MICHAEL POLANYI'S APPROACH TO BIOLOGICAL SYSTEMS AND CONTEMPORARY BIOSEMIOTICS

Phil Mullins

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ABSTRACT

Using the writing of Eliseo Fernandez and Jesper Hoffmeyer, this essay introduces important ideas in the emerging interdisciplinary field known as "biosemiotics." Later discussion summarizes Michael Polanyi's criticisms of the Modern Synthesis and his alternative constructive philosophical account of life, evolution and biological study, suggesting areas of overlap with contemporary biosemiotics.

Introduction

> I think the time has come when every statement on theoretical biology, or the logical structure of biology, should be made against a clear background of previous work that the author accepts or rejects. I have certainly been remiss in this respect, myself, in writing P.K. [*Personal Knowledge*] but I always felt that my own interpretation was so different from that of earlier writers that it would be excessively laborious to make their mutual relation clear. However, I regret the omission and hope you will be prepared to help me in remedying it.[1]

Michael Polanyi made this interesting comment in a January 14, 1963 letter to Marjorie Grene; it was his conclusion to a broader discussion about connections and

disconnections between his ideas about living entities and biological study and those of philosophical figures like Merleau-Ponty, as well as several other contemporary scientists writing about the nature of life. In this essay, I try to initiate the remedy Polanyi called for: I suggest it is worth exploring possible connections between some Polanyian ideas about living systems, evolution, and biological study and some ideas now discussed under the rubric of "biosemiotics." "Biosemiotics" is an emerging, interdisciplinary field that studies living things as environmentally embedded comprehensive entities whose agency and action can best be understood in conjunction with the operation of sign processes. Below, I first sketch important ideas developed in selected biosemiotic literature and then turn to a summary of Polanyi's main ideas about living beings, noting what seem to be possible bridges to biosemiotic approaches.

Biosemiotics: A Primer

In a very straightforward way, Eliseo Fernandez introduces the domain of inquiry of biosemiotics:

> Within each living being there is an unceasing deployment of signaling interactions between and among its constituent parts. These internal exchanges are regulated and coordinated with the assistance of another equally complex semiotic interplay. The second interactional traffic takes place between the whole organism and the entities and events occurring within its habitat (2014, 1-2).

As Fernandez sees matters, biosemiotics is an attempt to

> organize and reconceptualize our knowledge of living systems, their functions, origins and evolution, in terms of the crucial role played by semiotic causation and semiotic scaffolding in practically every aspect of their internal dynamics (i.e., energy and nutrients acquisition, metabolism, reproduction, etc.) as well as in their complex energetic and semiotic interchanges with their surroundings (2014, 1).

The primary issue here is concerned with what Fernandez and other biosemioticians such as Jesper Hoffmeyer term "semiotic causation" and "semiotic scaffolding" which are portrayed as the source of the telic in living beings.[2] Hoffmeyer suggests,

> The apparently purposeful nature of living systems is obtained through a sophisticated network of semiotic controls whereby biochemical, physiological and behavioral processes become tuned

> to the needs of the systems. The operation of these semiotic controls takes place and is enabled across a diversity of levels. Such semiotic controls may be distinguished from ordinary deterministic control mechanisms through an inbuilt anticipatory capacity based on a distinct kind of causation that I call…'semiotic causation' to denote the bringing about of changes under the guidance of interpretation in a local context (2007, 149).

Similarly, Fernandez contends that the "origin of purposive behavior" in living things resides "at the interaction of physical and semiotic causation" (2015, 1). Physical or ordinary efficient causation is triggered by signs or, more accurately, complex sign processes. In another essay, Fernandez suggests thinking of the sign process or "semiosis as a form of second-order causation: semiosis causes changes in the causal action itself. It alters the way in which energy is channeled by acting upon the habits embodied in the constraints that guide the flow of energy toward thermal equilibration" (2011, 4).[3]

The case for developing a rich semiotic account of living things can be put another way, which is akin to Polanyi's emphasis upon the achievements of living things. Polanyi masterfully portrays the continuity between living beings, simple and complex, making achievements through which they survive and flourish in the concluding three chapters of *PK* and in the concluding sections of several subsequent books and lecture series. Biosemiotics is an area of inquiry that appreciates this continuity among living beings; biosemiotic inquiry attends to, as Hoffmeyer puts it, not just natural selection but also natural play because all living creatures—while they are living—are striving:

> Making scientifically responsible sense of this "striving" is one of the challenges that the emerging field of biosemiotics sets out to accept, and it does so by presenting an understanding that biological communication is more than just machine-like exchange of information (2008, xiv).[4]

Semiosis is richer than the mechanical transfer of information "because the sign embraces *a process of interpretation*."[5]

> it is precisely the biological phenomena that comprise this interpretative activity that is neglected—or at least not recognized as engendering its own measure of causal efficacy in the world—in both traditionally conceived Information Theory and in most contemporary mainstream Evolutionary Theory" (2008, xiv).[6]

Hoffmeyer argues that, by focusing on semiosis which includes interpretative activity as essential to the dynamics of natural systems, biosemiotics is making an "empirically well-justified expansion" of science's basic view of nature; such a move

> reintegrates living creatures (including…human beings) into the natural world from which they came—but from which they have since been effectively excluded by a scientific ontology that has, at least since the time of Descartes, consistently encouraged scientists to de-semiotize all the naturally communicative and fundamentally interactive processes of living systems (2008, xiv).

Biosemiotics, Peirce's Triadic Semiotic Model and Habit

Fernandez, Hoffmeyer, and a number of other biosemioticians make ample use of Charles Peirce's ideas about semiosis.[7] Peirce's triadic approach recognizes signs as mediating between an object and an interpretant and sign processes are an ongoing cycle.[8] For Peirce, "the *telos* of semiosis is the generation of an interpretant, which can be a new sign, the performance of a meaningful action, or the acquisition of a new habit" (Fernandez, 2015a, 2).[9] Fernandez suggests that particularly the late Peirce's discussion of semiosis portrayed the mediating action of a sign as extracting a form from its object and conveying that form "through a suitable vehicle to a receptive structure capable of enacting its interpretation" (2015, 4).

Biosemioticians interested in "semiotic causation" and "semiotic scaffolding" argue for a dispositional account of causation, which is akin to Aristotle's notions about resident causal powers (i.e., intrinsic properties), which in Peirce's account of semiosis is recast in terms of the operation of habit.[10] A habit for a living creature is a disposition to respond in a particular patterned manner when some particular thing or process in the larger context triggers that particular response. Such a disposition for response can be viewed as an interpretant, an interpretative effect of the triggering sign which itself is a mediator of a predecessor object. For Peirce, "'habit taking'…can be seen as an act of interpretation, i.e., the formation of a mediating link between one regularity and another…Habituation, in other words, is semiosis (sign activity) in its most general sense…" (Hoffmeyer, 2007, 150).

Fernandez describes a dispositional account in terms of how "interactions transpire between energetic causal chains and a wide range of converging semiotic transactions unfolding within each individual organism and between organisms and their environment" (2015, 1). There is a pattern or a concatenation of elements or processes. Fernandez succinctly schematizes a dispositional account as follows:

> According to the dispositionalist standpoint an event **A** causes an event **B** when causal powers (which are latent in **A**) manifest themselves in a well-defined manner to produce **B**, contingent upon the occurrence of activating circumstances of a well-defined kind. For instance, a match has an intrinsic disposition to ignite which does not become manifest under usual conditions. When specific triggering circumstances occur (friction, dryness, etc.) the disposition to ignite manifests itself: the match ignites (2015, 2).

