaphysics*. Bloomington: Indiana University Press.
Heidegger, M. (2013 [1954]). *The question concerning technology, and other essays.* Harper.
Jakobson, R. (1971). *Selected writings II. Word and language*. The Hague: Mouton.
Kauffman, S. (2000). *Investigations.* Oxford University Press.
Kim, J. ed. (2002). *Supervenience.* Ashgate Ltd.
Kim J. (2008 [1999]). Making sense of emergence. In: Bedau MA & Humphreys P eds: *Emergence. Contemporary readings in philosophy and science.* Cambridge, MA: MIT Press, 127–153.
Kull, K., Deacon, T. W., Emmeche, C., Hoffmeyer, J., & Stjernfelt, F. (2009). Theses on biosemiotics: Prolegomena to theoretical biology. *Biology Theory, 4*, 167–173.
Lotman, Y. M. (2009). *1992]). Culture and explosion*. Berlin: Mouton de Gruyter 2009.
Markoš, A. (2014). Biosphere as a semiosphere: variations on Lotman. *Sign Systems Studies, 42*, 487–498. doi:10.12697/SSS.2014.42.4.03.
Markoš, A., Grygar, F., Hajnal, L., Kleisner, K., Kratochvíl, Z., & Neubauer, Z. (2009). *Life as its own designer: Darwin's Origin and Western thought*. Springer.
McLaughlin, B. P. (2008 [1997]). Emergence and supervenience. In B. MA & P. Humphreys (Eds.), *Emergence. Contemporary readings in philosophy and science* (pp. 81–97). Cambridge, MA: MIT Press.
Monod, J. (1976). *The chance and the necessity.* London: Collins/Fount.
Prigogine, I. (1973). Physique et métaphysique. In: *Connaissance scientifique qr philosophie.* Proc. *Acad Royale de Belgique*, 291–343.
Prigogine, I., & Stengers, I. (1984). *Order out of chaos*. Flamingo: *Man's new dialogue with nature*.
Rappaport, R. A. (2010). *1999]). Ritual and religion in the making of humanity.* Cambridge: Cambridge University Press.
Turing, A. M. (1952). The chemical basis of morphogenesis. *Philosophical Transactions of the Royal Society B, 237*, 37–72.
Uexküll, J. v. (2001). 1937]). The new concept of *umwelt*: a link between science and the humanities. *Semiotica, 134*, 111–123.
von Uexküll, J. (2010). The theory of meaning. In D. Favareau (Ed.), *Essential reading in biosemiotics.* (pp. 91–114). New York: Springer.
Wilson, M. (2010). Mixed level explanation. *Philosophy of Science, 77*(5), 933–946.
Zhabotinsky, A. M., & Zaikin, A. (1973). Autowave processes in a distributed chemical system. *Journal of Theoretical Biology, 40*, 45–61.