LIFE PROCESSES AS PROTO-NARRATIVES: INTEGRATING THEORETICAL BIOLOGY AND BIOSEMIOTICS THROUGH BIOHERMENEUTICS[1]

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ABSTRACT: The theoretical biology movement originating in Britain in the early 1930's and the biosemiotics movement which took off in Europe in the 1980's have much in common. They are both committed to replacing the neo-Darwinian synthesis, and they have both invoked theories of signs to this end. Yet, while there has been mutual appreciation and some influence, particularly in the cases of Howard Pattee, René Thom, Kalevi Kull, Anton Markoš and Stuart Kauffman, for the most part, these movements have developed independently of each other. Focussing on morphogenesis understood as vegetative semiosis, in this paper I will argue that the ideas of these movements are commensurate. Furthermore, synthesising them would enable us to see life processes as proto-narratives. Doing so will involve synthesising biohermeneutics, Peircian biosemiotics and Piagetian genetic structuralism with Waddington's theoretical biology, and this, I claim, would strengthen the challenge of these traditions to mainstream biology. At the same time, this should contribute to overcoming the opposition between the sciences and the humanities, developing a broader tradition of Schellingian thought which involves developing the humanities and then demanding of the physical and biological sciences that they are consistent with and can make intelligible the emergence of humans as conceived by the humanities.

KEYWORDS: Vegetative semiosis; Biosemiotics; Biohermeneutics; C.S. Peirce; Kalevi Kull; Anton Markoš; Morphogenesis; C.H. Waddington; A.N. Whitehead; Robert Rosen; Genetic structuralism; Piaget; Bourdieu; Narratology; Paul Ricoeur; David Carr; Process metaphysics; F.W.J. Schelling

INTRODUCTION

In the concluding sentences of the epilogue to the fourth volume of the proceedings of the conferences on theoretical biology, *Toward a Theoretical Biology* (1972), C.H. Waddington, who organized these conferences, wrote:

[1] This paper is the development of a presentation to the Gathering in Biosemiotics 2022 held at Palacký University in Olomouc, Chechia. It has greatly benefitted from comments by Don Favareau.

> To a biologist … a language is a set of symbols, organized by some sort of generative grammar, which makes possible the conveyance of (more or less) precise commands for action to produce effects on the surrounds of the emitting and the recipient entities. … And it is language in this sense – not as a mere vehicle of vacuous information – that I suggest may become a paradigm for the theory of General Biology.

These conferences brought together most of the world's leading theoretical biologists at the time, and the proceedings were immensely influential. For Waddington, they were the culmination of the theoretical biology movement begun at Cambridge University in the 1930s by himself, Joseph Needham, Dorothy Wrinch, J.D. Bernal and others, a movement that was continued after Waddington's death in 1975 by Brian Goodwin, Gerry Webster, Howard Pattee, René Thom and others who took seriously Waddington's suggestion that the study of language could provide a model for biological theory.

This movement should be seen as allied to the biosemiotics movement, similarly concerned to replace the reductionism of mainstream biology. However, while some participants at the Belagio conferences, notably Pattee and Thom, have had some influence on biosemioticians and recognition by some biosemioticians and biohermeneuticists of the theoretical biology movement, notably Kull and Markoš, for the most part there has been little interaction between these movements.

In this essay I will argue that theoretical biology influenced by Waddington, Piaget's Waddington influenced genetic structuralism, Peircian biosemiotics and biohermeneutics, all of which are influenced by or consistent with Jacob von Uexküll's work, share deep assumptions deriving from post-Kantian philosophy and process metaphysics, and so, despite appearances, are not only commensurate but complement each other. They take as their starting point that living beings, including humans, are first of all, embodied and active, and argue that reflective thought presupposes bodily form and active engagement in the world. They combine constructivism with a form of realism based on these assumptions, and to achieve consistency, acknowledge a place to predictability, indeterminacy, path dependency and creativity. In particular, I will argue that the integration of concepts such biofields, chreods (necessary paths) and catastrophes (in Thom's sense) with Piaget's concept of structuring structures, Peircian understanding of semioisis and the hermeneutics of narratives,

acknowledging multiple levels of semiosis active simultaneously, allows living beings to be understood as biological proto-narratives, that is, as living and lived stories, in their epigenesis, in their activities and in their interactions as biotic communities.

WADDINGTON'S PROMOTION OF THE LANGUAGE ANALOGY

Theoretical biology as a global movement grew out of efforts to establish physico-chemical morphology (later, mathematico-physico-chemical morphology) as a research program in Britain in the early 1930's. It was led by Joseph Needham, a Reader in Biochemistry at Cambridge University, in collaboration with C.H. Waddington, an embryologist. The aim of this project was to overcome the division between the physical and biological sciences. Building on earlier work in theoretical biology, it was influenced by the revolution taking place in physics, advances in biochemistry, radical ideas emerging in the Soviet Union in the 1920's, D'Arcy Thompson's work on growth and form in biology, and the philosophy of Alfred North Whitehead. The notion of 'biofields', originally put forward by the Russian/Soviet biologist, Aleksandr Gurwitsch, was central to their conception of biological organisms. While this movement struggled to gain support and was eclipsed by the development of molecular biology in the 1950's, it persisted, mainly through the efforts of Waddington. It was dramatically revived with the effort to advance theoretical biology in the 1960's, culminating in four conferences at Belagio on theoretical biology which brought together and advanced much of the best work in theoretical biology up to that time. The proceedings were edited by Waddington and published as *Toward a Theoretical Biology* between 1968 and 1972, and the movement was continued by the participants at these conferences, most importantly, by Waddington's former student, Brian Goodwin, by Stuart Kauffman and by Mae-Wan Ho, among others. In the epilogue to the fourth volume of *Toward a Theoretical Biology* (1972), Waddington argued that the 'mutual interaction between the complexity-out-of-simplicity (self-assembly), and simplicity-out-of-complexity (self-organization) processes, are … to be discussed most profoundly at the present time with the help of the analogy of language' (p.285).

Waddington noted in this volume that this approach had been pursued by two contributors to the volume, René Thom and Howard Pattee. Pattee had pointed out that a language must be different from the subjects which are talked

about; that is, a symbol can only be a symbol if it is different from what is symbolized. He also argued that a symbol can only function as such when it is part of a system of symbols; that is, a word must be a word in language. Once we have a language we can have a metalanguage where words can be defined by other words. Waddington claimed that most of the work of the participants at the conference represented in this volume could be seen in terms of the language-metalanguage analogy. For instance, he argued that Lewis Wolpert's effort to account for morphogenesis in terms of positional information and codes of interpretation was too simplistic. In some cases, the patterns can be the simple result of forces. In others, what is taken as 'positional information' is, as he put it, 'only the metalanguage of pattern', and Wolpert 'is neglecting the underlying language by lumping it into an unanalysed "cellular competence"'. It is this cellular competence that has to be understood, and it is here, Waddington argued, that the analogy of language is required.

However, Waddington suggested that at this stage, theorists of general biology were 'only feeling its way towards the language-metalanguage metaphor', while the study of language at the time was one of the most active areas of enquiry. In this regard he referred to Noam Chomsky, Jean Piaget, Jerome Bruner and Ludwig Wittgenstein. He then claimed that biology could make some contribution to this field. Since human language is produced by evolution where:

> [n]atural selection is concerned with actions in relation to existing circumstances; what the proteins *do,* as enzymes or what have you. … [A] coding of natural phenomena into symbols, in a language, could only produce effects if the basic character of language is to be imperative, not indicative; to express, in symbolic form, commands, instructions, programmes – not statements. (1972, 287)

From this he concluded:

> To a biologist … a language is a set of symbols, organized by some sort of generative grammar, which makes possible the conveyance of (more or less) precise commands for action to produce effects on the surrounds of the emitting and the recipient entities. … And it is language in this sense – not as a mere vehicle of vacuous information – that I suggest may become a paradigm for the theory of General Biology'. (1972, 288f.)

ADVANCING WADDINGTON'S PROGRAMME

Biologists building on the work of Waddington, Thom or Pattee took up the

challenge of developing the language analogy. In doing so, they turned to structuralism. The work of Ferdinand de Saussure and Claude Levi-Strauss along with Chomsky were most influential in this regard, although Piaget was also referred to occasionally. The essays in the most important work on this, *Dynamic Structures in Biology* published in 1989, focussed on the notion of structure and its transformations. Atuhiro Sibatani (p.17) attempted to extend Saussure's linguistic theories understood as structuralist by 'identifying, by analogy, the infinitely variable act of protein synthesis in the cell with the *parole* of Saussure.' He then related the creative aspect of synthesising different proteins to the creative aspect of personal discourse under the constraints associated with any language, the *langue* of Saussure. This should be the genetic code system, and if so, there should be an element of arbitrariness in this code. This, Sibatani claimed, had proved to be the case. As he summed up:

> We can now present the axioms that deep-seated, hardly accessible, arbitrary structures in biology mediate between physical/chemical laws on the one hand and biological surface phenomena readily accessible and familiar to biologists on the other; and that, as such, they cannot be reduced to physical/chemical laws, whereas all the biological phenomena may be reduced to such structures. (p.19)

Sibatani examined the work of Chomsky and Piaget on linguistics, concluding that Chomsky was superior to Piaget and consistent with Saussure, while adding an extra dimension to Saussure by granting a role for hereditary biological constraints in languages. He then suggested how this version of structuralism could explain the pattern formation in lepidopteran wings, the long neck of giraffes, the number of phalanges in the digits of tetrapod limbs, and facial expressions.

