Tradition & Discovery

The Polanyi Society Periodical

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ARTICLES

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JOURNAL AND SOCIETY INFORMATION

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PREFACE

We have a full issue this time, so I will largely let the table of contents speak for itself. I note that the first three articles are revisions of papers from last year's annnual meeting, which brought Alicia Juarrero's work into conversation with Polanyi. Her piece, drawing from her knowledge of dynamic systems theory, sets the stage for responses from David Agler amd Kyle Takaki that continue a most interesting and fruitful line of thought about how Polanyi's work fits with contemporary science. Andrew Grosso's article on interdisciplinarity began life as a presentation at an earlier annual meeting and should be of interest to many of us in light of the fact that interdisciplinarity is currently a "big thing" in higher education.

Still speaking of annual meetings, you will find below the preliminary schedule for this year's meeting in San Diego. The meeting will focus on the work of Charles Taylor. Do note that Taylor will be with us on Saturday; we are excited that he has agreed to join us, making this is one annual meeting you will not want to miss.

On a more somber note, News and Notes begins by recognizing the passing of two people associated with the Society: Ian Barbour, an early supporter, and Jim Tiles, member and mentor to our own Kyle Takaki. We celebrate their lives even as we mourn their passing.

Paul Lewis

2014 Polanyi Society Annual Meeting

This year's annual meeting, November 21 and 22 in San Diego, will feature a presentation by the eminent Canadian philosopher Charles Taylor and a variety of responses connecting the thought of Taylor and Polanyi. The following is a listing of papers to be presented at the three sessions we are requesting of the AAR. More specific details (including rooms plus full titles and respondents for Friday afternoon) will be provided in the next issue of *TAD*.

Friday, Nov. 21 (4:00 to 6:00 pm requested)

Richard Haney, paper on Taylor's social imaginary and Polanyian frameworks
Matthew Sandwisch, paper on moral practices in Polanyi, Taylor, and MacIntyre
Josée Boldoc, "Disclosing the Unspoken as a Locus of Meaning: Taylor and Polanyi on the Political Role of the Tacit"
David Stewart, "Elements of an Enchanted Naturalism: Towards a Postmetaphysical Christian Theology from Polanyi to Hegel"

Saturday, Nov. 22 (9:00 to 11:30 am requested)

Charles Taylor speaking on tacit knowing in its relation to social theory
David Rutledge, Andrew Grosso, Phil Mullins responding

Saturday, Nov. 22 (7:00 to 9:00 pm requested)

Charles Lowney, "The Emergence of Authenticity"
Jon Fennell, "Polanyi's 'Sense-Giving' and the Advent of the Secular Age"
Diane Yeager, "Taylor and Polanyi on Moral Sources and Social Systems"

NEWS AND NOTES

In Memorium

Ian Barbour, a pioneer in the science and religion discussion of recent decades, died on December 24, 2013 in Minneapolis. He was 90. Long a professor at Carleton College, his thought was influenced by a doctoral degree in physics and a degree from Yale Divinity School. Beginning with the publication of *Issues in Science and Religion* in 1966 through his two volume Gifford lectures, Barbour's books offer a vision of the relationship between science and religion that is largely harmonious with Polanyi's understanding of the personal participation of the knower in all knowledge. Indeed, Barbour often participated in the early meetings of the Polanyi Society during the 1970s and early 1980s.

Barbour was awarded the Templeton Prize in 1999 for his carefully worked out mediating approach to the relation between science and religion, which distinguished between the relations of conflict, independence, dialogue and integration. Personally, he adopted the position of critical realism. "On this view, models and theories are abstract symbol systems, which inadequately and selectively represent particular aspects of the world for specific purposes. This view preserves the scientist's realistic intent while recognizing that models and theories are imaginative human constructs" (*Religion and Science*, 117). In this work, Barbour offers on page 94 a fine one-paragraph overview of Polanyi's contribution to the science-religion discussion. He saw Polanyi's thought as contributing to his overall project, namely, "to articulate a theology of nature, for which we will have to draw from both religious and scientific sources" (105).

--*Walter Gulick*

James (Jim) E. Tiles, a leading pragmatist and Dewey scholar, died on January 13, 2014. He was the other half of Dr. Mary Tiles to whom he was married for almost 45 years and who will be incomplete without him. A US citizen, he first came to the UK in 1966 as a Marshall Scholar to study Mathematics and Philosophy at the University of Bristol. His doctorate was from the University of Oxford (Balliol). He taught Philosophy at the University of Reading until 1989, and then at the University of Hawai'i at Manoa until he retired in 2010. He was a dedicated, conscientious, and very patient teacher. His academic work ranged widely, and focused primarily on pragmatism and Dewey in particular—both of which are reflected in his articles in TAD.

On a personal note, Jim, under whom I apprenticed, was the finest of exemplars as a teacher, an academic, a tutor, and perhaps most importantly, a practitioner. He wrestled (in the noblest of senses) with his Kantian-Stoicism, a self-consistent mark, I think, of the genuine commitment of a philosopher: an enfleshed mensch in pursuit of wisdom and the significant burdens such a path involves. In essence, he was a pragmatist in the best of its senses (a theme that I think has a definitive Polanyian resonance). It has always been my tacit estimation that Jim represents struggle of the highest and best sort, and forms an image that informs and regulates my own practices (albeit poorly, by comparison). It is indeed a blessing and an honor to have known such a person.

--*Kyle Takaki*

Poteat Website Established

The Poteat Conference at Yale is concluding as this issue of *Tradition and Discovery* goes to press, but the website will stay up after the conference concludes and can be accessed from one of the following three urls: whpoteat.org, whpoteat.com, or http://rnithuama1.wix.com/william-poteat. There are plans to post 15 audio tapes of Poteat lectures. Look for more information in future issues and links on the Polanyi website (www.polanyisociety.org).

Poteat Archive at Yale Completed

Former Duke students, friends, and colleagues of William Poteat, during the past three years, have been generous in donating to the Yale Divinity School

Library their letters, audio recordings, lecture notes and other papers for the William H. Poteat Archive, the completion and digital indexing of which will be celebrated at the Poteat Conference at Yale University, June 6-8, 2014. It has been a work of deep affection and appreciation for the friendship and scholarship of the late William Poteat (BD, YDS 1944). The archive will serve as a valuable resource for present and future generations interested in pursuing the insights of arguably the most valuable single contributor to Polanyi-related thought in the twentieth century.

A special thanks go to Martha L. Smalley, Special Collections Librarian at YDS, and to the following individuals who have provided the materials in the archive: Gus Breytspraak, Dale Cannon, Ronald Hall, Murray Jardine, Ben Ladner, Walter Mead, Phil Mullins, Elizabeth Newman, David Rutledge, Milton Scarborough, Jim Stines, James van Pelt, and Sam Watson.

Anyone wishing to make further contributions to this archive should send their materials directly to: Ms. Martha L. Smalley, Yale Divinity School Library, 409 Prospect Street, New Haven, CT 06511. Any questions should be sent to either Ms. Smalley martha.smalley@yale.edu or Wally Mead wbmead@ilstu.edu.

New Polanyi Materials Now Avaiable on Web

Three new sets of materials have been posted on the Polanyi Society website (http://www.polanyisociety.org/). The first set consists of Michael Polanyi's Gifford Lectures (1951 and 1952), along with a short introduction and the Syllabus for Series I (summaries of the first set of lectures). Because the searchable pdf file for each lecture is rather large, files will likely not load quickly. The second is Richard Gelwick's 1963 microfilm collection of more than 100 Polanyi papers, the first collection of Polanyi's non-scientific writing. The third consists of a link \ to Polanyi's 1946 book *Science, Faith and Society*, which is hosted on another server.

John Polanyi, literary executor for Michael Polanyi, has approved the posting of the first two sets for non-commercial use. Thanks also go to the David M. Rubenstein Rare Book and Manuscript Library at Duke University for cooperating with the Polanyi Society to make Polanyi's Gifford Lectures more broadly available.

If you have difficulty accessing either Polanyi's Gifford Lectures or the Gelwick microfilm collection, (which is stored on a cloud) or write to Phil Mullins (mullins@missouriwestern.edu).

Canadian Researchers Awarded 2014 Polanyi Prize for Work on Antimatter

The Government of the Province of Ontario has established a fund to honor Michael Polanyi's son, John, who won the 1986 Nobel Prize in Chemistry. The fund provides up to five prizes each year to outstanding researchers in the early stages of their career who are continuing to post-doctoral studies or have recently started a faculty appointment at an Ontario university. John Polanyi wrote the following to the 2014 Winners:

> To Dr. Fujiwara and his team of seven; 2014 NSERC [National Science and Engineering Research Council of Canada] Polanyi Prizewinners:
>
> Throughout my career colleagues have assured me that the universe should not exist. Creation produced equal amounts of matter and anti-matter; they should have annihilated one another. Today's prizewinners give us hope that the universe may yet be saved. They have kept anti-matter away from matter for a full 15 minutes. The universe is older than that, so our prizewinners will be back on this stage. Meanwhile we congratulate NSERC for bravely recognizing the best and most basic research, and we applaud our prizewinners for adding an important milestone to the history of science.

For more on the winners and their work, see http://www.nserc-crsng.gc.ca/Prizes-Prix/Polanyi-Polanyi/Profiles-Profils/ALPHA-CanadaTeam-ALPHA-CanadaTeam_eng.asp,

Downward Causation: Polanyi and Prigogine

Alicia Juarrero

Key words: boundary conditions, emergence, self-organization, downward causality, hierarchical differentiation, mereology, Aristotelian causality, autocatalysis, evolution, preformationism, vitalism, context-sensitive constraints, complexity, far from equilibrium thermodynamics, Kant, Prigogine

ABSTRACT

Michael Polanyi argues that in the case of both organisms and machines the functionality of the higher level imposes boundary conditions that harness the operations of lower level components in the service of the higher level, systemic whole. Given the science of his day, however, Polanyi understands this shaping of boundary conditions in terms of the operation of an external agency. The essay argues that the science of nonlinear, far from equilibrium thermodynamics in general, and the phenomenon of autocatalysis in particular, explains how the endogenous closure of context-sensitive dynamic constraints shapes their boundary conditions such that self-organized, causally effective properties emerge.

It has been nearly forty-five years since Michael Polanyi's "Life Transcending Physics and Chemistry" and "Life's Irreducible Structure" appeared in *Science* and *Chemical & Engineering News* and are now available in *SEP* and *KB*, respectively. Over thirty-five years have also passed since Ilya Prigogine became a Nobel laureate in Chemistry for his discovery of dissipative structures. That same year, 1977, Prigogine coauthored (with Gregoire Nicolis) *Self-Organization in Non-Equilibrium Systems*, Prigogine's first book extending the concept of dissipative structures from physical thermodynamics into the biological realm. I would like to take the opportunity of these anniversaries to explore the role of boundary conditions in complex systems—in particular, how boundary conditions come into existence and are causally effective.

In "Life's Irreducible Structure," we find the following descriptions of the operation of boundary conditions on components: top-down (to use our terminology), each [level] "*reduces the scope* of the one immediately below by *imposing* on it a boundary that *harnesses* it to the service of the next higher level, and this *control is transmitted* stage by stage to the basic inanimate level" (*KB*, 234, emphasis mine). I cite this sentence in particular because the verbs *reduces*, *imposes*, *harnesses* (or their cognates) appear often in this piece—and elsewhere in Polanyi's writings—along with *integrates*, *comprehends*, and others. These terms refer to the *operation*s of downward causality. But the *operation* of boundary conditions is one thing; the *origin* of those boundary conditions is another. For that subject Polanyi uses the verbs and phrases such as *bring into existence, come into existence*, *emerge into existence*, or even *how it is that such structures can exist,* in contrast to the more commonly used verbs *control*, *shape*, and similar cognates which refer to the *operations* of those boundary constraints, not their *origin*.