In this example, event A triggers event B when event A's latent powers come to be realized. Fernandez thus tries to "visualize the way in which chains of efficient causation become coordinated by the actions of signs into mechanisms that bring about goal directed actions" (2015, 2). But to speak of "mechanisms" is a heuristic way to point to the complex, interactive operation of dispositions within living beings and between living beings and their lifeworld.[11] This complex, interactive operation of dispositions is a process in which forms are conveyed through suitable vehicles to receptive structures that enact the interpretation of such forms.

Like Fernandez, Hoffmeyer (and others biosemioticians following Peirce) emphasizes that living beings develop habits. Living beings have complex, related internal habit patterns but, because such beings are always embedded in a niche, these internal habit patterns, of course, are intimately connected with and related to elements of that niche. That is, the operation (and reform) of internal habits is bound up with the contributions to semiosis that originate outside in the niche. The fabric of internal habits operative at any given time in living beings is the outgrowth of evolutionary history; evolutionary history is always a complicated dynamic narrative in which the internal and the external are deeply intertwined. Put less abstractly, Hoffmeyer's concrete discussions as a biochemist often emphasize the importance of things like semi-permeable membranes through which elements pass as semiosis occurs (2007, 153 and 2008-17-31); both the distinction between internal and external and the connections or interactions between (1) patterns of internal habits and (2) habits in the environment in which living things are embedded are important in biosemiotics. In biosemiotic approaches to living beings, there is an internal-external dialectic grounded in a relational ontology.

Scaffolding, Dispositions and Anticipation

What Fernandez calls "mechanisms" and Hoffmeyer sometimes terms "scaffolding mechanisms" (2007, 160) operate in living things to realize anticipations, which are fundamental for living beings who strive to persist in a temporal flow in a dynamic niche replete with challenges.[12] Hoffmeyer suggests that scaffolding "operates by

assuring performance through semiotic interaction with cue elements that are characteristically present in dynamic situations such as the catching of prey, invading host organisms, or mating" (2007, 154).[13] He compares such a biosemiotic understanding of scaffolding to ideas formulated by Vygotsy about the way dynamic scaffolding works in human child development: small children often learn to tie shoe laces by being talked through the steps of learning to make bow knots. An adult's stepwise instruction is a helpful external memory scaffold, triggering the right response; for a while, children may more or less verbally repeat the adult's instructions to master the task, even if the adult instructor is not present (2007, 154).[14] Scaffolding essentially cues and shapes the response of a living embedded agent. The biosemiotic focus on scaffolding has a family resemblance to Polanyi's account of living beings (discussed below), which focuses on the development and deployment of a repertoire of skills. Hoffmeyer emphasizes the proliferation and intricate interconnection—the expansion—of scaffolding mechanisms in evolutionary history. He suggests this expansion produces an expansion of the range of indeterminacy in reactive response (i.e., semiotic freedom).[15] This perspective in some ways resembles Polanyi's suggestion that the range of tacit powers in living beings increases in evolutionary history. The growth of complexity is the growth of a repertoire of tacit skills. The expansion of the repertoire of tacit skills requires, Polanyi argues, increasingly sophisticated critical powers of the biologist. These are needed to evaluate more complex living beings. Polanyi couples his account of an expanding range of tacit powers developed in evolutionary history with his insistence that to speak of life requires acknowledging a center. Expanding powers and deepening centers are aligned. That is, in Polanyi's account, in evolutionary history there arises a more distinct center whose depth is more apparent and resonant to the inquiring biologist. Polanyi calls this resonance "conviviality" in more complex living beings that emerge in evolutionary history.

The need that living beings have to prepare for future events or situations is apparently what led to the development and evolutionary expansion of semiotic causation.[16] Anticipation involves making sense of a sign; that is, a sign's interpretant sets forth a relation between a current occurrence and an expected occurrence. Hoffmeyer distinguishes "genomic scaffolding" and the kind of scaffolding that involves learning in more complex living beings: "Genomic scaffolding necessarily operates through the controlled assembling of protein resources which are then released in sophisticated temporal patterns reflecting the upcoming needs of the organism" (2007, 160). But "large-brained animals" depend not only on

> instinctual reflexes, but the process of *learning*—and while such processes are assisted by genetically assured behavioral preferences, the whole advantage of learning ability must be the inherent element of flexibility inferred [sic, conferred?] on behavior by the

> learning process—and thus the transfer of behavioral control from the genomic level to the cerebral level. This introduces the need for even newer sets of scaffolding mechanisms—and foremost among these are the diversity of the control mechanisms exhibited by the neuro-endochrinological apparatus (2007, 160).

Living beings, viewed as habit takers in a biosemiotic account, are constantly engaged in setting up dispositions to cope with the future. The nature of such dispositions for response, of course, depends on the complexity of particular living beings. Hoffmeyer suggests for most living beings it is "the instinctual reflex system" that makes predictions about the future, but even when learning is involved "the underlying logic is the same: an animal profits from its ability (whether acquired through phylogeny or through ontogeny) to identify trustworthy regularities in the surroundings and to orient its own actions accordingly" (2007, 161).

Regularities that can be relied upon by living creatures are stable (even if incrementally changing) relations and this is the soil in which habits can form. Stable relations in a given context produce what Marjorie Grene, following the Gibsons, called "affordances," the kind of awareness that develops in embedded living beings which is a context-specific discrimination or differentiation based on invariance (Grene 1995, 129-151). A particular bird's habit of providing apparently impaired movement to lure a predator away from a nest—an activity which may or may not succeed—is a semiotic activity, a habit or disposition, put into play when the predator (who is also a habitual creature) is spotted close at hand. Anticipation, Hoffmeyer argues, is "essentially a semiotic activity" in which something is taken as a sign (although it is also something in itself) and "is interpreted as a relation between something occurring now and something expected to occur later" (2007, 161-162). A biological perspective that focuses on semiosis is one that is constitutively at once relational (or interactional) and temporal.

Polanyi on Knowing Life and Being Alive: The Potential Interface with Biosemiotics

Although the recent flowering of biosemiotic inquiry occurred after Michael Polanyi's death, it seems likely that Polanyi would have been quite interested in ideas like those sketched above developed by contemporary biosemioticians.[17] Polanyi was, of course, deeply interested in questions about what life is, how living forms evolve and how creativity in nature is akin to creativity in human endeavors (themselves part of nature) such as scientific discovery. The final section of *PK* treating "Knowing and Being" (*PK*, 327-405) explores these topics as do sections of later Polanyi books, lecture series and several important essays.[18] Although somewhat indirectly, Polanyi's account of tacit knowing articulates an account of living agency, one that might be dubbed an

extended agency account, which I suggest should interest contemporary biosemioticians.[19] But Polanyi's account of living agency is inextricably bound up with his claims about the nature of biological study (and, more generally, human knowing), and this makes his discussion complex and atypical. Polanyi insisted that the scientist does not stand outside of the world being investigated, and this provides a relation of knower and known that is integral to the ontology of life. Below, I sketch Polanyi's criticisms of the mainstream biology in his day and then outline his main ideas about living agency; along the way, I briefly note possible links to some themes in biosemiotics.