The remaining papers, while not focussing on language, were largely consistent with Sibatani's work, and illuminated and developed different facets of it. While it was semiotics or semiology that attracted biologists to structuralism, they embraced this as a more general theory of structures and their formation, and to some extent lost sight of the original concern to utilize the language analogy to advance biological theory. The language analogy was not forgotten, however. The last two chapters of *Theoretical Biology: Epigenetic and Evolutionary Order from Complex Systems*, edited by Goodwin and Saunders, also published in 1989, meant as a continuation of Waddington's project to advance theoretical biology, also attempted to extend this analogy. Both were strongly influenced by

Chomsky. Goodwin as a leading figure in the theoretical biology movement, along with Gerry Webster (1996, 110ff.) equated structuralism with Wolfgang Goethe's work on morphogenesis (which had strongly influenced F.W.J. Schelling), developing structuralism as 'process structuralism'. Goodwin did not forget his earlier work and allegiance to Waddington and returned to the challenge of advancing theoretical biology through the language analogy in his last major work, *Nature's Due,* published in 2007. Here he again alluded to de Saussure and Chomsky, but also endorsed hermeneutics and the biohermeneutics of Anton Markoš without trying to reconcile these different traditions. In parallel with such work, Sungchul Ji (1999; 2017) attempted to integrate ideas from Pattee, John von Neumann, structuralist semiotics and Peirce to develop a 'linguistics of DNA'. However, Ji made no effort to relate his work to Waddington's theoretical biology. Finally, Stuart Kauffman (2015) became acquainted with Kalevi Kull and his work and endorsed biosemiotics, showing how it was consistent with his own work on autocatalytic sets, his questioning of the ambitions of mainstream science to understand everything through mathematics, and his endorsement of the holism of Kant's conception of organisms.

This sketch of the work of those influenced by Waddington suggests only limited promise of advancing biosemiotics through the study of their work. Sibatani's work does appear to anticipate later work in biosemiotics, including code biology. However, the structuralism that he defended had limited ambitions. As Thom, who claimed that any science is the study of morphology, wrote of this:

> In the structuralist viewpoint, one only tries to improve the description of empirical morphology by exhibiting its internal unity through a formal mathematical modern which can be generated axiomatically. In this respect "structuralism" is a modest theory, as its only purpose is to improve description. (quoted by Miguel A. Jimenez-Montano, 'Formal Languages and Theoretical Molecular Biology', in Goodwin and Saunders, p.201).

Waddington's own suggestions and demands appear more ambitious, but were not taken up and worked out by those he inspired.

However, this assessment misses something. These theoretical biologists were advancing the language analogy as a development of the more general theoretical work of Waddington and the theoretical biology movement. And it is both their successes and their limitations that are important. The theoretical biology movement was ultimately successful against the molecular biologists and the

proponents of the neo-Darwinian synthesis. Epigenetics is now recognized by many biologists as essential to understanding life and evolution. It is this success that has shown the necessity for a fully developed biosemiotics that the theoretical biologists had not succeeded in providing. However, my claim is that biosemiotics requires the success of the theoretical biologists' theoretical revolution to make biosemiosis genuinely intelligible, as opposed to attempting to explain away semiosis by equating signs and information, or simply using the language of semiotics in describing physical processes without showing how biosemiosis could be causally efficacious. The best way to properly appreciate all dimensions of the possible contribution of the theoretical biology movement to biosemiotics and vice-versa is to examine it from a different angle, to recognize both theoretical biology and biosemiotics as part of a Schellingian tradition of science opposed to Cartesian dualism and the reductionist Newtonian assumptions of mainstream science.

THE SCHELLINGIAN TRADITION

It is not necessary to go into details in characterizing the Schellingian tradition of science to appreciate its broad strategy. It has involved taking characterizations of human minds, experience and thought, as the condition for there being science, as part of nature and demanding of all sciences that they understand nature in such a way that humans so conceived can be understood as having evolved within nature, while simultaneously doing justice the achievements of past science.

Friedrich Schelling (1775-1854) began by developing J.G. Fichte's characterization of minds and their development, and then speculating on physical existence from this starting point, characterizing inanimate nature, living beings, and human minds though an evolutionary cosmology. Fichte, attempting to overcome deficiencies in Kant's characterization of mind and experience while defending Transcendental Idealism, argued that we are first of all actively engaged in the world and only through action against resistances do we developed the categories to comprehend it. Appreciating this enables us to reconstruct the stages of cognitive development, a possibility that Kant had denied because it implies the possibility of knowledge of the noumenal realm, that is, of things-in-themselves. Furthermore, Fichte argued that the self-

conscious 'I' and associated selfhood only emerges through the relation to others in which one looks at oneself from the perspective of others who are recognized as free agents. Embracing Fichte's advance over Kant but opposing Fichte's Idealism and more broadly, the Cartesian dualism that still permeated both Kant's philosophy and Fichte's Idealism, Schelling argued that we can not only reconstruct the stages of cognitive development in people, but the stages of the evolution of the universe that had engendered life and then human consciousness and its cognitive and cultural development. He argued there is an unprethinkable being (*unvordenklicher Sein*) that precedes all our thought and cannot be doubted, and that through the advance of such knowledge, we are bringing nature to full self-consciousness though us. Kant offered transcendental deductions to justify the forms of intuition and categories through which we organize our experience, arguing that these are the necessary conditions for claiming knowledge. Schelling naturalized the transcendental by claiming that to be coherent we must conceive nature in such a way that beings can have evolved within it that can comprehend it, and themselves as part of it. While Kant claimed to have achieved a second Copernican Revolution, overcoming the marginalization of humanity with its consciousness and knowledge to an unintelligible speck in an infinite cosmos by recognizing the role of the mind in creating such knowledge, Schelling achieved a Third Copernican Revolution by seeing humans with their sentience, cognition and creative capacities as participants in nature, the beings through which nature is coming to understand itself and its significance (Gare, 2013a).

To make the reality of mind so conceived intelligible, Schelling argued that nature must be conceived of as essentially activity which, through being limited or constrained, generates stable or unstable forms which then play a further role in limiting such activity. Nature is 'an every-becoming product … in constant formation' (2004, 28), Schelling argued. Self-ordering patterns of activity or dynamical processes characterized by immanent causation and temporal becoming, only existing in relation to other processes, are the primary beings of the universe, with the most fundamental beings being 'actants', with objects having a derivative status. That is, Schelling defended a relational process conception of being, reminiscent of the pre-Socratics Anaximander and Heraclitus, combining Anaximander's conception of the cosmos as engendered by the limiting of the unlimited and Heraclitus's appreciation that such limitation

occurs through the clash and tension of opposites.

However, Schelling updated this cosmology to challenge and replace the Newtonian world-view. To this end, Schelling (2004, 43) defended natural history as the means to comprehend the evolution of the cosmos, claiming we have the capacity to reconstruct the stages of evolution of the cosmos that have generated first opposing forces, extension, inorganic matter, life and humanity with the capacity to achieve such comprehension and knowledge. In doing so, he began the modern tradition of process metaphysics (Gare, 2011). On this basis, he predicted that magnetism, electricity and light would be found to be interconnected and would be the basis for a new physics. Through his concept of activity, he influenced the development of thermodynamics, inspiring those who postulated the first law of thermodynamics. He inspired major advances in mathematics central to the advance of modern physics, and embraced the work of Michael Faraday, claiming Faraday's work realized his own philosophy of nature. From the perspective of this philosophy, crystals are formed by and exist as stable balances of opposing forces, while living beings, to maintain and develop their form, must actively engage with and exchange materials with their environments, which become worlds for them, anticipating von Uexküll's notion of *umwelt*. He influenced the development of evolutionary theory and anticipated systems theory, hierarchy theory and endophysics. He argued that humans have evolved from animals with the capacity to develop philosophy and science. It was on this basis that Schelling (along with Hegel) defended and further developed Fichte's account of mind, integrating it with Herder's account of experience and his concept of culture. Herder argued against the separation of the physical and the mental, the intellect, feeling, willing and imagination, arguing that we are embodied but also formed by our language, and that actions and art express the entire personality of the individual or the group. Schelling's synthesis provided a philosophy that reconciled science, the humanities and the arts, including literature.

This approach has been adopted and developed by opponents of scientific materialism ever since. This was the approach of Alfred North Whitehead in his efforts to make intelligible and advance modern physics. His characterization of the 'concrescence' of actual occasions, the ultimate existents of the universe (equivalent to Schelling's 'actants'), was based on examining experience. Before

Whitehead, Engels was using the same approach to develop his dialectics of nature. 'Dialectics' originally meant a form of dialogue, and characterizing nature as dialectical was also following in the steps of Schelling. Waddington was inspired by Whitehead, particularly his notion of concrescence, along with a range of post-reductionist philosophers and scientists whose basic philosophical views can be traced back to the influence of Schelling. This included Engels, who might have influenced Waddington to look to language as an analogy for biology. Closely aligned with Waddington, Piaget, apparently not at all influenced by Fichte and Schelling, but who began as a neo-Kantian philosopher, also took this path, arguing as Fichte had, that cognitive structures, including formal operations associated the abstract thinking of logic and mathematics, originate in efforts by human organisms to act effectively in their environments.