How are boundary conditions established? Polanyi explicitly states that "*shaping* boundaries goes beyond a mere 'fixing of boundaries'"; [it] establishes a "controlling principle," a constraint that works in virtue of the boundary conditions' *pattern*. In Polanyi's words, this patterning establishes "a *significant distribution of matter* not determined by the laws of chemistry" (*SEP*, 294, emphasis mine),a distribution that embodies a particular pattern.[1] Once this structuring pattern is in place, it controls, harnesses, etc.—in other words, constrains—the constituents of the pattern such that they carry out a function in the service of the pattern, that is, to maintain the pattern. The pattern serves as a semantic interface between the two levels insofar as it warrants describing the parts as functional or otherwise. Boundary condition shaping therefore places "the system under the control of a non-physical-chemical principle by means of *a profoundly informative intervention*" (*SEP*, 295).

It is not difficult to describe how fixing boundaries comes about in artifacts and machines. When humans design and manufacture machines they arrange and organize raw materials such that the resulting pattern and shape subsequently constrains matter and energy flowing through those boundaries. Humans effect that shaping by culling and modifying materials—reducing their state space—according to the intended function of the to-be-built machine. The desired function in light of which humans carry out the shaping provides the informational interface for the process. Suitably channeled, flows of matter and energy within that system thus carry out the intended function for which the designer created and manufactured the machine in the first place. I want to highlight the *externality* of the designer/manufacturer agent responsible for the bringing into existence the patterning of matter that constitutes the machine. In the case of machine design, manufacture and functioning, that is, and operating from the outside and before anything else happens, an intelligent designer fixes certain boundary conditions by selecting from among the available materials and thereby channeling the energetic and material flow through the suitably arranged parts.

But what about living things? "When I say that life transcends physics and chemistry," Polanyi explains, "I mean that biology cannot explain life in our age by the current workings of physical and chemical laws" (*SEP*, 294-295). Why? Because according to the chemistry and physics of the day (what, following Michael Lissack,[2] I will call Science 1.0),

> *no level can gain control over its own boundary conditions* and hence cannot bring into existence a higher level, the operations of which would consist in controlling these boundary conditions. Thus the logical structure of the hierarchy implies that a higher level can come into existence only through a process not manifest at a lower level, a process which *thus* qualifies as an emergence (*TD*, 45, emphasis mine).

A few pages later, Polanyi adds, "The first emergence, by which life comes into existence, is the prototype of all subsequent stages of evolution, by which rising forms of life, with their higher principles, emerge into existence" (*TD*, 49). Elsewhere, Polanyi reiterates this point by stating that "any particular application of such a [general] principle requires that these circumstances be fixed by some agency not under the control of that principle" (Wesleyan V-4). Mullins interprets this phrasing to mean that the "the boundary conditions of the system to which the law of physics is applied" are the "conditions which have to be fixed by an *external* agency."[3]

So at least with respect to these comments concerning boundary conditions and their application, the general principle at work in the case of living things remains the same as in machines: an external agent is required to fix or shape the boundary conditions that enable life to appear. Aside from the fact that principles governing the isolated particulars of a lower level *leave indeterminate* conditions at the lower level—properties of lower level components allow for the possibility of hierarchization—it is nevertheless the case that a process *other than* operations at the lower level is what shapes the boundaries within which the higher level can emerge. Even when a whole and its components are acknowledged as constituting one hierarchically differentiated entity, *the agency that brings about* the conditions that enable hierarchy's emergence are held to be external.

As ahead of his time as Polanyi may have been, the Owl of Minerva of today's nonlinear complex dynamical systems theory had not yet spread its wings. So, in apparent contradistinction to other of his positions, at least for purposes of the topic of the origin and operation of boundary conditions, Polanyi presumes several ontological principles. These include:

- The claim that only efficient causes are real (a modernist principle);
- the two Aristotelian principles that:
    1. nothing can cause itself [4] and
    2. there must be as much reality in the cause[5] as in the effect;
- the two principles inherent in atomist metaphysics, particularly as interpreted by Newtonian mechanics, that
    1. only those essential properties that inhere in those individuals and that define universals are real, and
    2. relations and other so-called 'secondary qualities' are subjective and merely epiphenomenal.

In *Dynamics in Action*, I tried to highlight the impact that this set of assumptions had on philosophical action theory during its heyday from the 1960s through the 1980s. Among the most egregious consequences is that together they render mereological causality—the mutual interactivity between parts and wholes—paradoxical at best, incomprehensible at worst.[6] As a result wholes are either uncritically relegated to the status of mere epiphenomena, pragmatic, heuristic labels with no ontological purchase; or paradoxical in the mode of Plato's Cretan Liar or barber paradoxes attributed to Russell, the only way out of which is the path even Russell takes: to insist that in fact, one part of a whole acts on another part, which acts on another, etc.[7] But to retain the Aristotelian principle that no whole exists or acts as such because nothing can act on itself (the first disjunct again), in conjunction with the thesis that the only type of cause is efficient causality, renders all wholes mere epiphenomena. With respect to the specific topic of boundary conditions, it means that boundary conditions cannot be self-produced.

In other words, with the dismissal of formal and final causes and the reduction of all exercise of causal power to efficient causality in the form of forceful impact of atomic entities,the accepted metaphysical stance was that individual particles cannot create truly novel wholes themselves and wholes cannot modify the particles that make them up.[8] True emergence, any form of radical novelty and creativity such as we will see in autopoiesis, therefore, becomes a logically inconsistent notion—only development is possible (Depew & Weber, 1995). And allowing chance to play a role, as in Darwin's mutations, just complicates matters even further—and I am not even addressing problems with the standard deductive-nomological account of explanation advocated by mechanistic Science 1.0. Once Aristotle's notion of *phronesis* was discarded and only *episteme* and *theoria* are allowed as scientific, appeals to random mutations disqualified any such purported explanations from the realm of science.

Accordingly, the accepted meaning of the term *evolution* at the time of Polanyi's writing still generally adhered to a Spencerian understanding of that term, the unfolding of pre-established potentialities, not radical novelty. Top-down, the Darwinian understanding of the environment is that of a passive container—round pegs don't reproduce successfully in square niches, so over time that phenotype dies off, but niches aren't active in any real sense. Niches are, at best, epiphenomena. Polanyi follows this understanding of evolutionary change (at least in "Life's Irreducible Structure") when he allows that although the higher levels "may be present in traces" they must not be "altogether absent" before they become "prominent" (*KB*, 234). Polanyi's preformationist description of development in this passage, is therefore of a type of "intensification…which is what we witness in the development of the embryo" (*KB*, 232). But it is obvious that Polanyi is tentatively groping towards an expanded notion of development that would allow boundary conditions to be self-caused in some way. Intensification is not to be conceptualized along the lines of blueprint implementation; development is the *evocation* or *eliciting*. However, the actual evocation or eliciting of a higher level comes from the outside, from atomic or molecular accidents (presumably random mutations. See *KB*, 235).

I want to argue that nonlinear dynamical systems theory has given us a way of understanding how recursive dynamics can endogenously bring about boundary conditions without the intervention of an external agent.

It was that in late Fall 1984 that I found myself reading Kant's *Critique of Judgment* during the same week I purchased Prigogine and Stengers's recently published (in English) *Order out of Chaos.* Immanuel Kant, of course, had realized early on that the Newtonian understanding of cause could not render tractable the intrinsic teleology of living things. As an example, Kant cites a tree, which produces leaves at the same time as it is produced by those leaves. In living things, that is, Kant recognized a recursive type of causality wherein the effect is a necessary condition for bringing about the cause that in turn produces that very effect. But since this kind of causality is absent from both Newton's mechanics and Hume's analysis of causal relationships, it is, Kant regrets, "unknown to us." He could only relegate the appearance of such intrinsic teleology to the "regulative (subjective) judgment;" it can play no role in the constitutive judgment of synthetic *a priori* epistemology.

But the causal power of boundary conditions is precisely what Prigogine's work on dissipative structures highlights. In particular, Prigogine showed how boundary conditions play a role in creating order and structure out of disorder and chaos. Bénard cells are good examples of physical dissipative structures. Heating a pan of water uniformly from below creates a temperature gradient between the cooler water on the top and the warmer water at the bottom. This disequilibrium, if increased beyond a particular point, eventually results in a bifurcation or phase transition; a macroscopic structure of rolling hexagonal convection cells composed of billions of molecules of water suddenly emerges. *Structure*, Polanyi's "pattern," thus emerges where there was none before, and it comes into existence in open far from equilibrium thermodynamic processes as a result of the interaction between the bottom up energetic flows and the boundary conditions of the pan's edges and the external heat source. Order, an ontological emergent, appears out of chaos.

Once caught up in a rolling hexagonal Bénard cell, the behavior of individual water molecules is altered. Its degrees of freedom are now restricted so as to maintain the rolling hexagonal convection pattern.[9] The behavior of the individual water molecules is shaped, controlled, restricted by the "pattern" of the higher level organization—indeed, the boundary conditions—of the rolling water cell in which the individual molecule is captured. As noted earlier, Polanyi often employs the term "pattern" to describe the higher level of organization that controls the lower level operations. He states: "We can now see more clearly why such shaping of boundaries may be said to go beyond a mere 'fixing of boundaries' and establishes a 'controlling principle.'" Boundary fixing creates a controlling principle—a constraint, in my vocabulary—by "imprinting a significant pattern on the boundaries of the system" (*SEP*, 294).

In the case of Bénard cells, an external agency is responsible for that boundary fixing: one can point to either the shape of the pan or the scientists themselves who set up the experiment and select the shape and size of the pan in which the water is poured, and who supply the heat that results in an energy gradient, and continues to increase the temperature to the critical threshold. So the analogy between machine and physical dissipative structures suggested by Polanyi holds on both counts when it comes to characterizing their boundary conditions: a Bénard cell cannot be explained solely in terms of bottom-up energetic considerations; and boundary conditions set by an external agency play a critical role in bringing about higher level organization.[10] But this is true of all open, nonlinear, far from equilibrium physical processes. So Prigogine's discovery of dissipative structures, I would argue, takes Polanyi's revolutionary pairing of machines and living things one step further by carving up nature at an even more encompassing set of joints, defining an ontological classification that includes dust devils, tornadoes, and Bénard cells in the same category as machines. In each case the boundary conditions actively shape/control/regulate the component parts; and in both machines and ***physical*** dissipative structures in general the boundary conditions are "set from without."

But one finds another principle at work in open, nonlinear, thermodynamic processes far from equilibrium from the stage of ***chemistry*** onwards. The "go of things," as Peirce would say, changes qualitatively once we reach the level of chemistry, which I suspect is why so many articles about the topic of emergence (such as those by Peirce and Polanyi) were either first published in chemistry journals or otherwise refer to examples from chemistry. It might also be the reason why Prigogine follows up his discovery of dissipative structures with an exploration of nonequilibrium systems in general to include first ***autocatalysis*** and then living things, both of which are classified as dissipative structures as well. To be sure, far from equilibrium, complex dynamical systems, including living things, are always and necessarily open systems. In the end, the only closed system is the universe, and so the ultimate fixer of boundary conditions on earth is the sun's energy. Nevertheless, the manner in which boundaries are fixed in chemical autocatalysis and in the earlier physical dissipative structures such as Bénard cells or dust devils is qualitatively different.

Autocatalytic processes rely on the mutually reinforcing dynamics of several positive feedback steps. The Belousov-Zhabotinsky reaction is a dramatic example. Schematically,

$$A \rightarrow X$$
$$B+X \rightarrow Y+Q$$
$$X \rightarrow P$$
$$Y+2X \rightarrow 3X$$

What is unusual in this example is that the fourth step in the reaction is autocatalytic: one of its products is necessary for the activation of the product itself. As more and more X is produced by this recursively interactive set of reactions, the resulting nonequilibrium reinforces the runaway cycle unleashed by the endogenous dynamics themselves. At a critical threshold far from equilibrium, a small randomly occurring fluctuation can no longer be damped; instead those same dynamics amplify it, thereby driving the reaction across a bifurcation threshold—across a phase transition—to a new mode of organization. In the case of the B-Z reaction, a chemical wave that oscillates from blue to red suddenly appears, an emergent macroscopic pattern that embodies the coherent, synchronized behavior of millions of individual chemical components. Note what makes all of these examples of nonlinear, far from equilibrium thermodynamics: in each case, a thermodynamic gradient reaches a critical threshold where a random fluctuation is amplified, driving the system over the bifurcation into a new level of organization marked by the emergence of a new macroscopic structure—a metastable *pattern* of relationships—embodying the coherent, coordinated behavior of previously independent particles. This new macroscopic regime exhibits novel properties that cannot be reduced to the aggregation of the properties of the component parts. Polanyi's characterization of "chance fluctuations…releas[ing] the action of an emergent, 'self-sustaining' reality" is most apposite here. However, his evaluation of non-living emergents as "comparatively poor in new features" (*PK*, 394), is not. I would like to point out that one finds a crucial new feature even in these chemical processes: the emergence of a proto- top-down causality.