Polanyi's Attack on the Modern Synthesis

Even Polanyi's early writing suggests he had a lively interest in questions treated in biology. In the 1941 essay "The Growth of Thought in Society" which focuses primarily on social (rather than natural) order, he notes that the development of embryos and the evolution of species are interesting matters that can be illumined by an adaptation of Gestalt ideas about "spontaneously attained order" to posit "a continued process of internal equilibration in living matter" (1941, 432-433). By the time Polanyi was preparing his Gifford Lectures and then *Personal Knowledge* (roughly 1947-1957), his interest in broad issues treated in theoretical biology had heated up. In 1950, he hired Marjorie Grene to help with his Gifford Lectures and then *PK*; one of her early assignments was to locate for him biological literature critical of the Modern Synthesis (Grene 1995, 91). His writing beginning with the Gifford Lectures articulated sharp criticisms of what he took to be the mainstream approaches and views accepted in biology.[20] Speaking generally, Polanyi accused biologists of too often taking a reductionist approach, a criticism that seems less on target today with developments like biosemiotic inquiry and systems biology (see Nobel 2011, 2012, and 2015). Marjorie Grene, almost fifty years after Polanyi's Gifford Lectures, aptly summarized Polanyi's view as well as her own: biologists should question "the thesis that biological explanation consists in considering least parts" (Grene 2002, 16). More specifically, Polanyi contended mainstream biology tried to provide explanations of life in terms of machinery wrongly assumed to be based on laws of physics and chemistry (*TD*, 38). Polanyi candidly acknowledged that one of the aims of his constructive philosophy's account of life was to "draw a truer image of life and man than the present basic conceptions of biology present" (*KB*, 238).[21]

Polanyi was convinced that the Modern Synthesis, by focusing on random mutation and natural selection, diverted attention from more important questions about the nature of life and the emergence and evolution of life. He contended, "the principal problem of evolution lies in the rise of higher beings from lower ones and, principally, in the rise of man;" evolutionary theory that recognizes only changes due to "the selective advantages of random mutations cannot acknowledge this problem" (1964, 18;

cf. *TD*, 46-48). Polanyi held that the misdirected attention of the Modern Synthesis led midcentury biologists to ignore the agency of living entities and the pattern of deepening agency emerging in evolutionary history. He argued that the way in which natural selection had come to be understood failed to acknowledge—but tacitly presupposed—the steps in evolutionary history (i.e., steps that constitute a creative, ascending evolutionary achievement) leading ultimately to the emergence of complex living beings who are conscious, i.e., are human persons, some of whom accept the calling responsibly to study life as biologists:

> the theory of natural selection by subsuming all evolutionary progress under the heading of adaptation as defined by differential reproductive advantage, necessarily overlooks the fact that the consecutive steps of a long-range evolutionary progress—like the rise of human consciousness—cannot be determined *merely by their adaptive advantages*, since these advantages can form part of such progress only in so far as they prove *adaptive in a peculiar way, namely on the lines of a continuous ascending evolutionary achievement*" (*PK*, 385).

Polanyi called the rise of individuals (some of whom engage in biological inquiry) the "spectacle of anthropogenesis" which "confronts us with a panorama of emergence" (*PK*, 389).

Polanyi's Emphasis on Principles

Polanyi's alternative constructive philosophical account countered what he took to be the narrow and unreflexive focus on mutation and selection in biology by directing attention to the importance of principles in living beings and in evolutionary history. He contended that "a principle not noticeably present in the inanimate must come into operation when the inanimate brings forth living things" (Duke 4, 15). With the emergence of this principle comes success and failure: "Inanimate nature is self-contained, achieving nothing, relying on nothing and, hence unerring. This fact defines the most essential innovation achieved by the emergence of life from the inanimate. A living function has a result which it may achieve or fail to achieve" (*TD*, 44).

Polanyi consistently also focused attention on the action of creative principles that subsequently, after the emergence of life, come into operation in evolutionary history:

> The action of the ordering principle underlying such a persistent creative trend is necessarily overlooked or denied by the theory of natural selection, since it cannot be accounted for in terms of accidental mutation plus natural selection. Its recognition would, indeed, reduce mutation and selection to their proper status of

> merely *releasing and sustaining the action of evolutionary principles* by which all major evolutionary achievements are defined (*PK,* 385).[22]

The emphasis on the action of principles led Polanyi to a hierarchical account of life emphasizing "dual control," which focuses on the relations between two biotic levels. That is, Polanyi argued that living beings and their evolution must be understood in terms of the ways in which higher level principles come to be operative in margins left open by lower level principles. A lower level sets the parameters within which the operation of a higher principle takes root and provides additional complexity and concreteness. The emergence and operation of a new, higher principle gives further shape to life. Hierarchy in Polanyi's model means there is a sequence of lower and higher levels of control in a complex living being as they emerge in evolutionary history. The lower level always imposes restrictions and the higher level provides further shape. Polanyi calls "the control exercised by the organizational principle of a higher level on its particulars forming its lower level, the principle of marginal control" (1964, 13). Polanyi thus discusses "possibility" in terms of marginal control of boundary conditions. The instantiation of one level of control in evolutionary emergence opens new possibilities at the same time it closes other possibilities for the next emergent level.

Polanyi's effort about fifty years ago to focus attention in theoretical biology on matters other than random mutation and natural selection seems to complement some contemporary theoretical biology, including some of the work in biosemiotics. Hoffmeyer, for example, acknowledges that "the Darwinian focus on hereditary mechanisms has tended to distort our understanding of evolution" (2008, 210). He notes that recent work in thermodynamics and complexity theory, has helped biologists better understand "the process of self-organization at work in species;" he acknowledges that something closer to a "Lamarckian scheme," recast in terms of current ideas about self-organization, does "approach the most modern conceptions of the ways of nature" (2008, 210). Hoffmeyer and biosemioticians such as Fernandez appear to be on a path that acknowledges something akin to Polanyi's "spectacle of anthropogenesis" (*PK*, 389) insofar as they "describe the progressive increase in complexity of life forms as driven, in great part, by a continuous expansion of their *semiotic freedom*" (Fernandez, 2015b, 3; cf. Hoffmeyer 2008, 185-188 and 196-197; 2010, and Hoffmeyer and Stjernfelt, forthcoming). Exploring the link between Polanyi's approach through marginal control and its expansion through the instantiation of new principles and the biosemiotic interest in the expansion of semiotic freedom seems a worthy project.

Centers, Achievement, and Tacit Powers

Polanyi's constructive philosophical account of life is grounded in affirmations akin to recent biosemiotic approaches oriented to the striving of living beings which semiotic causation actualizes. Polanyi insists that "we can know living things only by appreciating their achievements" (*PK,* 385).[23] Those who study living things must take a "molar" (*PK,* 327) view of living entities, and this involves recognizing "comprehensive biotic entities" (*PK,* 342)[24] and grasping their responsive actions, however primitive or sophisticated, in a particular dynamic context in which they are embedded.[25] This context is both separate from and connected with a living comprehensive entity; it sustains (or eliminates) and transforms the entity in the temporal flow. Above I have sketched the way in which Polanyi seems to conceive living beings and their evolution in terms of the principle of marginal control, which is concerned with the relation of higher and lower levels of control and the emergence of new higher levels of control. But Polanyi also suggests that living entities need to be thought about in terms of part-whole relationships. A comprehensive living system is more than an aggregate of parts. A comprehensive biotic entity has internal parts that operate in a coordinated fashion and this coordination can extend into the context in which an entity is embedded. In Polanyi's idiom, it is the tacit integration of particulars which produces a functioning whole that is deeply in relation to a local context beyond an entity's boundaries. The "integration" motif in Polanyi is his adaptation of Gestalt discussions of "spontaneous equilibration." This adaptation has both epistemic and ontological aspects. Polanyi regarded a comprehensive biotic entity as relationally constituted, that is, as a temporal and situated being that is (or has) a center which is an integrating system that produces achievements. He argues that in evolutionary history "there is a gradual intensification of the center in living beings" (Duke 5, 22), and this is a "gradual intensification of value" which is "accompanied at every step by an additional liability to miscarry" (Duke 4, 24). Thus there is a "parallel development of capabilities and liabilities" in the evolution of living beings and this accompanies "a consolidation of the center to which these are attributable" (Duke 4, 24).