This was also the approach of C.S. Peirce and von Uexküll, the major influences on biosemioticians (although von Uexküll downplayed the role of evolution). They both saw organisms as active in their environments, and explained reflective thinking as based on and a development of cognition developed through such action. Von Uexküll's notion of *Umwelten* and function cycles was clearly inspired by Kant and a major advance beyond both Kant and Schelling, while Peirce's characterization of semiosis as essentially social and applicable to the non-human world was an effort to overcome Kant's limitations. In doing so, Peirce endorsed Schelling's philosophy, claiming to be a Schellingian of some stripe, and developed symbolic logic and semiotics to advance it (Gare, 2013b). Proponents of biohermeneutics and those attempting to naturalize phenomenology, have again taken the same path, whether they recognize this or not (Kauffman & Gare, 2015). This approach, essentially the approach of Schelling, was described by C.D. Broad in *Mind and its Place in Nature* (1925). It involves identifying what is most basic to the existence of mind to characterize being as such, and then accounting for both the physical world and the mind in terms of this characterization.

If this is the case, work in the humanities and allied human sciences, including the conflicts between rival research traditions, should be taken very seriously to assess what post-reductionist biology will be required to make intelligible. The dismissal of work ascribing such ideas about humanity to the rest of nature as anthropocentric manifests the Cartesian tendency to deny that humans are part

of nature. Accepting that humans are part of nature justifies taking the study of humans, attempting to do full justice to what they are and are capable of, as a major source of insights into nature as such. I will suggest that it is on this understanding that the complimentary nature of the Waddington inspired theoretical biology movement and biosemiotics can be fully appreciated and their work integrated.

THEORETICAL BIOLOGY, THE HUMANITIES AND THE HUMAN SCIENCES

Firstly, in relation to Waddington, as we have seen, his followers embraced mainstream structuralism, particularly as this had been developed by Chomsky. However, Waddington himself was influenced by Whitehead. Whitehead himself was influenced by Hermann Grassmann, a Schellingian mathematician, Henri Bergson, an essentially Schellingian philosopher, James Clerk Maxwell who embraced and advanced Faraday's field theory, and more recent developments in physics. Waddington's characterization of chreods (sometimes spelt 'creodes') and the dynamics of biofields was inspired by Whitehead's notion of concrescence of actual occasions, the process of their self-creation and formation through relating to other actual occasions and their products (Waddington, 1969, 81). It was through reading Whitehead's philosophy that Waddington realized that changes in paths of development could be the result of the holistic dynamics of fields rather than of a switching agent. And Waddington (1972, 288) aligned himself with Piaget, who had been influenced by Gestalt psychology and Bergson's *Creative Evolution* (Piaget, 1971a, 5ff.), rather than mainstream structuralism. The notion of Gestalt developed in Gestalt psychology, subsumed by Piaget's notion of structuring structures, was influenced by the development of field theory in physics (Köhler 1966, 254; Ash, 1998, 171). Echoing the approach of Fichte, Piaget developed and defended genetic structuralism in the process of examining the development of life and cognition, which he saw beginning with action and culminating with the development of logic, mathematics and science. Those who embraced his genetic structuralism, such as Lucien Goldman and Pierre Bourdieu, also examined the development of literature and other cultural formations.

Waddington's judgement in embracing Piaget can be defended. Following Saussure, structuralism excluded temporality and focussed on the system of signs

as a theoretical object that could be represented synchronically. Giving a place to temporality within the framework of structuralism led to the post-structuralism of Jacques Derrida, now almost universally recognized as a dead-end. Chomsky's structuralism did give place to the temporal organization of word order, but his Cartesian linguistics gave no place to the emergence of structures. Conceiving of structures as structuring structures, developing through interaction between the organism and its environment as self-regulating systems of transformations, with new structures emerging from previous structures, temporality was presupposed by Piaget in proposing genetic structuralism (Piaget, 1970). There was a major conference in which Piaget and his supporters debated Chomsky and his supporters, published as *Language and Learning: The Debate Between Jean Piaget and Noam Chomsky* (1980), where Piaget again affirmed his alliance with Waddington (p.60). To most readers, Piaget won the debate. A crucial argument supporting Piaget's constructionism is evidence of plasticity in the brain. As Roger Sperry (1968) had already pointed out, people without a corpus calossum develop speech centres in both hemispheres.

The debate also demonstrated the enormous difficulty Piaget had in getting his opponents to understand that his constructivism took as its starting point that we are part of nature, resolutely rejecting Cartesian dualism. It is only when this is understood, that the superiority of Piaget's genetic structuralism over mainstream structuralism becomes fully apparent. Illustrating this difficulty, Piaget replied to Thom's critique of his work:

> In regard to the concept of space, Thom starts by offering an alternative which is precisely one I claim to have made obsolete: either a physical space outside or a construction of the subject. My answer is, on the contrary, that if mathematics is adapted to reality, it is because the subject, in his organic sources, is a physicochemical and spatial object, and because, in the construction of his own cognitive structures, he starts from neurological and biological sources whose laws are those of reality. (p.369)

Piaget saw cognition developing not just in the brain but in the organism as a whole in interaction with its environment, assimilating the environment to its own structures while accommodating these structures to the environment, adapting itself to the environment in the process while acting on the environment. Of course the human brain is important and essential to their potentialities for cognitive development and language. However, cognitive development, Piaget

argued, begins with the metabolism of the organism as a whole having only basic instincts, and then with the development of special cognitive structures associated with immediate action (sensori-motor intelligence), then perception independent of action, and finally, reflection and action on the organism's own cognitive operations. While initially focussing on cognitive development in humans, in *Biology and Knowledge: An Essay on the Relations between Organic Regulations and Cognitive Processes* (1971) Piaget extended his work to examining the development of adaptation and cognition in all organisms, in general aligning himself with von Uexküll (p.202ff.). He saw his own concepts of developing cognitive structures as entirely in accordance with Waddington's notion of the canalized necessary paths of development, showing how in this process new, more complex structures are made possible and develop out of more basic structures (p.19). Piaget's notion of structuring structures as self-regulating systems of transformations, in which actual phenomena are seen as particular realisations from a defined set of possibilities of such structures, is holistic and dynamic and commensurate with Waddington and Goodwin's notion of fields, and with how these fields develop biological structures.

Demonstrating the superiority of Piaget's structuralism to mainstream structuralism does not mean that Piaget's work cannot be criticised. Apart from empirical work showing the stages of cognitive development are far messier than Piaget thought, Maurice Merleau-Ponty criticised Piaget for failing to appreciate the holistic thinking of young children, whom, he argued, should not be viewed as just apprentice scientists, and for having an excessively constructivist account of perception. While the latter criticism can be questioned, since it ignores Piaget's emphatic view that our cognition develops the way it does because we are part of nature, which allows him to accept the kind of realism that Merleau-Ponty defended (somewhat similar to that of Peirce), the former criticism has some validity. Lev Vygotsky, who was strongly influenced by Piaget, argued against him that language plays a major role in cognitive development. This claim has been vindicated by recent research into the limited cognitive development of profoundly deaf people who are not taught sign language. However, these arguments can be accommodated to Piaget's genetic structuralism, and in doing so, strengthen it. Bourdieu's sociology of culture based on his notions of '*habitus*' as 'systems of durable, transposable dispositions, structured structures,

predisposed to function as structuring structures', integrating Merleau-Ponty's notion of embodiment with Piaget's notion of structuring structures, with experience and cognition understood as essentially social, involving communication, illustrates this, revealing how Piaget's insights can be built upon to overcome the limitations of his work (Bourdieu, 1990, 53; Gare, 2017a, 86f.).

Such integration should strengthen the claim that language can function as an analogy for life-processes. However, while Waddington referred to Piaget when calling for the deployment of the language analogy for life, as noted, Piaget himself tended to downplay the role of language. As he wrote in *Biology and Knowledge* (p.46f.)

> Language, although it is of course an essential instrument in cognitive constructions at the higher level, offers in itself no complete explanation and cannot help us sidestep the problems which arise. First, it should be noted that language is merely one particular instance of the semiotic or symbolic function … From the biological point of view it is therefore important to begin with a study of the semiotic function in all its manifestations. This in itself present a fine problem of comparative ethology before ever developing into a question of human psychology.

What is clearly needed to carry out Waddington's project is a general investigation into the semiotics of all aspects of life. This is where the work of the biosemioticians becomes relevant.