The qualitative difference between physical dissipative structures and autocatalytic chemical ones is dramatic: in the latter, it is the closure of an endogenous chain of positive feedback processes (A -> B

-> C -> D ->… back to A), not an external agent, that creates the boundary conditions within which the macro-systems level self-organizes. What is important is that these macroscopic emergent dynamics are not “other than” the operations of the lower level—they ***are*** the operations of the lower level, now newly or differently constrained. There is no external agency that shapes or patterns the boundary conditions as occurs in physical Bénard cells or machines. In chemical autocatalysis it is the constraint dynamics of the four steps in the B-Z reaction themselves, working in a mutually recursive loop, that create the boundary conditions within which the emergent chemical wave self-organizes. This is why autocatalysis is usually viewed as the locus of the emergence of *autonomy* or *autopoiesis.* as opposed to the mere self-maintenance of physical dissipative structures given the external setting of boundary conditions. So there is, I would submit, a significant qualitative difference between physical and chemical forms of self-organization, but insofar as understanding the mechanisms of the former enables us to naturalize the latter, an appreciation of nonlinear thermodynamics even at the physical level constitutes a significant advance from the time of Polanyi’s writings. Even physical dissipative structures allow us to appreciate how structure and pattern appear as a result of the interplay between the particulate level and the boundary conditions, a pattern that then loops back onto those constituents and affects their subsequent behavior. Autocatalysis in turn allows us to naturalize the notions of autonomy and self-cause. The thesis I defended in the 1985 *Review of Metaphysics* article on Kant and Prigogine is that the dynamics of context sensitive constraints exemplified by autocatalysis makes the concept of self-cause scientifically respectable and provides an account of mereological causality that allows a rethinking of both formal cause and intrinsic teleology.

Multiple realizability comes into its own at the level of chemistry.[11] Bénard cells, the example we used of physical dissipative structures, are composed of zillions of individual molecules of water, but each molecule of water is for all practical purposes identical to the next. As Moreno and Mossio (Springer, forthcoming) point out, there are only minimal constraints operating in physical dissipative structures. Not so in autocatalysis, which consists in various types of molecules and several constraints linked together in a concatenated set of reactions that closes back on itself. I would even go further. With autocatalysis we see the ontological emergence of a strong ***type-token distinction***. By definition each *type* can be embodied (enacted) in various different tokens. Moreno and Mossio (Springer, forthcoming) claim that truly *autonomous* self-organization takes place only in those cases where the closure of several recursively interacting constraints occurs. A catalytic function’s multiple realizability—any given functional type can be instantiated by any number of particular token arrays—the emergence of *degeneracy*, and the corresponding emergence of a proto-adaptability at the level of chemistry already loosens strict determinism as the higher level assumes control of the “go of things” and can alter its own structure by selecting a particular microarray that will embody the overall function in particular circumstances.

It goes as follows: an autocatalytic triad ABC embodying function ***f*** can prune or discard component C and replace it with component D (Ulanowicz, 1990, 1997). Over time a given autocatalytic structure ABC might therefore eventually evolve into DEF all the while carrying out the “same” autocatalytic function ***f***. In philosophical terms, the selection is performed, not in terms of energetic requirements; rather ***it is performed according to criteria established at the higher level (according to the degree of fitness or functionality)***—a paradigmatic example of strong or radical emergence’s characteristic feature: top-down causation (Fromm).[12] Since molecule D is selected in preference to C (which is discarded) because of the former’s improved functionality, a certain proto-normativity also emerges for the first time insofar as the global system selects D on the basis of its “better” functional fitness. Autocatalysis allows us to understand the emergence of whole-part causation as well as the origin of normativity.

So autocatalysis provides evidence of the emergence of a qualitatively different ***type*** of constraint, from whole to part, that is central to autonomy, and that appears as a result of the closure of context sensitive constraints. Autocatalysis, as an example of the closure of context-sensitive constraint, therefore marks the first appearance of the *normative* selection process that Polanyi claims does not appear until living things.

Since the selective process just described is clearly not an example of efficient causality, how would this kind of bottom up and top down causality work? What I attempted to do in *Dynamics in Action* (1999) was to cash out this kind of causality as the workings of *constraint*, a concept which physicists and mechanical engineers have long been accustomed to deploying. Constraints too, play a role in communications technology and information theory, and although I fully recognize that information transmission is understood in terms of quantity of bytes and not semantic *content*, following Lila Gatlin, I suggested that we can nevertheless understand the redundancy implied in information-theoretical constraints as comprising two sorts: ***context-free constraints***, which like the distribution of letters in an alphabet take the system far from equiprobability by altering their probability distribution;[13] and ***context-sensitive constraints***, which like syntactic rules take a system far from independence.[14] Context-sensitive constraints are the mechanism that establishes long-range correlations, which changes everything.

Because context-free constraints quickly reach a bottleneck, complexification requires context-sensitive constraints. Catalysts and feedback as well as syntactical rules are examples of *first order context-sensitive constraints*. The long-range correlations these interactions effect, particularly under conditions of closure, constitute radical ontological novelty possessed of causal power. They are not simply the rearrangements of the existing furniture of the world, or the eliciting or evoking of existing but unrealized features. What context-sensitive constraints do is alter probability distributions—a topological renewal. *Given* the presence of context-sensitive constraints, other events become more or less likely than under the earlier topological regime, both synchronously and diachronically. Because a higher level of organization emerges as a result of the long-range correlations established by the closure of context-sensitive constraints, these are indeed enabling, not restrictive, constraints; they expand a system's phase space. The *coherent integration* characteristic of organisms is thus due to the *closure of first order context-sensitive constraints* and the establishment of these long-range correlations. There is no need to imagine a different substance emerging; nor is there any need to postulate an external agency that shapes the boundary condition patterning that resculpts the state or phase space, the terrain. The emergent coherent organism, I claimed in *Dynamics in Action*, ***is*** the altered probability distribution, in an expanded phase space—the renewed dynamic potential—of the lower level component operations. The emergent patterns and shapings Polanyi insists upon *are* the causally effective, if not efficiently causal, renewed probability distribution of those components. A new probability distribution of a relational pattern is what defines or ***constitutes*** higher levels of organization, and it is the new probability distribution that is endogenously fixed or shaped by the dynamical closure of first order context sensitive constraints.

Viewing things from this perspective allows us to appreciate that boundary conditions (boundaries) function not as walls, but as "active sites," like *eardrums* or *membranes* (Cilliers, 2002). Boundary conditions are not walls that keep the outside world out and the inside in; by interacting with what might have formerly been "outside," dynamical systems produce novelty by creating long-term correlations so as to incorporate, or embody, that outside—which now becomes part of (inside) the macro-dynamical system. Dynamical boundaries or boundary conditions are thus *interfaces* whose ontology cannot be separated from their two aspects: an inside and an outside. The two aspects of boundaries, the inner and the outer, correspond to Polanyi's insight concerning *from/at* epistemological perspectives, but the point I'm trying to make here is an ontological one: that the symmetry break occurs thanks to closure of context-sensitive feedback and that the radical emergent is the newly formed relational, hierarchically differentiated whole, which, in turn, is not ***other than*** the lower level in any sense of substance or efficient causality. From the complex dynamical systems perspective, then, mind and body are not "two different things" as Polanyi claims (*KB*, 238), but decoupled levels in a hierarchically differentiated dynamics.[15] The question of whether whole-part causality violates the laws of conservation suddenly dissolves. What has changed is that mereological causality has been revitalized and higher levels of organization therefore given their ontological—and causal—due.

The concept of downward causality can therefore be reconceptualized as the operation of second-order top-down constraints. Once again, the operation of autocatalysis provides a respectable scientific example of the closure of first order context-sensitive constraints. Once closure of first order top-down constraints occurs, the dramatic phase change that creates the higher level of organization—the systemic meta-level—also produces properties and behaviors that are absent from the components individually; nor can these properties be deduced from the sum of the components. The emergent higher level's organization controls, constrains, and harnesses, i.e., regulates top down the operations of the lower level by restricting the previous phase space of the independent components so that the emergent higher level's integrity, qua higher level, is maintained and enhanced. Once entrained or synchronized (self-organized) into a system, the dynamics of the lower level are constrained so as *to enact* the higher-level properties. By evolving as described above, complex dynamical systems can evolve towards greater evolvability. Again, note the reappearance of teleological language. Not only can we now understand the workings of ***formal*** cause: decoupled from energetic considerations, formal causes are the operation of second order context-sensitive constraints acting as a process of selection (regulation, modulation).[16] Patterns, which are not other than relations, are far from epiphenomenal; they are indeed causally potent. So top-down causality understood in this manner, I believe, is all one needs to refute supervenience à la Kim. If causally effective, the higher level is real. And not only is it causally powerful; it exercises its top-down causality on *its* terms, that is, according to criteria determined at the higher level. ***Final*** causality is also thus compatible with real, ontological emergence: not only is the telos not pre-established or pre-determined; it is also self-organized and thus radically emergent. As mentioned earlier, formal cause (now reinterpreted as the operations of second-order top-down constraints) selects for inclusion in or deletion from an autocalytic cycle those molecules *that enhance and improve the integrity* or cohesion of the higher level. ***Final*** causes (now reinterpreted as the metastable coherence of the higher level organization) are the self-organized telos in evidence in autopoiesis and other autonomous processes. Spinoza's *conatus* identifies these dynamic vectors.

In summary, a rethinking of ***formal*** and ***final*** cause in accordance with science (Science 2.0, let's call it) becomes possible by rethinking the origin and role of boundary conditions in terms of the operation of second-order constraints. Polanyi describes the mind as dependent on the lower neurophysiological events, but, because it is able to harnesses them in such a way that it is undetermined by them, it is thus "free in its actions" (*KB*, 238). Complex dynamical systems theory is in agreement with this position. Beginning at the level of chemistry, each emergent level of dynamical organization is increasingly *autonomous* insofar as selection is carried out *according to criteria determined at the (next) higher level*. We noted earlier that in autocatalysis, molecule C can be replaced by molecule D in the B-Z reaction because of the latter's improved functionality. It is impossible to overemphasize the importance of this point: the top-down regulation or modulation is carried out according to whether the particular micro-array enhances or detracts from macro-level emergent property—its functionality, in this case. As emergent level is added on top of emergent level, cosmology and evolution show a progression towards increasing autonomy. Complex wholes are consequently able to adapt and evolve. In my language this is so because of the workings of top-down, second order constraints and their selection of particular lower level instantiations "according to criteria established at the higher level." This understanding of formal top-down cause as the operation of second-order context-sensitive constraints circumvents any possible charge of violating laws of conservation of matter and energy. On the other hand, the classical notion of substance, among whose essential traits was independence and self-sufficiency, and whose *internal* primary properties were definitive of their essence, must be discarded. Science 2.0 ontology is at once more complex and interesting once we understand the concept of coherence as the product of interrelationships, interdependence, and integration of constraints—in contrast to those features of independence and isolation so prized by Science 1.0.