By drawing attention to the "achievements" of living beings as entities that are or have an integrating center, Polanyi unequivocally adopts a first-person or living-entity perspective (in a way akin to Merleau-Ponty and Jacob von Uexkull) which phenomenological and biosemiotic approaches to life adopt (Harney, 2015, 4-5).[26] Polanyi's analysis of the logical levels of biological study (*PK,* 345-346; cf. notes 31 and 32) is another way to point out, as von Uexkull did, that living things generate, experience and live in terms of a species-specific model or map of the immediate context (one subject to incremental ongoing revision) in which they struggle to flourish. Achievement occurs in a niche, a familiar lived world, an Umwelt, which is an always already significant environment for the centered living entity as an embodied system with a history.

Familiarity is a skillful or habit-constituted orientation; it involves the possession of a second-nature set of responsive skills that can be deployed when the circumstances or timing is right. Achievements interactively unfold through a living entity's complex but tacit integration of particulars, internal and external. Particulars are that which the center dwells in or embodies on a particular occasion, and some particulars lie beyond the literal boundaries of the entity. A Polanyian framework recognizes an internal-external distinction but it attempts to avoid reifying that distinction (i.e., making it an ontological bifurcation) by emphasizing the indwelling capacities of living entities. A tacit integration of particulars is the realization of the tacit powers of a responsive subject, and those powers extend into the context in which a living being is embedded.

"Achievement" for Polanyi points toward the temporal nature of a comprehensive biotic entity, toward its unfolding future in a local context.[27] That future has both near and far horizons in longer term evolutionary history in which creativity blossoms into the emergence of more complex living forms. Polanyi insisted that biologists necessarily recognize the far horizons insofar as biologists can know the evolution of living beings "only by appreciating the development of their achievements in the course of succeeding generations" (*PK,* 385).[28] "Achievement" as that which unfolds or is realized in near horizons of temporal process means that a living entity protends or anticipates, and this anticipation is grounded in memory rooted in past living experience. Protensive elements are not only real elements in an individual entity's living, but such dimensions are real elements in broader terms of living achievements over evolutionary history.[29] For Polanyi, there is always an important reflexive element involved in appreciating the achievements of comprehensive biotic entities. Acts of understanding the achievements of living entities and their evolution are themselves achievements of living human beings, i.e., evolved (and still evolving) bio-cultural human creatures. These human knowledge-achievements reflect commitment and enrich reality. The kind of human "minding" involved in biological study should not be regarded as merely incidental; it is, for Polanyi, a central element to be mindful of in continuing biological inquiry.[30]

In *Personal Knowledge* and later writing, Polanyi presents a case that biological study is both "critical" and "convivial." His case, which seems akin to suppositions of some biosemioticians, effectively offers a particular ontology of life that he saw as required in biology. Polanyi saw in much of the biology in the middle decades of the last century an orientation focused narrowly on efficient causation understood mechanically.[31] If biologists examined more seriously the critical and convivial aspects of knowing life, Polanyi believed, biological thinking would move beyond narrowly mechanical suppositions shaped largely by the one level, non-relational ontology absorbed in the Modern Synthesis.

What Polanyi means by "critical," as an aspect of biology, is that the study of living things usually entails recognizing individuals and evaluating their performance in terms of success and failure.[32] What Polanyi means in suggesting biology is "convivial"

is that study of increasingly complex life forms necessarily is increasingly intertwined with "an increasing enrichment of relations between the critic and his object" (*TD*, 51). It is both the kinship between living beings and the differences among them (emerging in evolutionary history) that interested Polanyi. Biosemiotics opens up to science in a new way the exploration of both this kinship and difference.

Appreciating the critical and convivial aspect of biological study requires a molar view of living entities, which attends to achievements and tacitly acknowledges what Polanyi termed a "center" that is a "logical novelty" found in biology (*PK*, 344).[33] Where there is achievement, there is a center.[34] A center is a focus of comprehension, a focus, Polanyi argued, which is quite vague in simple life but becomes more distinct as life becomes more complex. A focus of comprehension attends to a comprehensive biotic entity that is more or less active since "it grows, produces meaningful shapes, survives by the rational functioning of its organs" and eventually is "something that can behave and acquire knowledge, and at a human level, can even think and affirm its own convictions" (*PK*, 344). Being a center means persisting as a comprehensive biotic entity such that "achievements," which are the means to persist are discernable in a particular dynamic context. As Harney suggests, using the language of Merleau-Ponty, where life persists there are certain reciprocal relations, which articulate a center's attunement to and anticipatory involvement in its niche. Like Merleau-Ponty, Polanyi offers a "relational ontology of the Umwelt" which suggests that a living entity and its environment can be regarded as separate and distinct only on the basis of a prior reciprocity that is constitutive for the living system (Harney 2015, 4).

Clearly, Polanyi's focus on a center and achievement does not imply the presence in most life forms of the conscious intentionality we associate with human beings and higher animals. Nevertheless, comprehensive biotic entities do manifest directedness.[35] This is what phenomenologists sometimes refer to as the "aboutness" (or "intentionality") constitutive of the activity of living forms. Polanyi envisioned this directedness as a focusing of attention and the tacit integration of particulars.[36] Living directedness is an attending from-to. But Polanyi consistently emphasized the tacit execution of most telic functions in living beings, even in higher animals. Polanyi shifted the ground in epistemic discussions to focus on an agent's skillful action, and skillful action is directedness in comprehensive biotic entities. Action is an integration of subsidiaries in which the subject dwells at a particular time, a performance which coordinates tacitly held elements to bear on a focus. This approach emphasizes the skillful living actor's orientation to a context and the ongoing effort to become re-oriented. Ongoing action reshapes the living actor's being, which is an embodied or embedded, niche-shaped being. Polanyi's ontology of life thus emphasizes that tacit powers shape and reshape living entities. Polanyi's reframing of "knowing" in terms of action grounded in particular skills used to address a particular context—a reframing which Grene described

as a 180-degree transformation of contemporary epistemology (Grene 1976, 168)—suggests how Polanyi provides an account of living agency that incorporates the tacit dimension.

Polanyi's discussion of a comprehensive biotic entity in terms of achievement and being (or having) a center is tightly bound up with his appreciation of skills as constitutive of living beings. Skills are that which a living comprehensive entity can make subsidiary in the effort to persist. Skills are akin to what biosemioticians, following Peirce, regard as the fabric of habit and the semiotic scaffolding through which life unfolds.[37] Skills, for Polanyi, are both vertically layered and horizontally linked. Insofar as an embedded comprehensive biotic entity flourishes, it does so by tacitly deploying skills. The tacit powers of living beings are powers mustered for achievement in a particular niche; such powers can be understood in terms of skill development and coordination, but for Polanyi skills reach deeply into the physiology of living forms and are not only or primarily consciously invoked. The from-to movements of efforts for achievement of a centered comprehensive biotic entity range from the somatic to the clearly conscious: "…subsidiary awareness will be found and accepted at all levels of consciousness" (1968c, 39). Although much of Polanyi's discussion of skills is concerned with higher animals, the framework applies to all living entities. Many combined skills developed and coordinated over time are involved in walking, seeing, hearing, and speaking intelligently for human beings. But also the amoeba's ability to "discern" when to propel itself involves a skillful coordination of elements. Skills are peculiar to a particular life form and a particular domain of living in which an entity is engaged. Skills are strategies for responding or coping, for striving. Skills are dispositional possibilities for response of a living entity engaged in the unfolding temporal drama of a particular context.