BIOSEMIOTICS AND THE HUMANITIES

The problem here is the that there are differences among biosemioticians. Biosemiotics inspired by Thomas Sebeok has been very strongly influenced by von Uexküll and Peirce (Emmeche & Kull, 2.). The commensurability of these two thinkers should be clear when they are seen as both strongly influenced by Kant, but in accordance with Schelling's reformulation of his philosophy as an evolutionary theory characterized by cognitive development. However, even with this synthesis, the central place accorded to Peirce in biosemiotics has been challenged. One of these challenges comes from those influenced by hermeneutics, such as Markoš (2002; 2008, 240ff.) and Sergei Chebanov, particularly as hermeneutics was developed by Martin Heidegger, Hans-Georg Gadamer and the Czech biologist/philosopher Zdeněk Neubauer. Another comes from the code biologist Marcello Barbieri. Here I want to argue that with modifications, all these schools of thought can be integrated, and this synthesis is

required to do justice to the questions posed by Waddington.

Hermeneutics, incorporating insights from phenomenology, is above all concerned to do full justice to human existence and the quest for the meaning of life, and the prospects for success of this project is the basis of its attractiveness. Heidegger developed the notion of human being as *Dasein*, being-in-the-world with others, thrown into this world that is already underway. Biohermeneuticists extend the 'others' to all living beings, with even the universal codes identified by Barbieri seen not as some frozen accident inherited from the far distant past, but actively negotiated, produced and maintained by organisms, including above all prokaryotic cells, to facilitate and maintain communication. As Markoš et.al. (2008, 237) put it:

> We start with the proposal that meaning, evolution, morphogenesis, imitation, mimicry, pattern recognition, understanding signalling, patterns, symbols from other beings, the ways that lead evolution into new dimensions, creative inventing novelties etc., – are facets and integral part of embodied existence of living beings; beings who care about their being, and who maintain uninterrupted corporeal lineages from the very beginnings of life on our planet. They are uniting the extant biosphere into a single, dynamic semiotic space, which is kept together by the mutual interactions and experiences of all its extant inhabitants, fitting and co-fitting (hence 'fitness'), storing memory traces, encoding them into negotiated codes or even in a form that we may regard as digital script.

The problem with invoking hermeneutics, however, is that despite its attractiveness, it has struggled to maintain its status in its conflict with scientism upholding an objectivism that does not really acknowledge the reality of life. The main opposition has come from logicians in philosophy, including Husserl as well as analytic philosophers, and structuralists and poststructuralists in cultural theory. Husserl was critical of hermeneutics because of its tendency to relativism and argued for a philosophy that would be a rigorous descriptive science of experience yielding apodictic knowledge, as in logic and mathematics as he understood these. Analytic philosophy, which continues to dominate academic philosophy, for the most part has revolved around symbolic logic and its interpretation, and analytic philosophers are dismissive of hermeneutics for being too vague, dismissing it as 'continental philosophy'. Both Husserl and the analytic philosophers were strongly influenced by Frege's anti-psychologist interpretation and development of symbolic logic and its apparent success. Husserl's project of achieving certainty through a presuppositionless description of experience failed,

and what was left of phenomenology appeared superficial with results idiosyncratic to particular phenomenologists, leaving analytic philosophy to dominate the field. In France both phenomenology and hermeneutics were sidelined by structuralism. The apparent early successes of structuralism as a research program promising an objective science of culture displaced hermeneutics, phenomenology and hermeneutic phenomenology.

The privileging of symbolic logic and its commitment to scientism has been contested, however, first by Robin Collingwood (who, along with Heidegger, was a major influence on Gadamer), then by the later Wittgenstein, and then by Alasdair MacIntyre who pointed out that societies are constituted by stories that are being lived out, and that it is through stories that we learn how to live and act. He argued in 'Epistemological Crises, Dramatic Narratives and the Philosophy of Science' (1987) that scientific research can only be understood through stories, with narratives required to constitute its traditions of enquiry, to judge progress and to orient further research. This is particularly evident with new theories associated with major advances in science, which alter the criteria of what counts as knowledge and science. These can only be recognized as advances by recasting the history of science to reveal the achievements and limitations of past science, showing how these limitations have been overcome by the new theories. The limits of atemporal structuralism have also been revealed by the poststructuralists, but as noted, this led to a dead-end. Hermeneutics has been defended against structuralism with some success by acknowledging the achievements of the structuralists, but also their limitations, and incorporating the achievements into an expanded form of hermeneutics. This was really the project of the Bakhtin school in Russia, particularly Vološinov, and the project was revived in France, notably by Paul Ricoeur, who while building on the work of Heidegger, not only accorded a place to structuralist explanations but acknowledged an affinity between hermeneutics and Peircian semiotics (Ricoeur, 1991, 62). He also aligned himself with MacIntyre in arguing for the central role of narratives in human culture and the formation of society and individuals.

Such work has provided better means to defend the humanities, but the dismissal of the work of the logicians has marginalized these thinkers among professional philosophers and thereby weakened their challenge to scientism and to analytic philosophers. To overcome the isolation of hermeneutics, it is

necessary to engage with and re-interpret the work and achievements of logicians. The project of most logicians has been to promote scientism to uphold mainstream science, undermining the claims to knowledge of the arts and humanities. If the Schellingian tradition is to be defended it is necessary to combat this view. As Jaakko Hintikka (1996) pointed out, the stumbling block here has been the acceptance of Frege's interpretation symbolic logic as the quest for a perfect universal language. It is this that underpinned the development of logical atomism, logical positivism and scientism. Peirce, who observed that increasing variety in the universe could never be explained through mathematics, provided an alternative way of understanding logic, defended by Hintikka (2007), Nicholas Rescher and Susan Haack. Peirce's understanding of logic as semiotic in which interpretants are not just deductions extracting from signs something already contained with them, gave a place to creativity. Conceiving of semiosis as triadic allowed for new relations to emerge and for endless increase in complexity, facilitating analysis without this leading to reductionism. Also, Peirce characterized logic as a major branch of ethics, claiming that its goal is to show how we should reason. Peirce's ideas on logic as semiotics played a major role in exposing the inadequacies of logical positivism, beginning in the philosophy of science with Norward Russell Hanson's work *Patterns of Discovery* published in 1958. Peirce's conception of logic has provided a way out of the sterility of analytic philosophy. These are important reasons for upholding the significance accorded to the work of Peirce in biosemiotics by those arguing for biohermeneutics. What is required is a development of Peircian semiotics so that it does justice to the insights of proponents of biohermeneutics, and vice versa.

To this end what is required, along with the development of Peirce's conception of logic as semiotic, is a Peircian account of narratives as characterized by proponents of hermeneutics. There are already characterizations of narratives through Peircian semiotics, notably the effort by Markus Arnold to connect Peirce and A.J. Greimas's structuralist theory of narrative; however, here I will take the work of a leading hermeneutic phenomenologist, David Carr, as a starting point, beginning with his *Time, Narrative, and History* (1991). Central to Carr's conception of narrative is its relation to action, including joint action. All human actions, he argued, involve narratives whereby completed states of affairs are envisaged on the basis of interpretations

of the present and anticipations of the future, at least in vague form, and embodied individuals are oriented in their current situations by these narratives to bring about these envisaged state of affairs. They are above all orientations for action. This is clearly true of joint actions where shared narratives facilitate coordination, but it is also true of the actions of individuals. Actions involve component actions, often more complex than the overarching actions, and this is taken for granted in narratives. Historical narratives are about actions, and therefore include the actors' narratives that constitute actions. More complex narratives highlight conflicts between rival actors, individual and collective, where there are rival definitions of situations, rival anticipations of the future, rival projects of action and associated with these, rival narratives of actors, resulting in reinterpretations of situations and reassessment of goals at multiple temporal and spatial levels. Narratives are inherently fallible, and the possibility of failure, often engendered by unintended and therefore unforeseen consequences of actions, is assumed by historical narratives. Consequently, historical narratives themselves are not just about history, but are also central to history, including the history of nations and civilizations. I am claiming this can be described in terms of Peircian semiotics and thereby applied to biology, but it requires modifying to some extent how such semiosis is understood.

INTEGRATING HERMENEUTICS WITH PEIRCIAN SEMIOTICS – NARRATIVES IN BUILDING

Peirce offered his most general definition of a sign as that which 'mediates between an object and an interpretant; since it is both determined by the object relatively to the interpretant, and determines the interpretant in reference to the object, in such wise as to cause the interpretant to be determined by the object through the mediation of the "sign"' (1998, 410). The 'object' referred to here is the 'dynamical object' which can only be cognized through the 'immediate object', that is, 'the Object as the Sign represents it' (1998, 482) or 'the object as cognized in the sign' (1998, 495). What is cognized in this way is the interpretant. Such signified immediate objects make up people's worlds, beginning with their *Umwelten* as characterized by von Uexküll. An interpretant can be a mental or symbolic interpretant, but it can also be action in response to the sign of the dynamical object cognized as an immediate object, with no separation between

'interpretation' and action. Finally, an interpretant can be growth of a particular kind in response to signs of the environment an organism has to engage with and adapt to, again without any separate 'interpretation' from the form taken in growth. As Kull (2000) argued, there can be vegetative, animal and symbolic semiosis, with symbolic semiosis presupposing animal semiosis, and animal semiosis presupposing vegetative semiosis.