The point I've been trying to make here is that the general metaphysical framework inherited from the scientific revolution of the seventeenth century and earlier took the following premises for granted: that there must be as much reality in the cause as in the effect and that nothing can cause itself, that nothing can come from nothing and at best emergence occurs through the interplay of two pre-existing somethings, one working bottom-up, the other—an external agent—working as an efficient cause from the outside in (and so emphatically not top-down from whole to part). Complex dynamical systems theory, in contrast, views the causal power of integral wholes and the environments in which they are embedded quite differently: far from being a passive container space that is shaped and thereby brought into existence thanks to the triggering action of an external efficient cause, the complex recursive dynamics of context-sensitive constraints both create and embed themselves in a strongly emergent phenomenon produced at the same time as ***it*** actively modifies the dynamics of its components. Boundary conditions are thus simultaneously cause and product. Such is the mechanism whereby radical novelty appears in nature.

This is not the end of scientific history, however: other philosophical puzzles concerning boundaries still continue to haunt us, foremost among which are issues pertaining to the identity and individuation of complex systems. But that is a story for another day.

ENDNOTES

[1]Pattern creation is information creation (Brillouin's structure creation as in-formation).

[2]Personal conversation.

[3]Mullins 2013, emphasis mine.

[4]"In so far as a thing is an organic unity, it cannot be acted on by itself; for it is one and not two different things" (*Meta.* IX.I, I O46a28- 30, emphasis mine). See also *Physics* VIII: "It does not move as a whole, and it is not moved as a whole; A moves and only B is moved" (258a22- 27, emphasis mine). The belief that nothing can cause itself can be traced to Aristotle. Despite his views concerning the need for an appeal to the four causes in every acceptable explanation, in *Physics* VIII Aristotle places unmeetable restrictions on any attempt to flesh out the meaning of formal cause because in his concern to establish that the universe does not bring itself into existence—and the way potentiality and actuality function in causality (causes, qua actual, transform the potential into the actual, so the potential, while not yet acted upon, has less actuality)—"nothing can cause itself." For an extensive discussion see Gill & Lennox, 1994.

[5]*Any* cause? Even Aristotle holds this view (see his proofs for a First Mover). The principle goes hand in hand with a metaphysics of substance such that substances are by definition capable of independent existence and are ontologically self-sufficient. Independence, stability, and equilibrium are the hallmarks of Science 1.0. In contrast, interdependence and resilience will become the hallmark of Science 2.0.

[6]How does one entity causally influence the other (without violating the laws of conservation of mass and energy)? Since the foundation of substance metaphysics was held to reside in the essential primary qualities (such as mass) of those atomic entities, relational properties such as temperature and color are held to be subjective and epiphenomenal, summarized in the dismissive term "secondary." Once relations are dismissed, the causal efficacy of interactions is rendered otiose–and there is no way to recover the integrity of organisms or explain how the whole affects the parts. "*Il faut tuer pour analyser*" (Montaigne).

[7]That is even Aristotle's way out. Despite his belief in the reality and efficacy of formal causes, his descriptions of intentional behavior are such that one part of the agent, qua active, causes or changes another part of the agent, qua passive. Because actuality has more reality than potency, this principle is

at work in cosmological proofs of the existence of God throughout history; pure potency on its own is causally impotent. So by claiming that one (qua actual) part of an agent causes another part (qua potential) to become actual, the principle that nothing causes itself is upheld. True emergence is absent in Aristotle; only development is ontologically possible. See note 3 above.

[8]Studying systems as if they were closed was a further assumption that compounded the problem (see Latour and Toulmin, for example).

[9]Note the reappearance of the language of finality.

[10]In the case of dust devils or tornadoes, for example, meteorological conditions establish the boundary conditions within which the dust devil or tornado organizes. The dust devil and tornado have no role in setting or maintaining those meteorological conditions.

[11]I am increasingly drawn to the thesis that although there must initially exist a minimal degree of openness at the lowest level for complexity to self-organize, quantum indeterminacy provides a foundation for this potential. Openness, therefore, doesn't just percolate upwards from quantum indeterminacy, but is expanded by the multiple realizability that hierarchization implies. Once context-sensitive feedback effects closure, the emergence of the type-token distinction and the relative indifference towards their particular instantiation is the hallmark of the evolution of evolvability. That is the progressive evolution of autonomy, so long as the "sloppier" (more abstract, more general) higher level criteria are satisfied.

[12]Clearly top-down causality does not violate energetic considerations.

[13]All languages have a characteristic distribution of letters: a smaller percentage of z's and q's in English, more in Czech.

[14]In English, given t-i-o, n is likely to follow. Context-sensitive constraints are measured by conditional probabilities.

[15]Note my reluctance to use the term "thing." The terms reflect the restructured dynamical relationships among the components of the lower level. See Moreno and Mossio for a thorough analysis of dynamic decoupling.

[16]Salthe and Hoffmeyer have analyzed the semiotic aspect of this selection process.

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Polanyi and Juarrero: From Tacit Knowing to Ontic Emergence

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Key words: boundaries, endogenous, importation, inextricably/irretrievably, inquiry, semiotics

ABSTRACT

There are potentialities to be harnessed in a fusion between elements of Alicia Juarrero's views and a Polanyian framework. In this brief response piece, I address the latent Polanyian dimensions of Juarrero's ontic approach to dynamical systems.

"If all men were exterminated, this would not affect the laws of inanimate nature." So begins Michael Polanyi's essay, "Life's Irreducible Structure" (LIS), appearing to convey a sort of common-sense realism. However Polanyi's realism is not flatly commonsensical, for all inquiry irretrievably bears the marks of the embodied sorts of creatures we are, where our personal commitments make contact with (or enact) reality via universal intent. It should be kept in mind that Polanyi is neither an idealist (Hegelian or otherwise), a mere empiricist, nor even a transcendental idealist. Polanyi's philosophy is post-Kantian (and more generally post-critical), where his pragmatic realism is both commonsensical in its recognition of orders of being "greater than ourselves," as it were, and radical in its manner of grounding ontologies in tacit knowing's epistemic workings. Furthermore, this is a realism not adequately characterized as "mutualistic" if such a conception implicitly divides knower from known, placing what is to be known in dialectical relation to knower (forming a reticulatory arc between the two). Such a divide is something Polanyi struggled with in attempting to form a philosophical framework where knower and known are inextricably bound up in a *field* of (semiotic) inquiry rather than related via poles of implicit division.

Exactly how is Polanyi post-Kantian (and post-critical more generally)? A simple answer lies in inquiry's consequential dimension: given the sorts of creatures we are, our inquiries are bounded by these constraints that are simultaneously enabling constraints allowing for exploration and discovery. So one initial sense in which Polanyi is post-Kantian has to do with the ways in which he examines the nature and contours of inquiry, in its indefinite manifestations. Kant delimits reason's capacities; Polanyi, as it were, starts there and then fleshes out the various creative capabilities of inquiry (which, as discussed below, is a broader notion than "reason"). But there is a deeper element to Polanyi's post-Kantian investigations that actually subtly undermines the Kantian framework itself. The open-ended nature of inquiry, in tandem with commitments, made with universal intent, actually reflect back upon the nature of cognition itself and its Kantian assumptions: the self-reflexive arc of inquiry also applies to the nature of inquiries made, and thereby changes just what "reason" and the like are. Thus a deeper sense in which Polanyi is post-Kantian has to do with this opening up of the very limits of the Kantian project: inquiry is affective, imaginative, fraught with risk that comes from commitments, bound up with communities of inquirers, and makes contact with realities. Knower and known are crisscrossed (and not merely dialectically related), as are the rather static Kantian notions like theoretical and practical reason, aesthetic and pragmatic judgment, and the like. Noumena, which are transcendental conditions of knowing for Kant, would be for Polanyi inextricably ensnared with the consequential fruits of indefinite inquiry—or in Peircean fashion, of indefinite semiosis.[1]

This general picture of Polanyi's philosophical orientation I think has crucial bearing on the important work that Alicia Juarrero is doing in relating dynamical systems and emergence to a new metaphysics.

There are potentialities to be harnessed in a fusion between elements of Juarrero's views and a Polanyian framework. In this brief response piece, I hope to convey some of the promise that this synthesis may hold.

Boundaries and Implicit Importations

Polanyi's ideas on types of boundary conditions and how they relate to dual control, emergence, and hierarchies have received discussion elsewhere (e.g., see *TAD* 39:2 and 40:1). The new issue that Juarrero raises concerns the status of boundaries as they relate to second-order constraints. Specifically, she discusses the notion of endogenously generated, emergent constraints, most especially exhibited in chemical processes like the Belousov-Zhabotinsky (BZ) reaction. As Juarrero insightfully observes, it is probably not coincidental that chemist-philosophers like Polanyi, Ilya Prigogine, and Charles Sanders Peirce took special interest in emergence. What Juarrero is arguing for—beyond mere resonance with Polanyi's active boundary conditions that exhibit controlling principles—is the endogenous, autonomous (in the sense of being self-generating and sustaining) character of second-order constraints, which she thinks can ultimately divorce itself from Polanyi's notion of active boundary conditions. In other words, *even if* a Polanyian account were to be given of the BZ reaction using the language of dual control, emergence, boundary conditions, tacit intimations of hidden realities made manifest via connoisseurship and universal intent, etc., such an account would miss the significant *ontic* dimension of what the BZ reaction and other similar phenomena reveal, namely, the endogenous generation of second-order constraints whose emergent and actual properties act on the world in novel ways. Given the emergence of such stable/resilient phenomena, which have claim to a significant degree of autonomy (even as they depend-on-and-enable their lower-level processes), such phenomena can, as it were, jettison the purportedly epistemic categories of dual control (active boundary conditions, etc.) by which we, in coarse-grained fashion, understand such phenomena. Ontics trump epistemics, in a nutshell.

How might a Polanyian respond? I think extended reflection on some of Polanyi's writings on physico-chemical laws and their intersections with biology can address Juarrero's concerns, as I hope to reveal. Let's first start with some insights on how biology differs from chemistry and physics. In LIS Polanyi writes:

> In the light of the current theory of evolution, the codelike structure of DNA must be assumed to have come about by a sequence of chance variations established by natural selection. But this evolutionary aspect is irrelevant here; whatever may be the origin of a DNA configuration, it can function as a code only if its order is not due to the forces of potential energy. It must be as physically indeterminate as the sequence of words is on a printed page (1308).

What Polanyi is drawing attention to here, I suggest, is that however order arose, resulting in fixed accidents like DNA (or any sort of adaptive complexity at any phenotypic level), the point is that the laws of chemistry and physics underdetermine the code aspect of DNA. For such a code is not merely an informational configuration; it also functions algorithmically, processing particular kinds of information in structured ways.[2] To borrow a distinction from the eminent biologist and philosopher of biology Ernst Mayr, Polanyi can be interpreted as distinguishing between "teleomatic" and "teleonomic" processes. Teleomatic processes (purposive, mechanical types of behavior) are studied throughout the sciences, most especially in physics where, say, inanimate objects are modeled when tracking projectile motion, whose end-state would be the projectile's predicted target. Teleonomic processes or behaviors, by contrast, owe their "*goal-directedness to the operation of a program*."[3] It is a mistake to conflate these two sorts of phenomena, for example by collapsing a physico-chemical description of DNA with the coding/programming functions it serves, which occur at a higher-level of understanding. On this very point Polanyi has been critiqued, in hindsight, as being wrong about life's irreducible structure on the grounds that the revolution in biochemistry (from roughly the 1960s on) actually bridged the gap between chemistry and biology, showing that life processes are essentially physico-chemical ones (e.g., *Chemical and Engineering News* 89:50, 3). Actually, a careful examination of this history by Horace Freeland Judson, in his classic work *The Eighth Day of Creation* (Touchstone 1980), reveals the importation of computational ideas into biochemical approaches to understanding life. Polanyi's prescient warning still holds generally: the importation of forms of dual control, determined by the connoisseurship of scientists, enabled a biochemical understanding of DNA and the like that expanded upon older conceptions of law-like behavior (mostly teleo*matic*) in chemistry and physics. In other words, teleo*nomic* resources were smuggled in, then thought to support a view of reducing biology (or more narrowly biochemistry) to physico-chemical processes, when in fact history supports quite a different view of biology's relation to physics and chemistry (a point that Mayr also hammers home in arguing how biology is an importantly different sort of science that cannot be reduced to physics or chemistry).[4]

In brief, this importation—smuggled in, ontically projected, and then ossified in certain (inaccurate) renditions of biochemical history—is the very sort of "non-personalistic" maneuver that Polanyi was pointing out in LIS (and his closely related "Life Transcending Physics and Chemistry" [LTPC]). Here's the point: might a similar importation occur in Juarrero's philosophical accounting of Prigogine's new and significant type of emergence? She calls Polanyi's science—still partially beholden, she thinks, to a positivist legacy—"science 1.0," which stands in contrast to "science 2.0" instigated by Prigogine and modern investigations into complexity and emergence. I suggest that Polanyi's science is more akin to science "1.5," as it were, and is actually closer to Prigogine than it may appear.[5] To draw out this claim, and how an implicit "importation" has occurred, let's continue with the quote from LIS above:

> As the arrangement of a printed page is extraneous to the chemistry of the printed page, so is the base sequence in a DNA molecule extraneous to the chemical forces at work in the DNA molecule. It is this physical indeterminacy of the sequence that produces the improbability of occurrence of any particular sequence and thereby enables it to have a meaning—a meaning that has a mathematically determinate information content equal to the numerical improbability of the arrangement (1308).