In sum, Polanyi thinks of living entities as possessing and refining a repertoire of tacit skills which are tacit powers that can be put into play when the proper occasion arises. Some skills are essentially inborn functional strategies but others are capacities clearly acquired in practice and revised in on-going practice in life. Skills can be acquired because of invariances in the broader living context. Not only does the development of one skill open the path for the acquisition of another skill but also the deployment of one skill can trigger the deployment of another skill. Skills are complementary as horizontal and vertical linkages in living beings.

To understand living beings in terms of a center, achievement and tacit powers, biology must, Polanyi argued, appreciate the "logic of achievement" (*PK*, 327-346). The opening chapter with this title in the final section of *PK* both links and distinguishes machines and comprehensive biotic entities which function with "interwoven principles, namely as machines and by 'regulation'" (*PK*, 342). Machine-like principles involve fixed structures and precise rules, "while the rules of rightness of a regulative achievement can be expressed only in gestalt-like terms" which means the appraisal

of regulation is "a connoisseurship" (*PK*, 342). The regulative achievements of biotic entities, Polanyi argues, involve "equipotential integration of all parts in a joint performance" (*PK*, 342). Such integrations are indeterminate (unlike machine-like principles) and sometimes serve as creative processes through which biotic systems under pressure achieve ends.

As I have noted above, Polanyi's most abstract descriptions of life and the transformation of life in evolutionary history focus on the dynamics of "dual control" (*KB*, 227) systems. Polanyi sets forth a hierarchical account of complexity and its emergence in history, but one that focuses attention on the interface of a higher and lower level of control in a comprehensive biotic entity. However, Polanyi argued the dynamics of dual control operate not only in living entities, but also in machines and in DNA, insofar as it functions as a code conveying information (Polanyi 1967a, 291-295). In dual control systems, higher principles operate in margins left open by the boundary conditions set by lower level principles. The higher level control established in the margins left open by the operation of lower level principles gives further shape to an entity, realizing possibilities that lower level principles operating alone do not realize but do not exclude. This Polanyi called the "logic of contriving" (*PK*, 328), and he contended that it must be recognized to understand machines themselves as well as comprehensive biotic entities. Biotic entities combine machine-like principles and regulative principles, and biotic entities (unlike machines created by human beings) change their contours or dynamics, once life emerges, as they evolve in evolutionary history. Living entities change in conjunction with possibilities released by mutation and selection, but Polanyi focuses attention on how new principles are emergent instantiations in margins left open by lower levels of control. Polanyi envisioned more complex biotic entities as a sequence of dual controlled levels; in such a hierarchy of levels, each level "relies for its workings on the principles of the levels below it even while it itself is irreducible to these lower principles" (*KB*, 233).[38] An emergent new principle "harnesses the principles of a lower level" in the service of the "new, higher level, establishing a semantic relation between the two levels," and the higher level "comprehends the workings of the lower and thus forms the meaning of the lower" (*KB*, 236).[39] In Polanyi's broad discussion of evolution, he posits "a progressive intensification of the higher principles of life" (*KB*, 234), and this is the ontological correlative of his epistemic emphasis upon the convivial nature of biological study.

Conclusion

These reflections have sketched important ideas developed by some contemporary figures in the emerging interdisciplinary "biosemiotics" area. I have attempted concisely to convey ways in which Fernandez and Hoffmeyer extend Peirce's triadic account of semiosis to try to address important questions about life in contemporary

philosophical biology. In particular, these figures develop a dispositional account of "semiotic causation" and "semiotic scaffolding," suggesting the fruitfulness of applying a triadic semiotic perspective for understanding life and evolutionary history. I find an affinity between the Peircean-shaped biosemiotic approach and some of the ideas about life that Polanyi tried to articulate almost fifty years ago. I have sketched both Polanyi's criticism of the mainstream theoretical biology of the mid-twentieth century (some criticisms shared with biosemiotics) and his constructive effort to discuss basic questions about the nature and evolution of life. My treatment of Polanyi's constructive account focused on Polanyi's view of embedded comprehensive biotic entities as centered entities deploying tacit powers to persist in the temporal flow. Living beings are "dual controlled" and hierarchical. In Polanyi's account then, evolutionary history is that of the emergence of a complex hierarchy as new "higher" principles become established in margins left open by lower level principles. I outlined Polanyi rich account of seamlessly related skills working as subsidiaries, noting that "achievement" reached through tacit integration is Polanyi's mark of the living. Finally, I have emphasized the reflexive character of Polanyi's discussion of life: understanding life is a calling of committed human persons, living beings with extraordinary tacit powers. The knower and the known are inextricably bound together, and this is a matter, according to Polanyi, about which human beings must always be mindful.

A promising future project might more integrally link ideas sketched here concerning what is central to biosemiotic discussions and ideas Polanyi emphasized about comprehensive biotic entities as centered subjects with tacit powers. Is it possible to illumine the growth of "semiotic freedom" and the increasing complexity of "semiotic scaffoldings" in terms of Polanyi's ideas about deepening centers in evolving living forms whose tacit integrations and achievements become more complex? Can the telic as formal causal elements in ongoing, interconnected semiotic processes in living forms also be understood in terms of skill deployment, which certainly seems to be connected with habit? Can Polanyi's emphasis upon hierarchy and "dual control" be unpacked within a more semiotized framework, a direction that Polanyi's late essay "Sense-Giving and Sense-Reading" already suggests? Can biosemiotics better address issues concerned with a relational ontology by adopting a more reflexive philosophical posture that examines ways in which biologists as living agents attend to life?

Treating questions in theoretical biology is an important domain of Polanyi's thought, first in the final chapters of *PK*, but also in his work in the 60s. Yet this seems a domain rarely touched by Polanyians and almost altogether overlooked by theoretical/philosophical biology. At least to this reader, this is rich territory worth close study since it is seems germane to discussions in more contemporary interdisciplinary approaches to questions about life such as that of biosemiotics.

Endnotes

[1]Polanyi to Grene, January 14, 1963, Box 16, Folder 1, Michael Polanyi Papers (MPP). The MPP are held by the Department of Special Collections in the Regenstein Library of the University of Chicago.

[2]Alicia Juarreo, a philosopher deeply influenced by dynamic systems theory, also interestingly analyzes the nature of causality and the telic in living beings; her discussions parallel some Polanyi discussions and also seem to share ground with biosemiotic discussions. See Juarrero (1999 and 2014), Takaki (2013 and 2014), and Agler (2014) for discussion of connections with Polanyi's ideas. The discussion below of the several aspects of "semiotic causation" and "semiotic scaffolding" (no doubt odd notions to those primarily familiar with Polanyi's terminology) unfolds in stages.

[3]In a later essay, Fernandez points out that "in ordinary physical causation we deal with transfers of energy in which the magnitude of the effect is quantitatively related to the energetic level of the operating causes. The results of an explosion, for instance, are so related to the quantity of the explosive; the loudness of a radio is similarly a function of the amount of electric energy delivered to the speaker" (2012, 10). In the case of semiotic causation, "energy transfers also mediate semiotic causation but, once a minimum energy threshold is reached, the magnitude and nature of the effect is quite independent of those of the cause. The nature of the effect will depend instead on the character of a relational pattern that the causing agent managed to embody into an energetic vehicle. Upon reaching a suitable constituted receptor, this vehicle triggers a specific type of behavior, which constitutes the effect" (2012, 10). This paper and much of Fernandez's writing is available at Linda Hall Library (http://www.lindahall.org/reflibpapers/) and at the Peirce Group's Arisbe (http://www.iupui.edu/~arisbe/menu/library/aboutcsp/fernandez/efpapers.htm).