Interpreting Carr's characterization of narratives through this scheme, the narratively defined actions (and their products) are interpretants, and the 'dynamical objects' are what make up the situations of the actor or actors, interpreted through signs as a world of 'immediate objects' produced by both previous and current interpretants. However, it should be clear that interpreting narratives in this way requires acknowledgement that semiosis does not occur atomistically. In defining situations and formulating projects, each instance of semiosis is in the context of a complex of other instances. These are often in hierarchical order in the sense that some semiosis are components of other semiosis. This complexity has been recognized by Robert E. Park and Ernest Burgess, George Herbert Mead (1938, 77) and W.I. Thomas in developing the notion of the 'definition of the situation', but can be fully appreciated when characterizing these complexes of semiosis as narratives.

As lived narratives unfold in the context of broader narratives and are composed of shorter, more specific narratives, so instances of semiosis will take place in a context of a broader instances of semiosis and be composed of more specific semiosis. And then the situation the actor or actors are ultimately engaged in will not be just a collection of dynamical objects, as implied by Peirce in characterizing semiosis. As I have argued elsewhere (2007), in the tradition of Schellingian thought, these should be understood as dynamical processes in complex relationships to each other, producing and reproducing structures or 'structuring structures', with 'objects' having a derivative status. In fact, 'objects' identified as such by organisms, including humans, are recognized first of all as 'affordances'. As the Gestalt psychologists, Piaget, and more emphatically, Maurice Merleau-Ponty (1967, 104f.) pointed out, 'objects', when identified as such, are experienced as parts of *Gestalten*, with differentiation into discrete objects only being perceived with more highly developed cognition. Semiosis itself is clearly a process rather than an object, especially when action involves coordination of many actors defining their situations, including each other's

definitions of these situations. What is signified by particular instances of semiosis include the broader narratives of which these instances are part. There is a reflexivity involved, an essential feature of anticipatory systems, as Robert Rosen argued (1991, 133). Furthermore, appreciating that the actor's own existence, with its semiotic activity, is part of the world, suggests that signs can be more that signs of objects in an external world. They can play a creative role, creating objects or processes in this world. This is clearly the case in the formation of communities, including the formation and development of nations, civilizations, and also research programs in science and philosophy. These come into existence and are sustained through signs of them. Signs and associated acts of semiosis are associated with organisms' or actors' appreciation of and concern for their own continued existence, the continued existence others and the communities of which they are part.

All this can be clarified by examining what is involved in building, especially as undertaken before the Twentieth Century, when architects did not design every detail and left details to artisans. This was described by the architectural theorist, Christopher Alexander (2002, 84ff.). Those involved in such building have to have some appreciation of the whole project they are engaged in, especially where very large buildings are concerned. The capacity for this derives from a history of building, associated with traditions of beliefs and skills, and manifest in the built-up environments in which they are living. Medieval cathedrals, inspired by earlier churches and cathedrals, were only completed over generations, and in the case of cities, it was (and is) normal for their building to stretch over many generations. Such projects required narratives to coordinate actions over these extended durations. These narratives consist of the production and interpretation of signs. Individuals took on or formulated specific projects defined in relation to the larger projects of which they were part as unfolding narratives within broader narratives. Their own lives were incorporated into these narratives, defining their identity as builders, artisans, stone masons, etc. involved in this particular project. They responded to various forms of verbal communication, but this should not be overemphasised. Builders also orient themselves by what has already been constructed and to the identities and actions of other participants in building. Incomplete buildings are a field of signs of what had been done, what is being done and what needs to be done, what was

successful and what unsuccessful. Interpretants of these signs include productive actions and further building. What is built in turn become signs. Most importantly, all these signs are components of the narrative of the unfinished project.

Builders are also constrained by the environment and of the materials used in construction which function simultaneously as facilitators and limits, whether these are recognized as such or not. Actions and what is produced are interpretants of signs of these. These interpretants could be routine, as the obvious implications of signs defining the situation, but they could also involve focussing on particular aspects of the situation, required to develop creative responses and products to deal with problems. Routine definitions of situations are global, grasping whole situations in the process of responding to them, while problematic situations require focus, but always in the context of global definitions of situations. On the basis of these and other signs, some of those engaged in building would try to anticipate what will be wanted by those who will occupy or use the building when it is completed, or would examine more closely particular aspects of the overall project and the possibilities for advancing it. In all cases, their utterances, actions and products of these actions are interpretants of complexes of signified objects which function as guides and sometimes imperatives, and it is through these that builders orient themselves in the process building, taking into account that they themselves are part of the process of building, providing the signs for others to take up and continue their projects. This is evident in the case of simple speech acts, as when a builder shouts 'wood', meaning pass up the wood. This utterance only makes sense in the context of the unfolding narrative of the construction of the building, which includes defined and defining roles for various actors. Actions and products of actions function in the same way, helping to embody the narrative of the whole project in the unfinished building and in the *habitus* of the builders (to use Bourdieu's terminology). Through such semiotic activity, humans are involved in the morphogenesis of buildings, and participating in the morphogenesis of their human communities and of nature.

Not all those involved in such building take much explicit interest in the whole project. For workers coming in later, the narrative is 'inchoate', to use the terminology of another hermeneutic phenomenologist, Paul Ricoeur. Inchoate

narratives, not explicitly articulated, can provide coherence to a variety of actions. Ricoeur and Carr disagreed on how much coherence to actions can be provided by inchoate narratives, with Carr arguing that these unarticulated, prefigured narratives are still narratives being lived out and do integrate sequences of actions (see Carr, Taylor & Ricoeur, 180). Drawing on Bourdieu's notion of *habitus*, I will support Carr's claim. My contention is that narratives can be embodied as a *habitus*, a disposition to interpret situations, including other people, that reproduces both their orientations and their relations to each other. As embodied in this way, inchoate narratives can be passed on from person to person and from generation to generation without ever being fully articulated. Furthermore, as projects proceed, they can develop a logic of their own, constraining those working on sites through various signs to realize these projects. The process of building is canalized, so that interruptions and problems, while they might hinder the project, do not significantly alter the final outcome. This is not always the case. Major interruptions might lead to modifications in the goals and means of attaining these, leading to a switch to a different path of development, which in turn will have some degree of stability to neutralize the effects of perturbations. In the Middle Ages, the discovery of flying buttresses led to significant alterations of buildings already begun.

INTEGRATING THEORETICAL BIOLOGY, GENETIC STRUCTURALISM AND BIOSEMIOTICS

I began this paper with an account of the work of C.H. Waddington and the theoretical biology movement, and the call by Waddington for a deployment of a language analogy to advance theoretical biology. Beginning with Waddington's research program, a development of mathematico-physico-chemical morphology situates life within the physical world, utilizing and modifying pre-existing structures and creating new structures, most importantly, spatial structures, structures which support the fields within which new kinds of processes and structures can emerge and develop. Piaget recognized that Waddington's work was commensurate with his genetic structuralism. As he pointed out, physical structures precede biological structures which are dependent upon them, and psychological, linguistic and cultural structures presuppose and are dependent upon these in turn.

As Piaget (1970, 49f.) characterized Waddington's contribution to comprehending biological structures:

> In embryology the structuralist tendencies that were first given currency by the discovery of "organizers," structural regulations, and regenerations, have now become accentuated through the work of C. H. Waddington, in which introduces a notion of "homeorhesis" … according to which embryological development involves a kinetic equilibration whereby deviations from certain necessary paths of development ("creodes") are compensated for. More important still, Waddington has shown that environment and gene complex interact in the formation of the phenotype, that the phenotype is the gene complex's response to the environment's incitations, and that "selection" operates, not on the gene complex as such, but on these responses. … Waddington, by reestablishing the role of the environment as setting "problems" to which genotypical variations are a response, gives evolution the dialectical character without which it would be the mere setting out of an eternally predestined plan whose gaps and imperfections are utterly inexplicable.

What is still missing from this characterization of the structures of life, and what is provided by biosemiotics, is a characterization of signs and semiosis in all this. That is, there needs to be a place for the organism to appreciate and respond to signs that are different from what is signified and are related to other signs, in the present and the past, and anticipatory of the future.

To integrate biosemiotics with Waddington's theoretical biology I have argued that it is necessary to appreciate the Schellingian roots of both these traditions. One aspect of this is appreciating the fundamental place in the Schellingian tradition accorded to both immanent causation and temporal becoming, notions central to the tradition of process philosophy (Emmet, 1984; Emmet, 1992). Immanent causation in the physical and biological worlds is associated with the development of fields and subfields which constrain and coordinate components, including component sub-fields. Waddington's student, Goodwin (1984, 107) defined as field as 'a domain of tissue capable of forming a structure, such as a limb, with the capacity for responding as a unitary, self-organizing whole to a variety of disturbances.' Markoš (2002, 94f.) offered a general characterization of such fields:

> A field is any entity whose components know of each other and therefore behave differently than when removed from the field. The verb 'know' stands for coherence and nonlocality. It follows that (1) changes in any part of the field are felt in all places within the field (coherence), and (2) such changes are inherent in the field, not a product of any external forcing (nonlocality).

Piaget's 'structuring structures' are such fields considered from a different perspective.