In alternate terminology, DNA's coding aspect exhibits higher-order properties, whose dual structure allows for it to act as a boundary condition, thereby granting meaning (the relevant enabled reduced space of informational configurations) made possible by these very constraints. Bound up with this novel ontic projection—DNA's coding aspect—are the epistemic ways by which scientists understand such phenomena. Before ontics can trump epistemics, the right sorts of epistemics need to be settled upon by a community of inquirers. And such ontics, if carefully reflected upon, still bear the marks of our epistemic projections. I suspect that a similar epistemic importation occurs in Juarrero's accounting of the emergence of second-order constraints, whose epistemic traces, I suggest, can never be wholly erased. If so, this suggests a bridge between Polanyi and Juarrero's new view of dynamical systems.

Boundaries: Tacitly Projected *and* Endogenously Generated

There is a parallel between endogenous emergence in the BZ reaction and the epistemic importations concerning the algorithmic aspect of DNA. The Polanyian point here is that what is endogenous is a latent function of what inquirers take interest in when making contact with reality. Even though in the BZ reaction there are no external boundary conditions (BCs)—either human-induced, or physically imposed like in Bénard convection—the identification of self-cause and the emergence of second-order constraints are still *phenomena of interest* whose ontic import is inextricably bound up with what we are trying to understand.[6] In this sense, such new forms of endogenous emergence remain with the (semiotic) field of inquiry, making it problematic to separate knower from known.

It might be objected that this doesn't really address the endogenous, self-generating aspect of the emergence of second-order constraints in the BZ reaction. For even acknowledging the above, we can, as it were, let go of our categories of understanding in coming to see what reality does of its own accord. Furthermore, ossifying to some extent our categories of understanding seems warranted in stable/resilient cases like this, so even if epistemics allow for grasping such phenomena, it is really the world we are after and not merely the ways in which we come to understand such matters. This good objection actually strengthens the Polanyian framework in my estimation, as when pushed further it reveals the inextricable ways in which tacit knowing is bound up with projected ontics. Before expanding on this point, a brief rhetorical detour is in order.

Are boundaries really real? It surely seems that way; think of lakes, mountain ranges, islands, planets, the "outer skins" of organisms, and so forth. But remove our categories of understanding. Now does nature really have these things? More generally, does it really have colors (secondary properties, perhaps); wavelengths (mathematical abstractions); initial conditions (tools of grasping, taming, and understanding phenomena—all embodied notions); top-down processes (which presuppose embodied orientation); boundaries (further reflection indicates how fuzzy these often are, making problematic just what they are and where they occur); and so on?[7] Metaphysically speaking, perhaps all we can say is that *natura naturans*, and the rest is the human story of striving to understand—in irretrievably embodied ways—our relations to nature (or more accurately, our semiotic "en-naturing").

In hitting upon stabilities/resiliencies like the BZ reaction, we often forget just how slathered such phenomena are with our projected embodiments. What emerges? *Colored*, *visual patterns* of *interest*. How do we *understand* such phenomena? By *symbolic* representations of the feedback cycle and how specific types of catalysts issue in a self-sustaining dynamics, through which endogeneous emergence (the *inner* process of coming into *view*) occurs. How does the entraining occur which issues in "phase-transition-like" emergence (note the latent element of *connoisseurship* required here)? Fractal accounts (another symbolic device) are sometimes deployed to *explain* the transition. From a broader perspective, inquires about what makes possible such emergence have been carried out using cellular automata *simulations*, which indicate that there is a range of enabling initial conditions and BCs by which the BZ reaction can take place (see note 6). Emergence occurs apparently at the edge of chaos and order (a *metaphoric* image). These notions tend to be so completely immersed in embodied projections and (accredited) judgments taken for granted that we can, perhaps fortunately, *focus* on what they project, and thereby discount the tacit elements making possible such wondrous understandings.

But alas, tacit knowing remains throughout. Even the all-too-human tendency to be "natural dualists" in separating off what is known from how it is known carries a hidden assumption: the already present, enabling powers of tacit connoisseurship committed to make contact with hidden realities. Polanyi not only recognized this and built a philosophical framework respecting such a fundamental insight, he also incorporated its dimensions into all aspects of inquiry.[8]

Semiotics, Science 1.5, and Beyond

Umberto Eco, in a piece on Charles Sanders Peirce and unlimited semiosis, writes that when "Peirce provides his famous definition of lithium as a packet of instructions aimed at permitting not only the identification but also the production of a specimen of lithium, he remarked: 'The peculiarity of this definition is that it tells you what the word *lithium* denotes by prescribing what you are to *do* in order to gain a perceptive acquaintance with the object of the word' (*CP* 2.330)."[9] From a Peircean (and Polanyian) point of view, there is really no hard divide between knower and known, as how we come to know what we know is irretrievably mediated by our semiotic activities: our use of symbols (e.g., schematic symbols representing the BZ reaction), reasoning (arguments for how to understand the chemical autocatalytic cycle), citing of evidence (employing tools that are probes of our extended embodied cognition), and so forth. It is a general Polanyian insight that our projected, focal preoccupations with ontic matters still remain subsidiarily ensnared in (and enabled by) semiotic "thickets."[10]

Such thickets ensnare as well the origins of emergent phenomena like in the BZ reaction. While it may appear that we can peel off Polanyi's account of boundary conditions[11] and inquire about the independent status of the origins of emergent phenomena—a latent Cartesian seduction—it still remains that such inquires are semiotically grounded, mediated, and projected, and are either instances of tacit knowing or rooted in it. For what we choose to focus on (e.g., emergent phenomena), what we choose to investigate (the origins of such phenomena), what accounting we give of such matters (symbolically rendered), and what we deem to be irrelevant or choose to selectively ignore, cannot remove this element of personal knowing.

As all this bears on Polanyi's science 1.5, Polanyi writes that the "laws of chemistry have similar limitations. …Generally, to have a definite chemical process, we must frame it by boundary conditions not fixed by the laws of chemistry" (LTPC, 61). But chemistry has progressed, and some of these very "definite chemical process[es]" have in turn evolved from "fixed conditions" to "control principles" (LTPC, 61) in the form of endogenous emergence—the origins of which Polanyi was not aware of, yet nevertheless his account of tacit knowing applies through and through. That is, understanding such endogenous emergence—even in this expanded "2.0" realm of chemical "laws"—is thoroughly ensconced in semiosis, where there is already present an implicit use of dual control in grasping such originative dynamics (see again note 6 below).

Polanyi's science (especially in LIS and LTPC) is not science 2.0, yet it is closer to science 2.0 than it is to science 1.0. Most importantly, his framework for personal knowing, coupled with indefinite semiotic inquiry, the ever-expanding continuum of tacit knowing, and his corresponding heterarchical hierarchy continue to engender and enact science 2.0 and beyond. This is perhaps the crucial upshot of taking Polanyi seriously regarding his bearing on complex-systems thinking and Juarrero's insights: ongoing inquiry—tacitly grounded, accredited, and projected—can not only be accommodated within Polanyi's general epistemic-metaphysical framework; even stronger, such semiotic inquiry and the framework itself, by their very open-ended nature seeking to make contact with reality, are "complex adapting systems" that accommodate Juarrero's insights as well as science 2.0 and future versions beyond.

ENDNOTES

[1]See also J.E. Tiles 1988, "Iconic Thought and the Scientific Imagination," *Transactions of the Charles S. Peirce Society* 24:2, pp. 175-177.

[2]Compare Robert Causey's 1969 article, "Polanyi on Structure and Reduction" (*Synthese* 20:2, 230-237), which I think misses the point of Polanyi's argument. Much of what I say in the essay indirectly addresses Causey's critiques of Polanyi.

[3]Ernst Mayr, *Towards a New Philosophy of Biology* (Cambridge: Harvard University Press, 1988), p. 45.

[4]It should be noted that we need not bring on board any "Spencerian baggage" in this modern (revisionist?) defense of Polanyi; for it is consistent with his project to emphasize the *consequential* aspects of inquiry and the *ever-expanding* continuum of tacit knowing's projected, heterarchical hierarchy—neither of which should be interpreted as instances of Hegelian "manifestation" or Spencerian "preformation-

ism." Indeed, in line with this modernized approach to Polanyi, see David Agler's sympathetic defense of a Polanyian view of development and emergence: "Emergence from Within and Without: Juarrero on Polanyi's Account of the External Origin of Emergence" [in this issue of *TAD*, ed.]. Note further that we need not read a Polanyian reconstruction of morphogenetic fields and the like in vitalistic fashion given recent advances in evolutionary developmental biology (see *PK* pp.357-9, 383 fn.2; and then compare Scott F. Gilbert *Developmental Biology, Eighth Edition* [Sunderland: Sinauer Associates, 2006], Sean B. Carroll *Endless Forms Most Beautiful: The New Science of Evo Devo* [New York: Norton, 2005], and Scott F. Gilbert et al. 1996, "Resynthesizing Evolutionary and Developmental Biology" in *Developmental Biology,* 173 and 357–372). Indeed, Polanyi's parallel between comprehensive entities and morphogenesis can be read as expressing the projected embodied tools by which we come to grasp ontics.

[5]The characteristics of science 1.0 are dubious as they relate to Polanyi. Concerning the first characteristic Juarrero lists, it isn't clear that Polanyi shows the symptoms of having a philosophical fixation on causality (especially mechanical); rather as a once practicing scientist, his writings seem if anything to indicate a concern with *patterns,* whether physical, chemical, mathematical, etc. Concerning the second characteristic, it isn't clear that Polanyi holds that there cannot be self-causation (given his background as a chemist, it seems he would be open to this idea); and the other feature—there must be as much reality in the cause as the effect—definitely does not apply to Polanyi, since cobblestones, for example, are less real (and their "effects" can be more real). Concerning the third, there doesn't seem to be a commitment to universals as such, but rather universal intent (metaphysics is grounded in epistemology for Polanyi); and secondary qualities wouldn't be merely epiphenomenal—the very opposite if anything, since personal knowing and its phenomenological dimensions ground the whole Polanyian project.

[6]Polanyi writes that certain mechanisms, "whether man-made or morphological, are boundary conditions harnessing the laws of inanimate nature, being themselves irreducible to those laws" (LIS, 1311). As I read this, insofar as those laws operate at one level of inquiry, they by themselves do not suffice to bring into view the phenomena of interest; it is the imposition of the relevant BCs that then enables and brings into view the objects of study. This is likewise true of simulations of the BZ reaction, suggesting that such reactions are only endogenous *once tacit connoisseurship is taken for granted* in parameterizing various BCs and initial conditions (see, for example, Alasdair Turner 2009, "A Simple Model of the Belousov-Zhabotinsky Reaction from First Principles," http://eprints.ucl.ac.uk/17241/1/17241.pdf; and Adamatzky et al. 2008, "Universal Computation with Limited Resources: Belousov-Zhabotinsky and Physarum Computers," *International Journal of Bifurcation and Chaos* 18:8, 2373-2389). The focal objects of emergent interest—in this case the endogenously generated, emergent phenomenological patterns witnessed in the BZ reaction—are still irretrievably framed by the subsidiary workings of tacit knowing.