[4]In an earlier essay, Hoffmeyer provocatively remarks that taking striving seriously "already implies a telos, something of the kind philosophers call 'aboutness' or intentionality, (although *intentionality* in this case does not imply thoughts or consciousness)" (2007, 155). He notes that actions involved in striving are not "explainable through schemes of simple efficient causation, for they all presupposes [sic] some kind of kind of 'orientation' from the system toward the environment and towards the *future*" (2007, 155-156).

[5]"Embracing" a process of interpretation for Hoffmeyer means a sign has an ongoing effect as signs do. This continuing set of effects, the process, is not captured by what Hoffmeyer above calls an account that focuses on a machine-like exchange of information. But biological processes that are interpretative do not necessarily involve a conscious interpreter. See the further discussion below.

[6]In a comment akin to Fernandez' account summarized above (see especially note 3), Hoffmeyer identifies "semiotic causation" as operating through the mechanisms of material efficient causation but as a particular kind of causation "bringing about effects through interpretation...as when, for example, bacterial movements are caused through a process of interpretation based on historically defined needs of a sensitive system" (2007, 152). Later in the same essay, he suggests that living systems maintain themselves by "a very intricate system of dynamic interactions;" living systems are "powered by metabolic energy" but are "controlled by semiotic means" (153).

[7]Not all biosemioticians make use of Peircean triadic semiotics; some who do find the broader cosmological scope of Peirce's semiosis perplexing. Some biosemioticians adapt the dyadic semiotics of Saussure or other approaches to semiotics and communication. Many biosemioticians make use of Jakob von Uexkull's *Umwelt* theory, and combine this approach to the study of living things with

elements of a Peircean account of semiosis. Von Uexkull's biological perspective focused attention on the phenomenal world as apprehended by a living creature in a particular niche. The events of the phenomenal world as apprehended in a particular niche by an inhabitant is an apprehension of engaged "aboutness" or "intentionality." Von Uexkull's approach apparently influenced philosophers like Heidegger and Merleau-Ponty in the phenomenological tradition who work out an account of Being-in-the-world. Von Uexkull's perspective also seems to converge with the "ecological" account of perception developed by James J. and Eleanor Gibson which focuses on "affordances" produced by "invariance." See Hoffmeyer 's discussion of von Uexkull (2008, 171-176) and Grene's summary of the work of the Gibsons, which she links to Merleau-Ponty's embodiment and Polanyi's tacit knowing (1995, 129-151).

[8]"Interpretant" is Peirce's term for the effect of a sign, a term that reflects Peirce's effort to generalize his account of the sign process (see the discussion in Colapietro 1989, 6-7). See De Waal (2001, 67-77) for a succinct, general discussion of Peirce's triadic account of semiosis.

[9]Fernandez ultimately argues that sign processes should not be thought of as something like Aristotelian final causes but as formal causes: "The origin of goal-directed behavior is to be found… in the telic nature of semiosis. The teleos of semiotic action is the generation of an interpretant, not the attainment of a final state. Semiotic causation is a type of formal causation, not a manifestation of physical final causation" (2015, 5).

[10]Hoffmeyer points out that many modern philosophers and natural scientists have trouble with Peircean semiosis in part because of Aristotelian overtones. Most modern philosophical and scientific accounts lack "a concept of purpose that can free itself from its uniquely human connotations" since the nominalistic Cartesian tradition in the background of modernity so steadfastly separates mind and body and nature and culture. But for Peirce there is not just a single concept of purpose delimited to consciously conceived end causes but two concepts, "one specifically human, and the other a general principle of emergent organization," which should not be confounded (2008, 40).

[11]Fernandez defines a "mechanism" as "an arrangement of parts connected as a chain of causes and effects that consistently brings about the production of the same phenomenon under repeated circumstances" (2015, 4).

[12]Hoffmeyer contends an aspect of the evolutionary process is "the building up of a pattern of *semiotic scaffoldings*, a tightly wound web of checks and balances gradually establishing itself through myriads of semiotic interactions…" (2015, 154).

[13]Hoffmeyer is the biosemiotician who early developed and popularized ideas about "semiotic scaffolding." But other biosemioticians have contributed to the effort to richly articulate how scaffolds work as an instantiation of concatenated sign processes. Fernandez (2015, 3) quotes recent efforts of Favareau and Kull to pull together a comprehensive but concise statement. Favareau says "Semiotic Scaffolding consists in biologically instantiated sign relations interlocking with and reinforcing one another, and by so doing, providing directionality towards and away from other sign relations in the network, through the dynamic emergence and canalization of semiotic pathway biases and constraints. Such ongoing semiodynamic re-adjustment enables new scaffolds and new pathways within and between scaffolds to arise, increasing semiosic capacity exponentially." Kull suggests that "Semiosis as an active meaning-seeking-making process results often with the building of some relatively static or even quite solid structures that somehow embed in themselves the findings of that active searching-event of semiosis. The resulting structure is scaffolding. It canalizes further behavior. It is the frame for habits."

[14]Hoffmeyer's discussion helpfully alludes also to the way in which the recent "extended mind" discussion in philosophy has emerged in robotics research, where ideas about a central planner/"brain" in robots is being rejected in favor of ideas about information that is available anywhere in the system. Autonomous activities interacting with each other and the environment produce emergent behavior of the system and thus there is no need for a centralized decision-making center in which goals are represented (2007, 154-155). Long before recent philosophical discussions of "extended mind," Polanyi insisted on focusing on "minding" (Grene's apt phrase, although she uses it a little differently than here—see 1966, 242) in terms of a living creature's indwelling, its efforts to extend its bodyliness.

[15]The growth of semiotic freedom in evolutionary history is a central idea in biosemiotics: "By semiotic freedom we mean the capacity of species organisms to derive useful information by help of semiosis or, in other words, by processes of interpretation in the widest (Peircean) sense of this term... The evolution of a richer semiotic capacity is of course only one among many strategies available in the evolutionary game. Yet this particular strategy potentially ignites a self-perpetuating evolutionary dynamics, since each step taken by a species along this route potentially opens new agendas for further change: the more capable some species are of anticipating and interpreting complex and fast-changing situations or events, the more will evolution favor the development in other species of a well-adjusted set of semiotic tools. Note that tools for anticipation, semiotic tool sets, are categorically different from tools for exerting a direct material interaction" (Hoffmeyer 2015, 153).

[16]Hoffmeyer notes "history thus not only matters to the cell, but literally operates inside the cell through the structural couplings—or semiotic scaffolds—that it has served to build into the system. And this is exactly what distinguishes living systems from non-living systems: the presence in the former of historically created semiotic interaction mechanisms which have no counterpart in the latter" (2007, 152).