The immanent causation of fields involves downward causation or 'supervening causation', constraining components through the environments they provide, thereby often producing and maintaining the conditions for the very existence of these components. Such downward causation is holistic and cannot be analysed into linear cause-effect relations or in terms of efficient causation. Efficient causation or 'intervening causation' involves fields or their structures actively responding to their environments, largely constituted by these broader fields, producing changes that can then influence the broader fields of which they are part. As Waddington suggested, these changes can be interpreted as imperatives which are then responded to by the broader fields. Illustrating this, an increase in population density of short-horned grasshoppers, responding to visual, olfactory and auditory cues from their environments, results in young developing as locusts rather than grasshoppers, with a different colour, size of limbs etc. with all these changes in component developmental fields and associated cells coordinated. In this case, changes within the sense-organ fields, which have been produced by the organism as whole to be receptive to particular kinds of vibrations associated with touch, light, chemicals or sounds, provide the conditions for chemical changes such as the production of different enzymes that become imperative signs to biofields. These fields then develop accordingly, their chosen path of development being interpretants of these signs. More radically, environments stressful to biofields can induce alteration of DNA, as Barbara McClintock demonstrated, inciting the production of different proteins, in turn inciting the development of radically different chreods, creating and exploring new possible structures as creative interpretants of stressful conditions.

Component fields that emerge with the development of organisms can be more complex than the fields from which they emerge. Waddington's work on embryology described the emergence of sub-fields out of broader fields, giving rise to the morphogenesis both of the whole and of the different organs and limbs with their particular characteristics. The cells develop according to their place in the organism as interpretants responding to 'instructions' from the fields in which they are situated, and in doing so participating in the development of the fields. Some idea of the complexity of what is involved in such relations comes from

experiments on embryos, interfering with normal development. If tissue taken from an eyecup of a developing frog is transplanted under its skin, it will develop into a lens. A divided eyecup will develop into a number of smaller, but complete eyes. Waddington (1969, 180) revealed further complexity associated with hierarchical order by transplanting tissue from the thigh of a developing chick embryo to the wingtip, which then develops as a claw. Tissue has been first canalised to develop as thigh tissue, then according to its position within the limb. As Waddington argued, these emergent fields with their paths of development are not simply the effects of their originating conditions and environments, but are self-creating to some extent, 'prehending' (to use a term from Whitehead's philosophy) the conditions from which they emerge, including the DNA utilized to produce different proteins.

Such causation is associated with durational becoming and complex forms of temporality. The nature and role of temporality was most fully examined by Henri Bergson (Bergson, 1960; Capek, 1971, 313ff.; Gare, 2020). Bergson showed how the appreciation of duration and different levels of duration have been blocked by using spatial metaphors to characterize time and then to privilege supposedly timeless knowledge (1960, 113). Whitehead embraced Bergson's insights and these informed Waddington's theoretical biology. His chreods, understood as necessary paths, are temporal, not spatial, although they produce spatial order necessary for the development of these paths. And there are a multiplicity of these paths with different temporal characteristics, with some developing over longer durations than others, partially autonomous but also to some extent components of each other. Development can deviate from these paths due to perturbations, but then return to the original trajectory. That is, they are 'homeorhetoric'. Such homeorhetoric paths have different degrees of stability and instability. However, there are also a multiplicity of possible paths, and instability combined with perturbations can lead to switches to alternative possible paths. Such alternatives can be unpredictable, as when fish in an environment short of oxygen gulped air and absorbed oxygen through their floatation bladders, switching the path of development and evolution of fish through the development of lungs and all that followed from that path.

Like Bergson and Whitehead, Waddington was attracted to auditory analogies to illuminate this temporal complexity, and used them to critique the

influence of substance metaphysics:

> We could not have 'a neural plate substance, a fore-limb substance, a hind-limb substance', etc. but neural plate, forelimb or hind limb oscillatory patterns, which could be regarded as analogous to musical themes or chord sequences. The later phases of differentiation into the various cartilages, bones, muscles, etc., must certainly involve the 'activation' of different structural genes controlling the proteins in these different sorts of cells; but we could interpret these changes as similar to the development of the initial theme according to the conventions of some school of classical musical composition - I suppose the analogue of what jazz musicians do to a chord sequence in a jam session would be some sort of cancer! (1969b., 180).

This process orientation, with its focus on the essential temporality of existence, was further developed by Goodwin in his early work, *Temporal Organization in Cells* (1963), showing the importance of different process rates, was revived in his later work, and further developed by Mae-Wan Ho (Gare, 2017b).

Appreciation of immanent causation and temporality is also central the tradition of biosemiotics. This is clearly the case with biohermeneutics, which was indirectly influenced by Bergson and his notion of durational becoming through Bergson's influence on the later work of Wilhelm Dilthey and through him, on Heidegger and Gadamer, the hermeneutic philosophers who inspired biohermeneutics. Incorporating the work of Carr and Ricoeur into biohermeneutics, reinforces this appreciation of temporality. It is likely that von Uexküll was influenced by Bergson also. Maurice Merleau-Ponty quoted with approval (in *The Structure of Behaviour*, p.59) von Uexküll's claim that 'Every organism is a melody which sings itself.' I have claimed that Peirce's characterization of semiosis, which includes logical inferences, is of a temporal process. The difference between Frege's and Peirce's understanding of logic can be traced back to Frege's effort to portray logical relations as a timeless order without acknowledging any place for temporality, while Peirce's conception of logic, even when giving a central place to diagrams, presupposes the essential temporal nature of semiosis with continuity-in-process (synechism) and a place for creativity. Taking this seriously could further advance Peircian semiotics, for instance, by recognizing that the most basic iconic relations are temporal rather than spatial, and that multiple temporalities associated with different frequencies are involved. The development of sub-fields within fields and the way they develop can be understood as interpretants of the broader field, which in turn are interpretants of the field of the whole organism in its environment, utilizing a

diversity of signs associated with different frequencies and responding holistically to these.

By focussing on semiosis in individual cases and using the word 'interpretant', Peirce for the most part elided questions about how signs are differentiated, and thereby how such differentiation involves the generation of the systems of signs focussed on by structuralists. As a term, 'interpretants' condenses Kant's notion of schema and the imaginative activity involved in their application. Piaget characterized all this through his notion of structuring structures (which he originally referred to as schema) assimilating what they receive from their environments and accommodating to these environments, and also 'equilibrating' structures, taking the best form possible. By recognizing the Kantian roots of both Peirce's philosophy and Piaget's genetic structuralism it should be evident that there is no difficulty in incorporating into the notion of 'interpretant' the concepts developed by Piaget and systematised in his genetic structuralism. Such assimilation and accommodation can operate at multiple levels, and can include the creation and development of codes to facilitate communication. Historically developed codes are ubiquitous in the organisation of living beings (Barbieri, 2003), and underlie the biology of even the most symbol-dependant and semiotically sophisticated ones. Once generated, such codes can facilitate the development of symbolic signs and the increasing levels of reflexivity these make possible.

The driving force is ultimately the elimination of energy gradients, but with life, this is achieved by storing and controlling exergy transformations in order to maintain access to energy gradients, maximise the efficiency of energy transformations and oppose tendencies in the environment to eliminate its autonomy, and ultimately, its existence. Beyond that, the telos of life is to augment the conditions for life. With life, what began as a means, becomes the end. (Gare, 2021). Mae-Wan Ho (2008, 128ff.), following Herbert Fröhlich, argued that quantum coherent electro-magnetic fields created through vibrations in the liquid crystals within cyto-skeletons are central to such storage of exergy, facilitating rapid deployment and transformation of this exergy over multiple spatial and temporal scales when needed, while at the same time facilitating memory and communication over all scales within organisms. Much of what is actually involved in what Piaget referred to as assimilation and accommodation

and then equilibration can then be understood through the inter-relating of patterns of oscillations at multiple levels as characterized by Ho (Gare, 2017b).

BIOHERMENEUTICS AND PROTO-NARRATIVES

We can now return to the claim of this paper that living processes are proto-narratives. While temporality is represented most fully through music, as Ricoeur (1984, 3) pointed out, temporality is recognized most explicitly in narratives. Various aspects of morphogenesis and the genesis of other structures can be modelled mathematically, but the heterogeneous nature of all these developments, with the possibility of creative responses by organisms that are not only not logically entailed, but, as Stuart Kauffman (2000) argued, even their possibility could never be represented in mathematical models. On this basis Kauffman defended stories or narratives as more basic means to make sense of the world than mathematics. My argument is that this is not only because narratives can make intelligible complexity associated with contingencies and real creativity, but because living organisms are proto-narratives, narratives involving complex semiosis before they have been formulated as explicit narratives by those who study them. As with the narratives by which humans contribute to the morphogenesis of nature through their buildings and other constructions, these bio-narratives involve anticipation and have a telos, and involve a variety of kinds of semiosis. The example I gave of building as a human form of morphogenesis understood as a narrative, was designed to show how hermeneutics and the Peircian characterization of semiosis could be integrated in a way that would illuminate what is involved in the morphogenesis of organisms. These in turn should be understood as highly integrated ecosystems (Depew & Weber, 1995, 407). Morphogenesis in organisms should then be seen as a particular case of morphogenesis of ecosystems, and if the argument presented here is valid, it might be possible to show that ecosystems also are partly constituted by proto-narratives.