[7]In a related vein, Matteo Mossio and Alvaro Moreno have written on "organizational closure" in biology, which is congruent to Juarrero's discussion of second-order constraints (e.g., "Organisational Closure in Biological Organisms," *History and Philosophy of the Life Sciences* 32 [2010], 269-288). Most interestingly, in their discussion on constraints and how self-maintenance relates to closure, they discuss Howard Pattee, whose core claim is that we make "epistemic cuts" in order to have any hope of grasping and projecting ontic claims (without epistemic impositions of BCs and initial conditions, scientists don't have systems, models, and so forth by which to study phenomena of interest). I suggest there is a definitive, yet submerged Polanyian element at work here that remains always-already present.

[8]One of the authors Juarrero cites is Paul Cilliers, whose work comes closest to Polanyi yet still falls short of how radical Polanyi's vision is. Cilliers' historical-contextual view of knowledge doesn't fully appreciate the crucial Polanyian dimension of inquiry as forward-looking.

[9]Umberto Eco, "Unlimited Semeiosis and Drift: Pragmaticism vs. 'Pragmatism'" in *Peirce and Contemporary Thought: Philosophical Inquiries,* edited by Kenneth Ketner (Fordham University Press, 1995), pp. 216-217. The referece to CP is to *The Collected Papers of C. S. Peirce*, vols 1-6, ed. Charles Hartshorne and Paul Weiss; vols. 7-8, ed. A. W. Burks (Cambridge: Harvard University Press), 1931-1958.

[10]This holds even for Stanley Salthe's semiotic explorations of development (e.g., *Development and Evolution: Complexity and Change in Biology* [Cambridge: MIT Press, 1993], p.15). Crucially, what Salthe seems to miss in his appropriation of Peircean semiotics is how for Peirce all inquiry is an exercise in semiotic activity, which is also a key link between Peirce and Polanyi (See *TAD* 38:3 for several articles that explore the connections between Peirce and Polanyi).

[11]For example, Juarrero's employment of information as it applies to boundaries invokes Leon Brillouin's discussion of information, which is based on the incompleteness of physical systems (*Science and Information Theory* [New York: Academic Press, 1962], p.xii) and correspondingly how systems are individuated or "chosen" so as to then impose statistical measures (Brillouin, pp. 8-10). The point is that while Brillouin (and Juarrero) distinguish "human" senses of information from measurable in-forming patterns, what remains in the background are epistemic cuts (see Pattee, *Laws, Language, and Life* [New York: Springer, 2012]) making possible the individuation of systems that *then* bring into focus talk of measurable information, "negentropy" and the like. In other words, such ontic projections are grounded and sustained by tacit knowing's explorations and operations. (Pattee, it should be noted, goes on to divide knower from known, and is guilty of some degree of Cartesianism; this same Cartesian "error" can similarly be found in Robert Ulanowicz's use of information, e.g., *Ecology, the Ascendent Perspective* [New York: Columbia University Press], p. 65).

Emergence from Within and Without: Juarrero on Polanyi's Account of the External Origin of Emergence

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Key words: emergence; Michael Polanyi; Alicia Juarrero; Complex Systems Theory; 19th Century Embryology; Vitalism

ABSTRACT

This paper assesses a recent criticism of Michael Polanyi's account of the origin of complex entities by Alicia Juarrero. According to Juarrero, Polanyi took higher-level complex entities like machines and organisms to come into existence through the imposition of external, top-down forces. This paper argues that while Polanyi took the emergence of machines to come about in such a way, Polanyi's reading of 19th and early 20th-Century experimental embryology indicates his position is more sophisticated. Polanyi appears to have thought a synthesis was possible between reductive-mechanical and holistic-vitalistic approaches in embryology and he appears to have relied on this synthesis in his account of the origin of complex organisms. While I argue that this synthesis is unclear, it suggests that Polanyi conceived of the emergence of organisms as the result of internal, complex, and non-deterministic processes.

Introduction

There is significant overlap between the work of Alicia Juarrero (1998, 2000, 2002, 2008) and Michael Polanyi.[1] Their hierarchal ontologies, hermeneutical models of explanation,[2] and certain accounts of tacit knowing (Polanyi) and explanation of vague or schematic intentions (Juarrero) overlap and interact in philosophically significant ways. In this paper, however, I focus on a way in which their ontological theories diverge. More specifically, I address a criticism by Juarrero of Polanyi's account of the *origin* of emergence. Juarrero contends that Polanyi's explanation of how complex entities emerge is *too narrow* as it explains the origins of emergence *only* by appealing to an *external force* that carries lower-level physical-chemical particulars to a higher-level of complexity. Juarrero's account in *Dynamics in Action* and elsewhere is that emergence *also* occurs as a result of complex networks of internal, autocatalytic reactions.[3] Such emergence is *internal* to a system. While Polanyi offers nothing near the nuanced account of emergence through complex systems theory that Juarrero provides, I argue that Polanyi's account is more sophisticated and scientifically sensitive than is typically realized. In drawing on work done in experimental embryology and morphology, Polanyi attempted to articulate an account of the maturation (embryological differentiation) of living beings and use this account to explain emergence of organisms. I will argue that Polanyi sought to synthesize *both* causal-mechanical and vitalistic accounts of maturation, and this synthesis, at least in outline, can avoid Juarrero's criticism. However, I will argue that Polanyi isn't always clear on his view and he often speaks in a vitalistic way, i.e., where external top-down forces play a role in maturation.

Emergence from Without

Polanyi rejects the view that all of the complexity of the universe can be derived from a complete description of physical-chemical particulars considered in isolation from each other. Complex entities are ontologically different than the aggregation of the lower-level parts that compose them and new laws or principles are required to explain the behavior of such higher-leveled entities. Polanyi offers a wide array of arguments for why the behavior of higher-ordered things like machines, organisms, and conscious human beings cannot be adequately explained, reduced, or even identified by the language and laws of physics and chemistry. These arguments have been the subject of intense scrutiny by Polanyi scholars, but my goal here is not to rehash them.[4] For the purpose of discussing Polanyi's account of emergence, however, it is necessary to give a very general idea of this hierarchal ontology.

Polanyi's Hierarchal Ontology

Bottom-Up Considerations

(O1) *Supervenience:* higher-level things and laws (e.g. organisms and machines) depend upon lower-leveled things and laws (e.g. physical and chemical entities). That is, higher-order objects are not free-floating entities, but, as Polanyi writes "each level…relies for its workings on the principles of the levels below it" (LIS 233; cf. *PK* 382; Wesleyan V:5).

(O2) *Underdetermination:* lower-leveled objects and laws do not fully *determine* higher-leveled objects and laws. Rather, a lower level "leaves open" different possibilities at a higher level. As Polanyi puts it, "the principles governing the isolated particulars of a lower level leave indeterminate conditions to be controlled" (LIS 233; cf. *PK* 382; *TD* 45; Wesleyan V:3-4).

(O3) *Restrictive Control:* Lower-level things and laws place restrictions (constraints) on higher-level things and operations. They limit what types of activity is possible at the higher level.

Top-Down Considerations

(O4) *Marginal Control:* Higher-level principles control the marginal conditions (the indeterminate space) left undetermined by the lower-level principles (*TD* 45; Duke IV:16, V:1; Wesleyan V:5)

(O5) *Entities of Various Complexity:* there are low-level entities composed of relatively isolated parts and there are high-level entities whose parts are functionally related (Wesleyan V:5).

(O1)-(O5) produces a *hierarchal ontology* that involves higher-order (emergent) objects like machines, organisms, and minds which are subject to *dual control*, i.e., they operate within the confines of physical-chemical laws (O3) yet nevertheless are controlled by their own set of rules (O4). No purely physical explanation can, according to Polanyi, tell us whether an object is a machine, how a machine works, or what purpose a machine is supposed to fulfill (see Agler 2013:24-5). Yet none of this is to say that any machine can break the laws of chemistry and physics.

In *Dynamics in Action* and her "Downward Causation: Polanyi and Prigogine," Juarrero holds that (O1)-(O5) is not a complete account of a hierarchal ontology. While (O1)-(O5) may be used to fend off reductionist foes, a *genetic* account of how higher-order entities and laws emerge is needed. As Juarrero notes, it is one thing to discuss the operations of boundary conditions, but it is another to give an account of the *origin* of these boundary conditions. This raises an important question. How, according to Polanyi, do the higher layers of reality emerge from physical-chemical parts and laws in the first place? If machines, organisms, and consciousness are real emergent entities (and not merely epiphenomenal) operating on a higher-level of reality, what is Polanyi's story for the origin of this emergence?

At first glance, Polanyi's answer appears to be that the organizing/operational principle dictating marginal control is always *external* to the lower-levels. Polanyi seems to say as much when he writes that "boundary conditions expressly left open by physics and chemistry are controlled by principles *foreign* to physics and chemistry" (*TD* 42, my emphasis). And, when speaking about living things, he writes that "a principle not present in the inanimate must come into operation when it gives birth to living things" for a "higher level can come into existence only through a process not manifest in the lower level, a process which qualifies as an emergence."[5] In other words, bottom layers "leave open" room for novel activities; i.e., space for some *external* force to establish marginal control and cause new, ontologically higher-beings to emerge. So, to (O1)-(O5) above, (O6) can be added:

> (O6) *External Origin Thesis:* Higher-order entities and their operations are established by something that is *external* to what is found in the lower-order parts and their laws.

What Polanyi means by a principle being "external" can be partially clarified by his account of the emergence of machines. Polanyi indicates that the organization of machines (i.e., how the boundary conditions of machines are set) is imposed upon it by a designer. Polanyi writes "[t]he machine as a whole works under the control of two distinct principles. The higher one is the principle of the machine's design, and this harnesses the lower one, which consists in the physical chemical processes on which the machine relies" (LIS 225). He writes that "no part of a watch is formed by the natural equilibration of matter. Each is artificially shaped and connected to perform its function" (Wesleyan V:4). In other words, complex entities (machines) emerge as a result of an intelligent external force imposing a design on chemical-physical particulars in a way that gives them purpose, organization, and greater complexity. This new being is fundamentally different in kind as its behavior can only be explained by relying upon a new set of operative (in this case engineering) principles.

When considering *living things*, it may be tempting to say that Polanyi also holds (O6), especially given the fact that he repeatedly stressed that living things are equipped with a number of "living mechanisms" that make organisms very similar to machines. He says that animals have organs that perform functions as parts of a machine do, that morphogenesis—or the process by which the structure of living being develops—is similar to that of the shaping of a machine, and that machines (like organisms) have purposes (LIS 227; Wesleyan V: 15-16). In addition, while he notes that the analogy between machines and living beings is weakened by the fact that origin of the *parts* of a machine are *artificially shaped* while the origin of the *organs* of a living being are the result of a *natural transmission* of information in DNA, Polanyi concludes that in the case of machines and living things, their boundary conditions are "always extraneous to the process which it delimits" and the DNA molecule, much like the design for a particular machine, "is a blueprint of the growing organism" (LIS 227-228, 230). Polanyi thus appears to equate living things with machines and thereby accept (O6) for both, with the caveat that the type of external origin of machines is *artificial* but *natural* for organisms.

But, Polanyi's repeated emphasis on the similarities between living beings and machines must be understood in context. Namely, he equated the two in order to criticize the claim that organisms can be reduced to physical-chemical particulars and their laws. According to Polanyi, the debate between organicists and reductionists revolved around the issue of whether living beings are fully explicable in terms of physics and chemistry. He notes that the aim of writers like 17th century naturalists like Cudworth and John Ray and late 19th/early 20th century biologists like Hans Driesch, Paul Weiss, and Hans Spemann was to undermine the possibility of "explaining life in terms of mere inanimate matter in motion" (Wesleyan V:12; cf. LIS 232). That is, non-reductionists aimed to substantiate the existence of non-machine-like or "organismic" processes. However, Polanyi argues that this concedes too much for it falsely assumes that *machines can be reduced to physics and chemistry*. Polanyi writes that

> [t]hroughout the subsequent controversy between the scientists who supported the organismic view and the predominant school who defended a mechanistic explanation of life, it was taken for granted that the issue between the two camps was whether living

> beings could be represented or not by the laws of inanimate nature—whereas in my opinion both sides equally excluded the representation of life in terms of these laws, whether the process was mechanical or organismic (Wesleyan V: 13).