[17]There are striking historical connections between Polanyi, Marjorie Grene and some early figures contemporary biosemioticians often reference. Helmut Plessner and Erwin W. Straus, both figures treated in Grene's *Approaches to a Philosophical Biology* (1965) gave papers at the Ford Foundation-funded 1965 Bowdoin College conference on reductionism organized by Polanyi, Grene and Edward Pols; these are included in Grene's monograph (1969) of selected conference materials. The follow-up 1966 Bowdoin College conference featured a paper by F.S. Rothschild, a neurophysiologist and phenomenologically-oriented philosopher of biology, often cited as one of the first figures to use the term "biosemiotics." Polanyi cites and praises Rothschild in "The Structure of Consciousness" (1965, also included in *KB*, 211-225 [see *KB*, note 13, 223-224]) and "Logic and Psychology" (Polanyi, 1968c). Hans Jonas, an important philosopher of biology, was also a participant in this 1966 Bowdoin conference. Francisco Ayala and Ilya Prigogine were involved in a 1968 follow-up conference on questions about reduction in biology. Polanyi corresponded with C. H. Waddington and seems to regard ideas about "epigenetic landscapes" as akin to his own views about the way a field can guide morphogenesis (*KB*, 232). Howard Pattee, a biophysicist and biosemiotician whose main work Umerez describes as "the elaboration of an *internal epistemic stance* to better understand life, evolution and complexity" (2001, 159), interacted with Marjorie Grene and Harry Prosch in the sixties and seventies (and may have had contact with Polanyi in the sixties). Umerez says the idea that best represents Pattee's approach is the "need to introduce a generalized epistemological stance to address the study of natural phenomena once life is originated" (2001, 160). This certainly sounds like Polanyi. Pattee publications very frequently cite an important late Polanyi article, "Life's Irreducible Structure" (1968b). What Pattee suggests about hierarchy and the operation of

codes seems in part to draw on Polanyi's arguments. Pattee does not seem, however, to have grasped the broader context in which Polanyi's arguments for hierarchy are embedded, i.e., Polanyi's broader philosophical discussion of knowing in science and life. But his reference to the 1968 Polanyi article apparently has led many later biosemioticians also to cite this Polanyi article. Nevertheless, Polanyi's thought has not been carefully studied as a resource for biosemiotics in the way that Peirce and some phenomenologists have.

[18]See *TD*, 29-52; Polanyi, 1967 [also in *SEP*, 283-297], Polanyi, 1968a [also in *KB*, 225-239]; Polanyi 1968b [also in *SEP*, 299-303], and Duke Lectures, 4 (available at www.polanyisociety.org). See also Harry Prosch's careful account of Polanyi's views in "Biology and Behaviorism in Polanyi" (Prosch 1977, 178-191).

[19]See Mullins (2004 and 2009) for earlier discussions of Polanyi's account of living agency. "Extended agency" is Kendig's term (Kendig, 2015), although she uses it a little differently than I do. She links discussions of "extended mind" with "extended agency," which I also wish to do, although I suggest using Polanyi's account of agency as constituted by indwelling and integration.

[20]Polanyi contended Neo-Darwinism had a "fundamental vagueness" that concealed its lack of "any acceptable conception of the way in which genic changes modify ontogenesis" and this is a deficiency "due in its turn to the fact that we can have no clear conception of living beings as long as we insist on defining life in terms of physics and chemistry." He counters Neo-Darwinism with "a different conception of life" which regards "living beings as instances of morphological types and of operational principles subordinated to a centre of individuality." He insists "no types, no operational principles and no individualities can ever be defined in terms of physics and chemistry" (*PK*, 383).

[21]Polanyi argues that in science and other human affairs, "explanation must be understood as a particular form of insight" (Polanyi, 1968c, 37).

[22]Much of Polanyi's alternative account focuses on how life emerged and developed in stages by the action of principles; the action of a first principle arises from inanimate matter but subsequent principles Polanyi seems to view as points in evolutionary history at which arise "novel modes of operation" (*PK,* 383). Polanyi is always careful to distinguish the conditions that give rise to and sustain a principle from the action of the principle: "…I shall acknowledge that the *ordering principle* which *originated* life is the potentiality of a stable open system; while the inanimate matter on which life feeds is merely a *condition* which sustains life, and the accidental configuration of matter from which life had started had merely *released* the operations of life. And evolution, like life itself, will then be said to have been *originated* by the *action* of an ordering principle, an action released by random fluctuations and *sustained* by fortunate *environmental conditions*" (*PK,* 383-384). See Haught and Yeager's summary (1997, 557-561) of Polanyi's major claims, including his five stages in evolutionary history in which novel modes of operation emerge. It is interesting to compare Polanyi's five stages and more recent theoretical accounts of stages or transitions in Hoffmeyer and Stjernfelt, in Smith and Szathmary, and in Mark Lane, succinctly summarized by Fernandez (2016 forthcoming, 3-9).

[23]Haught and Yeager (1997, 546-547) suggest Polanyi's "robust metaphysics" (547) centers on "the reality of living organisms" (546); this metaphysics focuses on two principles, participation and achievement which "can be gathered together as forms of action. Being is acting. Knowing (or at least knowing life) is acting-by-participating so as to understand acting-as-achievement" (546). My discussion emphasizes how Polanyi always intertwines his discussion of participation which is concerned with the active, skillful character of understanding and his discussion of achievement

which is concerned with the organization and skillful operation of a living system. The knower and the known are inextricably bound together in Polanyi's "ontology of commitment" (*PK*, 379). Polanyi argues that "calling; personal judgment involving responsibility; self-compulsion and independence of conscience; universal standards ...exist only in their relation to each other within a commitment." But he further contends "this ontology can be expanded by acknowledging the achievements of other living beings. This is biology. It is the participation of the biologist in various levels of commitment of other organisms…" (*PK*, 379).

[24]"Comprehensive biotic entity" is the careful terminology Polanyi sometimes uses in *PK* to clarify that he is discussing living forms. But "comprehensive entity" is also a term used occasionally in *PK* (e.g., 64); especially after *PK*, Polanyi uses "comprehensive entity" very broadly to refers not just to living entities but to specify any focal performance or distal awareness arrived at by an integration of particulars in which the subject dwells. See the discussion of the history of Polanyi's terminology in Mullins, 2007.

[25]"Grasping" or "understanding" is "sense-reading," in Polanyi's later terminology developed in his essay "Sense-Giving and Sense-Reading" (1967a, also *KB* 181-207) that interestingly opens in some but not all versions by comparing his triadic account of tacit knowing with Peirce's semiotic triad (see Mullins 2012 and *PK*, 181-210).

[26]Harney provides an illuminating recent discussion connecting the late views of Merleau-Ponty and the ethnologist Jacob von Uexkull (2015, 4). She also sets forth Merleau-Ponty's relational "ontology of nature" (2015, 5-7) and attempts to link this to Peirce's contention that life and the cosmos can best be understood in terms of semiosis (2015, 7-9). Some of what she says about Merleau-Ponty's account converges with what Polanyi suggests about living entities and knowing life. From about 1960, Marjorie Grene began to put together Polanyi's tacit knowing and Merleau-Ponty's philosophical approach: "Cartesian extended nature was suited to a geometrizing Cartesian mind. A new nature will become intelligible to us only when we have assimilated a new concept of our own activity in knowing. Such a concept we have found in Polanyi's theory of personal knowledge, with its unit of tacit knowing, and its distinction between focal and subsidiary awareness. Very close to the same theory is Merleau-Ponty's account of the phenomenology of perception with its distinction between 'positing' and 'non-positing' consciousness." (Grene, 1966, 224; cf. 14, 23-24, 90, 224, 244) Grene argues Merleau-Ponty shows perception is primordial and pervasive; however, "as there is no sharp cut between belief and knowledge [as Polanyi argues], so there is no sharp cut between perception and belief" (Grene 1995, 25).