Of course there are differences between human building and the morphogenesis of organisms or ecosystems, but through abstraction it is possible to identify the central features of all such morphogenesis, whether vegetable, animal or human. Most basic is an appreciation that morphogenesis is a temporal process of becoming, in which the path to the future is constrained by the past and the current environment, but not entirely determined by these. Living

morphogenesis involves immanent causation of existing processes and is also constrained by semiosis and proto-narratives to realize final causes. Morphogenesis is vegetative semiosis, and portraying this as a proto-narrative is designed to emphasise its temporality in this sense, along with its spatiality, and also that what occurs later is not simply determined by the past but involves responses, sometimes highly creative, by existing processes to the conditions they have inherited and from which they themselves have emerged to bring about an anticipated future. Morphogenesis takes place over multiple durations, and what comes later is internally related to its preceding stages. The most basic iconic relations between signifier and signified can be temporal, associated with frequency, rather than spatial, and causation can be through internal resonance, as Gilbert Simondon (2005, 7) argued, and entrainment. The final outcome is to some extent made possible by the initial semiosis, but as in both building a cathedral and the development of an organism, a multiplicity of more complex processes, more complex signs and more complex semiosis emerge with new proto-narratives developing as components of the broader proto-narratives. These narratives in turn are components of the broader narratives of whole organisms in their environments, of ecosystems, of the evolution of lineages, and beyond these, of the evolution of terrestrial life, as this was described by Markoš and Švorcova (2001, 59).

In the case of organisms, semiosis begins in organisms with appreciation of the difference between themselves and their ambiance or environments, associated with semi-permeable membranes separating the two and a telos to preserve and augment themselves against environmental tendencies by regulating interactions and exchanges with their environments. In the case of multi-celled organisms, this involves not only maintaining a metabolism and reproducing themselves, but growing through self-differentiating to produce complex forms, guided by signs provided by parents and ancestors and the existing environment of the organisms, of what environment the organisms will have to live and survive within. In Rosen's terminology (2012), a living organism is above all an anticipatory system having a model of itself, differentiating itself from its ambiance. However, as I argued in 'Biosemiotics and Causation' (2019), such a model is best understood as a sign of itself. And as Markoš et. al. put it in *Life as Its Own Designer*, it is 'the sign of the presence of the original living reality. … [T]he

body is its own sign, its signifier and the object signified' (p.65). However, it is important to appreciate that, as Simondon put it, this signified object does not coincide with itself because it cannot be seen from a single point of view (2005, 232f.).

The initial direction in development is as an interpretant of signs bequeathed by 'parents' or ancestors of the organism. This underpins the semiotic activity in which materials to ingest and expel are identified as part of their *Umwelten*. In this process, there must be selection from different possible paths of development of which paths to take, and thereby which forms to develop. The most general proto-narratives are very basic directions for maintenance and development of the organism as a whole, and maintaining and developing the means to do so, and all other narratives presuppose this holistic narrative. As organisms develop, there is a differentiation of the biotic fields with signs playing a role generating such fields and in the production of different functional components of the organism and their coordination. Waddington's work on embryology described the emergence of sub-fields out of broader fields, giving rise to the morphogenesis both of the whole and of the different organs and limbs with their particular characteristics. The cells develop in response to their place in the variety of fields constituting the organism, and in doing so participate in the development of these fields.

It might still be asked, Why should these processes be characterized as proto-narratives? And why should they be treated as developments of the language analogy? In mainstream structuralism, narratives are treated as among the most complex development of signs, with the most elementary units being phonemes, followed by morphemes, lexemes, and so on. What I am suggesting, in accordance with hermeneutics, is that lived narratives as processes, involving memory and anticipation, are primordial, and sub-narratives and their component semiosis should be understood in relation to whole narratives. This is analogous to the relationship between cultural fields, including scientific research programs and the narratives of their development, which provide the context of the particular instances of semiosis associated with research. These narratives and their component semiosis are central to the morphogenesis of humanity in its built-up environments. In the same way, I am also suggesting that proto-narratives play a constitutive role in the development of biofields, in which again

wholes precede their components. That is, proto-narratives which constitute living beings are more fundamental than individual semiosis. The complex temporality associated with this, absolutely essential to understanding such part-whole relations, is both a feature of and best understood through narratives.

As Rosen argued, functional components of organisms should not be identified with fractionated components, although these fractionated components can be utilized by and serve functional components. This is clearly the case with DNA, which is used as a sign vehicle, but as the code biologist Barbieri has shown, cannot be identified with signs, since their role is mediated by an 'arbitrary' or 'conventional' code. The instrumental role of DNA in this regard is evident in the mechanisms that organisms have developed to maintain and repair DNA. As Rosen (1991, 250ff.) argued, this presupposes a model of what the DNA should be. Then there is the ability of organisms to use the same string of DNA to produce different proteins. DNA serves memory and anticipation as essential to the living organism, but cannot be identified with these. Memory and anticipation are functions, and as Rosen argued, are aspects of the functioning of the whole organism.

However, I am also suggesting that these functional components are not merely effects of the whole, but emerge with partial autonomy with their own immanent dynamics, temporality and spatiality, while still being functional components. Their functionality is partly constituted through signs as significant functions, both composing and being responded to as such by the whole organism and its other components as they develop. To understand this it is necessary to appreciate that the most important causation is immanent causation through which processes as patterns of constraining activity maintain and reproduce themselves, often in hierarchical order in which facilitative constraints create new possibilities for their components and thereby themselves, but also in heterarchical order in which processes are components of each other without being reducible to each other (Gare, 2019).

Hierarchical and heterarchical order can be defined in terms of spatial relations, but process rates are at least as important in the causation involved in such order, or ordering (Goodwin, 1963; Ahl & Allen, 1996; Lemke, 2000; Pattee, 2000). There can also be processes combining these two forms of relationship, and these are important for understanding the semiosis making up narratives.

Morphogenesis involves complex sequences of productive activities which are interpretants and thereby signs for further productive activities and their products, which are also interpretants, with both hierarchical and heterarchical relationships between them. Hierarchical order in semiosis was made evident by Waddington's research on the development of wings and thighs of embryos, showing how canalization operates at different levels. But this also revealed the existence of heterarchical order, as legs and wings with their differentiated components are what they are because they have functions in the whole organism. As functional components of the whole organism which only exists through these functional components, they are also components of each other's functioning. It is by virtue of and in such complex relations that semiosis plays an essential role in living beings, clearly evident when semiosis goes wrong. It is this complexity of causation and semiosis that makes organisms proto-narratives.

PROTO-NARRATIVES, PEIRCIAN SEMIOSIS AND CAUSATION

Much of this semiosis is what has been characterized as proto-semiosis, the lowest threshold of what can be counted as semiosis (Nöth, 2001; Prodi, 2021, 117f.; Faltynek and Lacková, 2021; Lacková and Faltynek, 2021). Proto-semiosis is exemplified by what Markoš (2002. 166ff.) characterized as 'the speech of proteins' in which regulatory molecules play the role of signs. Lacková and Faltynek defended the status of the production and folding of proteins as the lowest threshold of what can count as semiosis.

The work of Giorgio Prodi is important for identifying and characterizing this threshold. Prodi was seriously concerned with how semiosis as it was being studied at the time by Umberto Eco and others, could have arisen, and was attempting to explain this through biology. He argued, in opposition to both Saussure and Peirce, that signs in their most elementary form do not represent something else, but are natural objects that correspond to or are a function of something else. There is no intentionality, no mediation and no interpretant. The relationship is dyadic, not triadic. However, showing that something is a function of something else, while it might be a condition for semiosis, is to identify a purely physical relation - unless it is serving some other function. There is no reason to equate this with semiosis unless life itself is presupposed for which functional relation functions for the organism. Life itself, as anticipatory systems, involves

triadicity, as I have argued elsewhere (2019), and my claim is that triadicity is involved even at this lowest level of semiosis. From the perspective I am defending here, while Prodi makes a good case for claiming that semiosis requires a functional relationship between two different components of a living process, he has failed to recognize that when such a functional relationship takes place in a living process in a way that is utilized by the organism, there is really a triadic relation.

My claim is that this failure derives in large part from assuming the priority of objects over processes and fields and failing to appreciate the complex causality and temporality involved in life and semiosis. Markoš (2002, 174) suggested the presence of cellular machinery to develop latent genetic information, but acknowledged the possibility of fields rather than machinery to serve this function. Following Waddington, Goodwin and Ho, this is what is being defended here, emphasising that fields themselves are not only wholes but develop to realize final causes, and so are essentially temporal. Fields exist as components or aspects of processes. Protein production and folding having a semiotic function is identified as such only because it is participating in complex hierarchically and heterarchically inter-related and inter-dependent fields of anticipatory systems.

Biosemiosis becomes intelligible from the perspective of such anticipatory systems, especially when it is appreciated that iconicity can be temporal, as occurs with resonance and entrainment of oscillations. With temporal iconicity we have the beginning of anticipation and memory. To begin with, the first stage of proto-semiosis involves recognition of one 'object', process or aspect of these being an instance of a kind, and therefore a sign of this kind, and being responded to accordingly, the response being an interpretant of the sign of this kind.