Thus, by stressing the similarities between *living things* and *machines*, and then arguing that *machines* don't reduce to physical-chemical particulars and their laws, Polanyi aims to undermine arguments that reduce *living things* to the *physical-chemical particulars* because they are machine-like. "Living beings operating as machines," Polanyi writes, "can not be described in terms of physics and chemistry" (Wesleyan V: 5).

However, the argumentative tactic of equating living things to machines should not imply that Polanyi thought organisms could be reduced to machines. Instead, Polanyi rejects the ontological equation of machines and living things (especially human beings). He claims that despite the fact that organisms have a number of mechanical functions, complex living beings operate on a higher level of reality than machines. For instance, he characterizes the mind's relation to the body as a hierarchy where an individual integrates information from the sensory organs to form the sight of some object, writing that the "mind harnesses neurophysiological mechanisms; though it depends on them, it is not determined by them" (LIS 238).[6]

Emergence from Within

Thus far, my account of Polanyi's hierarchal ontology has taken Polanyi to hold six claims (O1-O6) and Polanyi to specify at least three different kinds of entities: (i) *chemical-physical particulars* and their laws, (ii) *machines* and their laws, and (iii) *organisms* and their laws. In accordance with (O1)-(O3), the latter entities are said to depend upon, not be determined by, yet be constrained by the former. In accordance with (O4)-(O6), the latter items are thought to exist and manifest certain behaviors neither explicable by nor emerging out of the former.

Juarrero seems to agree with much of what Polanyi says here. She claims that certain phenomena (e.g. Bénard cells) "cannot be explained solely in terms of bottom-up energetic conditions" and the "boundary conditions set by an external agent play a critical role in bringing about higher level organization" (Juarrero 2013:5). In the case of machines, Juarrero (2013:2) claims that "an external agent is required to fix or shape the boundary conditions that enable life to appear…It is nevertheless the case that a process *other than* the operations at the lower level is what shapes the boundaries within which the higher level can emerge." In other words, the emergence of *some* complex entities is a result of externally setting certain boundary conditions. In doing this, new properties emerge that cannot be predicated of the constituent parts in isolation.

One example where Juarrero and Polanyi would agree that the emergence of a complex entity occurs through the imposition of external (environmental) constraints on lower-level interactions is the production of laser light (light amplification by stimulated emission of radiation). Consider that when we apply energy to a collection of atoms, atoms absorb this energy insofar as electrons move to higher energy orbits. As the electrons are unstable at these higher energy orbits, they will return to lower energy orbits. In so doing, they release a photon (or particle of light) that has a particular wavelength. The particular wavelength of a photon emitted by an atom depends upon the energy difference between an electron in excited state (high energy) and relaxed state (low energy). The emission of a photon along a particular wavelength increases the likelihood that other atoms will also emit photons and so the initial release of a photon operates as a catalyst for the release of other photons. Without specific environmental controls, what we get is a cascade of disorganized light like in a flashlight. However, by setting environmental controls (e.g., mirrors) and supplying the atoms with an external source of energy (e.g., by using an energy pump), more and more atoms become excited and laser light begins to form because a dominant wave track forces (or "slaves") atoms to release energy along its wavelength rather than along some other wavelength (cf. Haken 1988). This positive feedback process ultimately leads to the generation of a dominant wave track of laser light. In becoming laser light, the organized wavelength of photons take on properties that are not found in the individual atoms, i.e., it is monochromatic, coherent or organized, and directional (rather than the weak, scattered light of a flashlight). Such light can be used, as Juarrero notes, in ways that individual photons cannot, e.g., to cauterize flesh (*DiA*, 143). In short, a set of bottom-up constraints along with external boundary conditions (mirrors, energy pump) make new qualities and behaviors possible by harnessing the physical particulars in a way so that their behaviors can only be ascribed to the system as a whole and not to any of the isolated parts.

While some forms of emergence occur through external controls, Juarrero rejects (O6) as exhaustive of emergence. That is, Juarrero says that Polanyi's emphasis on boundary conditions being set *externally* is not the full story. On her more complex account, the dynamics of organisms and certain chemical reactions can be *endogenous* (the result of complex internal interactions) rather than simply *exogenous* (fixed by some external force or environmental boundary). Juarrero (2013, 5) notes that there is "a qualitative difference between the way boundaries are fixed in chemical autocatalysis" and the way that the boundaries of "physical dissipative structures such as Bénard cells or dust devils [or lasers]" are fixed. The difference can be accounted for through complex dynamical systems that involve "[a]utocatalytic processes [which] rely on the mutually reinforcing dynamics of several positive feedback steps" (2013, 5). In short, the emergence of complex entities can also occur through certain internal, complex, and reinforcing interactions between lower-level parts.

One of Juarrero's many examples of an autocatalytic reaction is the Belousov-Zhabotinsky (BZ) reaction, but some related chemical-clock reactions—the Briggs-Rauscher (BR) reaction, the Bray-Liebhafsky reaction, the iodine clock reaction—equally fit the bill. These reactions are distinctive in that they are *autocatalytic* and involve *feedback loops*. For example, the BR reaction is characterized by two processes: (i) a slow expenditure of iodine by malonic acid at a rate proportional to the concentration of iodine and (ii) a fast autocatalytic process that converts hydrogen peroxide and iodate to iodine and oxygen. The two processes are interrelated. When the BR reaction begins, the fast autocatalytic process—which only occurs when iodide levels are low—begins to produce more and more iodine until this process ceases. The slow process, however, consumes this excess iodine until iodine concentrations return to levels low enough for the fast autocatalytic process to start up again. What is noteworthy concerning this reaction is that it is *mutualistic*: on its own, the slow process only works when iodine is present, the fast autocatalytic process only operates when iodine levels are low.[7]

Reactions of this kind lead Juarrero to conclude the following:

> *The difference between physical dissipative structures and autocatalytic chemical ones is significant enough: in the latter, the closure of a chain of positive feedback processes (A -> B -> C -> D ->… back to A) creates the boundary conditions within which the macro systems level self-organizes*. And what's important is that these processes, these dynamics, are not "other than" the operations of the lower level—they *are* the operations of the lower level, now newly or differently constrained. So there is no external agency that shapes or patterns the boundary conditions as occurs in physical Bénard cells or machines (2013, 6).

And, in *Dynamics in Action*, Juarrero uses these kinds of internal dynamic interactions to develop a hierarchal ontology. When networks of autocatalyic processes or mutually reinforcing dynamics (positive feedback processes) get linked together in a dynamic system, this has the effect of driving "the system far from equilibrium" (*DiA*, 121), and driving "the reaction to a new mode of organization" (*DiA*, 121), driving "the initial regime into a new dynamical organization" (*DiA*, 122) and thereby taking a low-level aggregate of disorganized, uncomplex, and relatively meaningless parts to a higher level of complex and meaningful organization. For Juarrero (1998, 238), the physical make-up of the world, when put into context-sensitive relations generates a hierarchy of complexity where "[c]hemical phenomena can access states that physical phenomena cannot; biological phenomena can access states that chemical phenomena cannot."

In short, Juarrero's criticism of (O6) then is that the origin of complex, higher-order systems is not only through the *external shaping* of the particulars in this way or that way (as we do with machines). And, it is not simply by *externally setting* environmental controls and constraints (as we do with the production of laser light). The origin of certain complex entities can also be explained through the complex, internal dynamics of the lower-level particulars. And, this account of the origin of emergence is a difference in kind.

Polanyi on Field Theory and Regulative Processes

At this point, it is tempting to conclude that Polanyi's account of the origin of emergence was incomplete. He *wrongly* took higher levels to emerge wholly as the result of *externally* imposed operative forces whose presence cannot be found in the particulars that compose those higher levels. We might excuse Polanyi as he was working before complex systems theory, or try to position him as a proto-complexity figure (see Takaki 2013a, 8). However, in this final section, I argue that there are certain aspects of late 19th century/early 20th century developmental embryology that suggest that Polanyi did not fully accept (O6). Polanyi's use of embryological research that aimed to synthesize both bottom-up mechanistic and top-down vitalistic causal forces in embryological development (e.g., Hans Spemann's use of the organizer) suggest that Polanyi held a view similar to Juarrero (although for different reasons). That is, I will suggest a way of reading Polanyi's use of embryological work that has him say that the origin of complex living things is *not the result of external forces* but is rather the result of *complex, non-deterministic internal interactions*.

Despite his general claim that the origin of emergence is external to the lower-level parts, Polanyi says—with respect to living things—that the origin of higher-level entities is through a process of *maturation* and maturation is driven by factors internal to the system. Polanyi writes that "[n]o new creative agent, therefore, need be said to enter an emergent system at consecutive new stages of being. Novel forms of existence take control of the system by a process of *maturation*" (*PK* 395). If living beings are driven to emergence through a process of maturation, Polanyi points out that it is necessary then to explain whether the process of maturation (or the increasing development of higher-order levels) is "predetermined from the start," the result of an "external creative agency," or driven by some third way (*PK* 395).

In discussing DNA, Polanyi writes that the "[g]rowth of a blueprint into the complex machinery that it describes seems to require a system of causes not specifiable in terms of physics and chemistry, such causes being additional *both to the boundary conditions of DNA and to the morphological structure brought about by DNA*" (LIS 231-232, my emphasis). Polanyi pulls from the neo-vitalistic work of Driesch, as well as field theorists like Paul Weiss, Hans Spemann, and Waddington to explain the missing "system of causes" that direct the growth of morphological features (*PK* 354-359; *TD* 42-3, 46; SC 219). Given (O6), we would expect to find that this missing system of causes, one that would account for the maturation of things to the point of emergence, is *external* to the structures that are the result of DNA. But, drawing from figures like Driesch, Polanyi claims that the tradition of developmental mechanics in embryology (e.g., Wilhelm Preyer, Wilhelm His, Wilhelm Roux, Jacques Loeb, T. H. Morgan, et al.) need not be abandoned but rather supplemented with organismic principles and a more holistic outlook.

To see this more clearly, it is worthwhile to point out that Polanyi was impressed by a series of experiments that Driesch performed to undermine Roux's version of the *mosaic theory of development* (cf. *TD* 42-43, 46). According to Roux, hereditary particles in cells are distributed in a qualitatively imbalanced way when the cell undergoes division.[8] This uneven distribution of hereditary particles meant that the potentialities of individual cells became increasingly restricted and associated with the development of one tissue type or another. By the time the organism had fully developed, each cell type contained only the hereditary particles that determined that cell type. That is, skin cells had the "hereditary particles" that determined skin cells. Roux's mosaic theory was testable: if hereditary information is equally distributed throughout the blastomeres, then destroying the blastomeres or cells that contained hereditary particles that specified the development of a particular cell type should lead to abnormal development. In that case, that organism should fail to have the corresponding cell type that it determines. In 1883, Roux tested this theory by destroying (but not removing) one blastomere in a two-cell frog embryo with a hot needle. The results were a collection of half-embryos, leading Roux to conclude that an embryo's differentiation proceeded according to a bottom-up, mechanical process where the different cell types were entirely determined by hereditary particles.