[27]Grene argues for taking "one step more" (1966, 244) beyond the recognition of tacit knowing and the parallel structure of comprehensive entities, and that step involves recognition of the temporal nature of knowing as a "reaching out from past to future" (244). She notes the appropriateness of Husserl's term "protensions" as focusing attention on the tension-filled "ways in which the future pulls us toward it" (245). She succinctly summarizes the temporal nature of achievement: "achievement...is a pervasive character of life; and achievement, that is success or its contrary, are temporal categories, categories constituted by the *future*, by their eventual result. For living things, therefore, past and present depend on the future as primary...time itself, as lived time, is telic in structure (245).

[28]Polanyi noted that he does not "disregard the occurrence of accidental mutations which may prove adaptive." But he assumes "these can be distinguished from changes of the type achieving new levels of existence." He acknowledged this is a difficult distinction but if accepted it "allowed for the autonomous thrust of evolutionary ascent" (*TD*, 48).

[29]Evolutionary history, in its broadest dimensions, Polanyi tends to view cosmically in terms of the "awakening" of the cosmos. These broader implications are often sketchily discussed in the final sections of Polanyi books and lecture series (e.g., *PK*, *TD*, and the Duke Lectures). Such a cosmic turn makes many biologists uncomfortable in just the way in which cosmic dimensions of Peirce's semiosis does.

[30]Marjorie Grene succinctly notes what is philosophically at stake in acknowledging that the starting point for biological inquiry is the recognition of a living individual entity embedded in a niche and capable of achievements: "To know life is to comprehend comprehensive entities; to know knowing is to comprehend those particular achievements of living things which consist in their acts of comprehension. Mind is once more a natural reality, and nature once more both the medium and the object of mind's activity" (1966, 224). "Minding" (1966, 242) is Grene's provocative term for the active kinds of richly real achievements of living, thinking human beings, achievements which include generating the body of knowledge biologists have produced. Her 1966 discussion draws on the *PK* project and the 1964 Duke Lectures, and, perhaps most importantly, is written after Grene begins seriously to work on integrating of the ideas of Polanyi and those of existential phenomenology, especially Merleau-Ponty.

[31]Most biologists share the view that insofar "as life can be represented as a mechanism, it is explained by the laws of inanimate nature" (Polanyi 1967, 284) but this account, Polanyi argues, fundamentally misunderstands machines (Duke 4, 10; Polanyi 1967, 286-288, and also discussed briefly below). Further, as I discuss below, Polanyi holds that not only mechanism (properly understood) but also regulation must be used to represent life. As noted above, one stated aim of Polanyi's constructive philosophical account of life is to present "a truer image of life and man than the present basic conceptions of biology present" (*KB*, 238).

[32]Although he carefully qualifies this in his comments on tissue cultures, viruses, and fragments of plants and lower animals, Polanyi claims "the bulk of living matter is found embodied in a finite set of individuals, circumscribed in space and of limited duration in time. Each has come into existence at a definite moment, to remain alive for a certain period, after which it will die" (*PK*, 343). Recognition is a molar feature which is bound up with evaluation of a living comprehensive entity, an evaluation that attends to the operation of "rules of rightness" (i.e., principles that account for success—see *PK,* 328-332) and the causes of failure which are manifest in performance. Polanyi suggests there are hints of evaluation (i.e., critical aspects) in terms of success and failure in some inanimate studies (e.g., crystallography), but it is at the level of life where the knower's appreciation of function is imperative.

[33]There is, to be sure, continuity between Polanyi's discussion of simple biotic entities as centers making achievements and his discussion of persons (human beings) acquiring personal knowledge. Polanyi emphasized not only the "logical novelty" of a center in a living entity but, more generally, the logical levels involved in the study of living beings: "Biology…is three-storied in so far as the individual under observation is doing or knowing something, and two-storied when it observes an individual existing…without bearing on things outside it" (*PK,* 345). But "there is no discontinuity in the transition from the two-storied biology of plants and the lowest animals, to the three-storied biology of the more active and more knowledgeable animals" (*PK*, 345-346). If an observed living entity is centered and active, this means it has a peculiar systemic or organizational integrity, which implies temporal continuity as an embedded, interacting being. Polanyi's notion of a centered living entity in striking ways parallels descriptions found in the autopoiesis theory of cellular life, whose

contours Manturana and Varela began to work out in the seventies after *PK*'s publication and during the last years Polanyi was writing about life (Luisi, 2003).

[34]Haught and Yeager (1997, 546-547) suggest that Polanyi worked to reinstate notions about "active centres—as opposed to the receptive mirrors or isolated ghosts that critical thought" (546) gave us about living subjects: "correlative to the objectivist ideal of knowing, scientific thought, in its representation of living and thinking phenomena, has purged them of all personal or centered initiative"(546). Polanyi seeks to "reanimate nonhuman creation, rehabilitating our intuition that the living systems that chemistry and physics treat as inert extended stuff are, in fact, complex centered systems of initiative and striving, ontologically distinct from the inanimate processes upon which they rely" (547).

[35]Grene notes "this directedness, from proximal to the distal pole of tacit knowing, is a reaching out from ourselves to the world—and by the same token a reaching out from past to future, a reaching drawn by the focal point of attention, which is future" (1966, 244).

[36]In the case of the human animal, we are bio-cultural and our agency is a broadly extended or distributed kind agency since we are complex tool-using cultural animals. We can dwell in this vast array of tools (including language, which is perhaps our most powerful tool) as we more or less consciously direct our attention in order to make sense of what is of interest (see Gulick, 2012). In the popular idiom of contemporary philosophy, human minds seem to be extended and potentially very broadly extendable and human agency is a broadly extended species of agency. But even simple living forms have a center and tacit powers and this means their agency is somewhat distributed or extended. It is worth noting that Polanyi is very careful to emphasize that having an extendable human mind and the broadly extendable form of human agency means human beings can and should aspire to responsible action. In this respect, Polanyi's perspective is akin to Peirce's broader outlook on living agency in human beings: human agency, Peirce emphasizes, is a very complex and sophisticated dispositional matter (including our dispositions for thinking) but we humans ought to aspire to self-control.

[37]Polanyi focuses on skills in connection with living beings and, as I suggest below, skills within a Polanyian account of agency framed with the theory of tacit knowing may be regarded as tacit powers. Peirce focuses on habit-taking not only in living beings, but in the larger cosmos which living beings inhabit. Polanyi thinks of skills as both deeply instinctual and social but the development of skills reflects the larger emerging order that skill-taking living beings inhabit.

[38]In an interesting criticism of phenomenology connected with his claims for "dual control," Polanyi notes that phenomenology has taught us "how to save higher, less tangible levels of experience by not trying to interpret them in terms of more tangible things in which their existence is rooted." However, Polanyi contends "phenomenology left the ideal of exact science untouched and thus failed to secure the exclusion of its claims." Phenomenological studies of life thus "are suspended over an abyss of reductionism" and the "relation of the higher principles to the workings of the lower levels in which they are rooted was lost from sight altogether." Polanyi contends his "principle of stratified relations does offer at least a rational framework for an inquiry into living things and the products of human thought" (*KB*, 236-237).

[39]Polanyi suggests "the fact that the effect of a higher principle over a system under dual control can have any value down to zero may allow us to conceive of the continuous emergence of irreducible principles with the origin of life" (*KB*, 231). See also Roth's discussion (2014, 282-290) of Polanyi's

"dual control" as applied to the operation of DNA, and, more generally, the implications of "dual control" for molecular biology plus parallels between Polanyi and Kant on life.

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