This takes place in the context of hierarchical and heterarchical ordering. In the case of the production and folding of proteins, the importance of hierarchy is evident in that what is produced is significant for the broader semiosis, and serves as imperative signs for this broader semiosis. However, there are also heterarchical relations evident here as different levels in the hierarchy are also components of each other without being reducible to each other, as each is an instance of semiosis only by virtue of the other semiosis. For instance, the protein production and folding of proteins is semiosis only insofar as it functions as a

contribution to the semiosis of the broader semiosis of the field or fields of which it is a participant, while the broader semiosis only exists as such insofar as protein production and folding functions effectively as signs for this semiosis. It is this combination of hierarchical and heterarchical relationships that makes the complex of semiosis into a proto-narrative. By being constrained to function as they do by the broader semiosis or proto-narratives, and ultimately serving or mis-serving the whole organism as an anticipatory system of which they are participants, proto-semiosis such as protein production and folding, issuing in products that are significant components of this system, signify (and thereby are signs of) these broader semiosis or proto-narratives. They are responded to by being constrained not only physically but as signs relevant to the process of realizing or failing to realize the telos of the whole organism. It is in this way that there can be triadicity, even in the most basic proto-semiosis associated with production and folding of proteins. The 'object' (really, the 'process') of this proto-semiosis is the unfolding proto-narrative of the broader living processes in which it is functioning as a sign.

To recognize this triadicity it is important to appreciate that the chemicals and their interactions, which function as proto-semiosis, are processes. Rather than being understood as interacting particles, objects or bits of matter simply located in space, they are patterns of activity that are to some extent immanent causes of themselves while interacting with other processes, also partially immanent causes of themselves). It is because they are processes that chemicals and their interactions can be components of each other while being partially autonomous from each other, making possible real emergence of patterns and structures that are more than the sum of their parts. Living processes should be understood thermodynamically as dissipative structures as characterized by Ilya Prigogine (who rejects the reduction of thermodynamics to statistical mechanics), and in terms of quantum chemistry and quantum field theory. Quantum theory should be interpreted to acknowledge the reality of possibilities (Kauffman & Gare, 2015). Thermodynamics and quantum theory need to be integrated to fully understand living processes, as in the work of Herbert Fröhlich (Hyland, 2015, 174ff.) and Mae-Wan Ho (Ho, 2008; Gare, 2017b).

Changes in these living processes associated with interactions with other processes are not merely effects of outside forces but are responses to their

environments. They are modifying themselves and in doing so, influencing component and environmental processes. A condition for proto-semiosis is that there are different possibilities in such responses, so there is, in a primitive form, exploring of possibilities and 'choosing' which paths to take in response to environmental changes. 'Choosing' here should not be understood as implying an independent agent selecting which path to take, but as the whole process as an immanent cause of itself taking one path rather than another in response to what can be very small changes in their environments, a discontinuity characterized by Waddington in terms of chreods with alternative paths of development and then conceptualized mathematically by René Thom and, following him, Christopher Zeeman, as 'catastrophes'.

This characterization of chemicals and their interactions accords with and supports Markoš and Švorcova's (2021, 99.) rejection of the 'prevalent view in molecular biology that from a DNA sequence, the protein shape and thus its function can be predicted', and their observation that '[m]inute changes of temperature, acidity, salinity, and other environmental factors as well as, before all else, the everchanging presence or absence of other proteins may shift protein conformation substantially.' They noted that 'even the interaction of a ligand and an enzyme … is not a precise pairing. It is rather a negotiation or construction of a niche: both sides are adapting to each other' (p.101). Such interactions are in the context of the living organism which partly creates the environment where this can takes place and which then constrains these interactions to serve the whole organism, utilizing their responses to perturbations to serve the realization of their telos. These 'choices' and their environments are constrained by broader fields and associated semiosis or proto-narratives, while being components of these broader fields, so that they are involved in realizing or failing to realize the final causes of these fields, contributing to the way they develop and occasionally modifying these final causes, including their forms or structures. The existence of such fields is associated with downward causation, which is not mechanical causation, but involves constraining component processes without completely determining them. By virtue of changes in how they fold, proteins can alter how they function as enzymes, which are effectively affordances. Already constrained by the broader fields to serve their final causes, this response to their conditions can then influence how the broader fields, including the whole organism with its

Umwelt, develop.

The consequent changes of pattern function as interpretants of the prior states of the field, being signs of the condition of the field, while signifying how it has been responded to. As noted, this local activity with its partial autonomy and capacity for 'choice' in response to its immediate field is constrained by a hierarchy of fields, which though such constraining, serve to facilitate the existence and activity of their components. Being constrained by the broader fields, these 'choices' serve to signify or are signs of the broader fields of which they are part, and thereby of the proto-narrative of the whole organism. It is by virtue of signifying this context that these 'choices' can be characterized as interpretants. The components of such broader fields include such choices as interpretants of their own component fields, and are in part, composed of the semiosis of the broader fields. There can be multiple levels of such constrained responses and associated semiosis, with each level being a component of the other levels. For instance the proto-semiotic act of a particular protein production or folding in response to signs of environmental changes can be involved in and be significant for the response of the whole organism to its environment. This is illustrated by the example of the short-horned grasshopper becoming a locust rather than a grasshopper in response to increased population density signified by proto-semiosis at the level of protein production and folding as part of a proto-narrative of the whole organism. It is by being understood as proto-narratives in this way that biosemiotics can provide insight into the dual processes of the emergence of complexity-out-of-simplicity (self-assembly) and simplicity-out-of-complexity, that Waddington was concerned to explain.

CONCLUSION

Conceiving of living beings as proto-narratives, in accordance with biohermeneutics, facilitates the integration of the different strands of Schellingian thought, most importantly, the tradition of theoretical biology influenced by Whitehead and biosemiotics influenced by Peirce. It also facilitates the integration of genetic structuralism, which can supplement Peircian semiotics and explain the emergence of codes. While it has been argued that it is appropriate to accord a place to interpretants at the level of vegetative semiosis, there is more to being an 'interpretant' than Peirce considered, although the

triadicity he promoted was designed to give a place to complex relations between instances of semiosis. Semiosis is associated with constructive activity over multiple levels of organization, as the work of Waddington and Piaget suggests. Where, in accordance with biohermeneutics and process metaphysics, temporal activity or processes are seen as basic, multiple co-extensive processes can be understood as interacting so that they are partly hierarchical but also components of each other without being reducible to each other, that is, in heterarchical relationship. This makes possible the more complex forms of semiosis. It is on this basis that anticipatory systems as characterized by Rosen and the coincidence of the body and the sign noted by Markoš, can be understood (Gare, 2019). Such recognition of this complexity is consistent with Piaget's genetic structuralism, as Waddington realized, and Piaget's structuralism requires biosemiotics to fully comprehend the dynamics of structures. Waddington's interest in language can be regarded as an appreciation that Whitehead's notion of prehending through which actual occasions relate to other actual occasions and their products involves semiosis, responding to signs rather than merely 'objects'. Piaget did not provide an adequate theory of signs. Semiosis as characterized by Peirce provided the appropriate theory, and as I have tried to show here, this is evident in the study of vegetative semiosis as characterized by Kull (Kull, 2000).

Such signs to be identified have to be differentiated from other signs, and this facilitates the relating of signs to each other through codes, so that signs form a proto-language. It is in this way that the codes identified by Barbieri can be seen to emerge (Gare, 2021). It is in this much broader context that all those aspects of sign systems focussed on by structuralist semiotics (or semiology) become relevant. But as Umberto Eco (1979, 15) argued, Peircian semiotics is broader and more fundamental than structuralist semiotics. These theories are not incommensurable, however, and it is possible to reformulate Peircian semiotics to give a place to the insights of the structuralists. As James Pelkey (2019, 396) argued, 'rather than being a wholesale rejection of structuralism, or its antithesis, a [Peircian] linguistics can be seen as the emancipation of structuralism – structuralism coming into its own.' This is further facilitated by reformulating structuralism through genetic structuralism. With codes, formed through the quest to sustain life by organisms, we have the kind of complex interpretants that Sibatani identified and studied, but understood through Peircian semiotics in which signs are understood in the context of the development of whole organisms

- as proto-narratives.

While the focus of this essay is on morphogenesis understood as vegetative semiosis, by showing how these complement each other I have at the same time attempted to show how two strands of Schellingian metaphysics, Whiteheadian process metaphysics and Peircian metaphysics, complement each other and can be reconciled. This is designed to strengthen the challenge to Cartesian dualism and Newtonian reductionism, and along with this, to strengthen the challenge to the dualism between the sciences and the humanities. Supporting the contention of both Whitehead and Peirce, and before them, Schelling, that science is grounded in metaphysics and that metaphysics is required to reveal the tacit assumptions of mainstream science and the possibility of replacing them, this essay is also supporting the claims for biosemioticians to be advancing science by freeing it from the defective metaphysical assumptions that effectively made life and mind unintelligible. This new form of science provides support for the cognitive claims of the humanities and humanistic forms of the human sciences against claims that only reductionist forms of these are genuine science, and only such science can claim cognitive validity. In particular, narratives as characterized by hermeneutic phenomenologists become intelligible and can be legitimated by this new science as not only a genuine form of knowledge, but as an active organizing component of reality. Since narratives have been shown by MacIntyre to be essential to science, this also provides a defence of the cognitive claims of science.

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