In 1891, Hans Driesch tested Roux's mosaic theory of development by using the eggs of a sea urchin. Once the single-celled zygote became a two-celled embryo, Driesch separated the blastomeres of the sea urchin embryo using seawater and found that when the blastomeres were allowed to develop in isolation, each formed a normal albeit slightly smaller sea urchin larva. Thus, in contrast to Roux's mechanical mosaic view of differentiation where embryological development was a result of the uneven distribution of hereditary material, Driesch took the embryo to be a "harmonious equipotential system," one where the parts of the system were equally able to produce a whole organism. That is, the system as a whole was capable of reacting to imbalances between its parts through a process of *self-regulation*. Such self-regulation was certainly recognized in the capacity of lower-level species like hydra, which have the capacity to *regenerate* damaged parts, but Driesch's experiment was novel in that it implied that something like regeneration was occurring in higher-level species, albeit in their early stages of development (see *PK* 355). Driesch thought that this holistic, self-regulative power was *not materialistic* in nature, claiming that it was instead "guided by an 'entelechy', an organizing, directive force that consumed no energy, was immaterial" and was "the factor that distinguished living from non-living matter" (Allen 2005, 271; cf. Driesch 1913).

The debate between Roux and Driesch has ontological implications. Roux's results support a kind of *reductive materialism* insofar as an organism's development can be understood as *bottom-up* causal-mechanical forces operating on isolated parts. That is, Roux's experiment takes the isolated parts (hereditary particles) to be *fundamental* and completely determinative of higher layers of reality (specialized cells). These parts were fully predictive of the embryo's differentiation. While studying higher layers of reality is informative and instructive for scientists, all higher level entities and their interactions could be predicted by the analytical approach, namely by investigating the parts of a system in isolation and then calculating the behavior of higher-order interactions. In this kind of analytical mechanistic tradition, interactions between parts produce increasingly complex *quantitative* problems, not new *qualitatively* different properties. In contrast to this kind of reductive materialism is Driesch's *vitalism* (or neo-vitalism). Driesch, in pointing to the capacity of the embryo to self-regulate, adopted a *holism* where the complex organism reacts in a *top-down* way to direct the activity of its parts. In the context of experimental biology in the late 1800s/early 1900s, neo-vitalistic theories like Driesch's argue that regeneration, organized behavior, and self-regulation were behaviors that required a top-down, regulative force. Such behavior, so it was claimed, could not be adequately explained no matter how far the reductive approach extended its computational capacities. In short, Roux and the school of developmental mechanics in biology took maturation to be *internally* “predetermined from the start” while Driesch understood it to be the result of an “external creative agency” (*PK* 395).

Polanyi contends that there is a third way, one that synthesizes the two approaches. He writes that the “regulative principle of Driesch and the mosaic principle of Roux-Weisman actually operate in combination” (*PK* 355). In contending that there is a third way, the effectiveness of Juarrero’s criticism of (O6)—i.e., whether the *origin* of higher layers of reality is always “external” to the lower-level parts—hinges on the specifics of Polanyi’s synthesis of *mechanistic* and *organismic* accounts of maturation. I will not go into the details of Polanyi’s knowledge of experimental embryology nor will I give an exhaustive account of the ontological implications that Polanyi drew from this work. Instead, my goal here will be simply to point out that Polanyi’s view is more complicated than Juarrero’s objection seems to assume.

Polanyi’s synthesis of the two views relies on Hans Spemann’s notion of “localized embryonic *organizers*” (*PK* 355), the “embryonic field” of Spemann and Paul Weiss, and the concept of “competence” and “epigenetic landscapes” of C. H. Waddington (see *PK* 355-356; cf. LIS 232). The notion of “localized embryonic *organizers*” (or Spemann-Mangold organizer) refers to a cluster of cells situated in a certain region of the developing embryo that are responsible for inducing further differentiation and development. The influence of these localized embryonic organizers effects development by way of an “embryonic field”, an organizing force thought to *extend beyond* the embryo itself much like magnetic force extends beyond the spatial limits of a magnet.[9] Such organizers do not strongly determine tissues to certain developmental fates. Instead, a landscape of different outcomes is possible and Polanyi writes that tissues had to be “competent” or intrinsically prepared for development. Thus, organizers don’t strictly determine but have an *evocative power*. At an early stage of development, organizers are highly centralized in the embryo and capable of evoking a wide variety of different possible outcomes from the parts. However, as the organism becomes increasingly developed, and its parts become increasingly differentiated, organizers become increasingly localized and dedicated to more specific developmental tasks. As development occurs, the organism becomes more and more mosaic-like and the equipotentiality of the organism as a whole became increasingly diminished (see *PK* 356).

In interpreting Spemann’s organizer, Garland Allen identifies a change in Spemann’s thought that bears on Polanyi’s view. Whereas early on Spemann thought that induction was a “simple mechanism, such as pulling a trigger, from which a whole sequence of events proceeded,” he began to see it more as a holistic, interactive process.[10] This type of holism was *not* the vitalism of Driesch. Rather it was a *holistic materialism* (dialectical materialism) such that “all processes can be best understood in terms of the interaction of opposing forces, or agents within a system, and between any system and its external environment.”[11] Allen (1975:120) writes that Spemann saw the “initial induction produced a reaction in some target tissues, which in turn influenced the future activity of the inducer. It was not a one-way military hierarchy, but a multidirectional system of many interrelating effects.”[12] Thus, if emergence in living things is through a process of maturation, and maturation is through an internal, multidirectional, interactive process between inducers and induced tissues, then the origin of higher-order living things is *internal* rather than external.

Supposing then that Polanyi accepted the supposed synthesis of Roux’s mechanistic approach with the holistic approach of Driesch in the work of Hans Spemann, Weiss, and others, we might contend that Polanyi’s position concerning the origin of emergence of living things was this:

> *Polanyi’s Embryologically-Inspired Account of the Origin of Emergence*: the emergence of complex, higher-order living entities is (i) a continuous, mosaic development (not a hierarchy of discrete layers nor a quantitative increase à la preformationism), (ii) this

development was partly the result of mechanistic and organismic (regulative) processes, (iii) differentiation moves from a state where the system as a whole is highly flexible (parts are highly equipotential) toward one that involves increased (but not total) rigidity (parts are differentiated and dedicated to certain tasks), and (iv) the controlling force undergirding such organismic (regulative) processes is not vitalistic but field-like and explainable in terms of the system's internal and multidirectional dynamics (see *TD* 43; LIS 232).[13]

Given this picture, (O6) might be revised as follows:

> (O6*) *Internal-External Origin Thesis:* Higher-order entities emerge when either (a) the parts are put into certain functional relationships by some *external* entity, e.g., machines or (b) the parts integrate into certain functional relationships through mechanical principles and *internal*, multidirectional dynamics.

Attractive as this may be for an interpretation of Polanyi, it is somewhat difficult to discern whether Polanyi actually held this view or if he drifts toward a more vitalistic position.

On the one hand, there seems to be confirmation of (O6*) in what Polanyi says when writing about a parallelism that exists between the *structure of comprehension* and *morphogenesis*. He remarks that the two kinds of *biological achievement* are parallel to the two processes of *morphogenesis*. First, there are achievements that are "performed by the rational concurrence of several parts with fixed functions" and these parallel those "machine-like" processes that are "present in the stratagem of independent interlocking morphogentic sequences, based on a mosaic of fixed potentialities" (*PK* 357). This is the mechanistic view of Roux or the idea that there are regional organizers. Second, there are achievements that are "performed by the equipotential interplay of all parts of a system" and these parallel those "integrative" processes "induced by the field of an organizer, as well as in the autonomous morphogenetic responses of isolated tissues" (*PK* 357).[14] In this case, we don't have the acceptance of Driesch's vitalistic claim, but the synthesis relying on Spemann's work mentioned above.[15]

On the other hand, sometimes it appears that Polanyi might understand the above synthesis in a vitalistic way. For example, in Polanyi's discussion of the conception of the generalized field (see ch.13, §5 of *PK*), Polanyi recalls the parallelism mentioned above (*PK* 357) and extends it in several ways. Perhaps the most striking is that he attributes *unspecifiable yet identifiable entelechies* to embryos. Polanyi posits a parallelism between an agent's capacity to attain some successful intellectual achievement (e.g., the resolution to problem) and a corresponding intellectual capacity in embryos. The morphological development of living beings is guided by a biotic notion of success and the achievement of this success involves the organism calibrating itself with some notion of *morphological rightness* in view (see *PK* 398). Polanyi seems cognizant that this commits him to a kind of *vitalism* that many would regard as "spooky," for he remarks that most biologists would reject "the assumption that living beings have peculiar faculties for achieving biotic success, on the grounds that this would impute to them magical powers which could explain anything" and that biologists are likely to treat this power as "mere speculation" (*PK* 399).

Conclusion

In this essay, I have tried to give an account of how Polanyi's account of the *origin* of the emergence of higher-order entities is more complicated than Juarrero gives him credit for. I did this by pointing to Polanyi's understanding of the metaphysical significance of experiments performed in embryology and morphology in the late 1800s/early 1900s. I argued that the way to understand Polanyi's model of emergence of living beings requires dealing with his understanding of late 19th/early 20th century developmental embryology. While I did not provide a complete account of Polanyi's view here, in my sketch of his position, I took Polanyi to draw his account of emergence from those embryologists (Spemann, Weiss, Waddington) who tried to synthesize Roux's bottom-up reductive account with Driesch's top-down vitalistic account. I noted that this view is sketchy and Polanyi may not have been committed to such a synthesis. He may have preferred a more vitalistic understanding of emergence. If the latter is the case, then Juarrero's criticism of him sticks. To try and explain the co-constituting and co-evolving nature of things by appealing to a kind of vitalistic force regionally located in specific morphogentic fields would be to (i) appeal to something *other than* the parts that compose it (some external force) and this would (ii) betray an inclination of Polanyi to retain the modernistic assumption that the only kind of causes are top-down or bottom-up efficient causes.

ENDNOTES

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[1]Abbreviations for this paper follow the following conventions: *SFS*: (Polanyi 1964 [1946]); *PK*: (Polanyi 1962 [1958]); *TD*: (Polanyi 1966); Wesleyan: (Polanyi 1965b); *KB*: (Polanyi 1969); Duke: (Polanyi 1964); LIS: (Polanyi 1968; also in *KB*: 225-239 [copy cited here]); *SC*: (Polanyi 1965a; also in *KB*: 211-224 [copy cited here]). *DiA*: (Juarrero 1999).

[2]In Part III (chapters 14-15) of *Dynamics in Action*, Juarrero gives her proposal for how to explain activity in open, complex systems and she offers a brief outline of its social, political, psychological, and ethical implications of this new model of explanation. In contrast to covering-law models of explanation, which are deductivistic, acontextual, ontologically deterministic, which attempt to rid the universe of all aspects of randomness, and which seemingly ignore idiosyncratic events in favor of lawful regularities, Juarrero's *hermeneutic model* differs in many key ways. Explanation of action is context-sensitive, is sensitive to aspects of reality that are *indeterministic* and *unpredictable*; it is one that attempts to move back and forth between an understanding of the whole in terms of its parts and the parts in terms of a larger whole; it is a *fallibilistic* model, one that is sensitive to the fact that new information about the agent or the agent's previous behavior calls for modifying one's explanation; it is a model that focuses on explanatory *narratives* that often proceed by trying to explain why an individual acted in one way over another. With this new logic of explanation and account of action in systems theory, Juarrero contends that we get a new understanding of *free* action, one with important implications for how we conceptualize decision-making in the real world, how we account for resolve and weakness of the will, how we think about teaching children, developing and resetting habits, what type of social systems we should develop, and how to think about the gains and losses involved in being a part of a social system.

[3]For reviews of this book, see Adams 2001, Riley and Turvey 2001, Towl 2001, and Pols 2000. For a helpful précis of *Dynamics in Action*, see Juarrero 2000.

[4]For a useful overview of three arguments Polanyi uses to block ontological reduction, see the argument from the correspondence thesis (Margitay 2013a:42-43), the argument from dual control (Margitay 2013a:43), and the argument from identification (Margitay 2013a:44). For debate over these arguments and Margitay's criticisms of them, see Gulick 2012, Kertész 2012, Agler 2013, Apczynski 2012, Héder 2013, Takaki 2013b, Lowney 2013; cf. Margitay 2010, Margitay 2013a, and 2013b. For the development of these ideas in Polanyi's work, see Mullins 2013.

[5]*TD* 44; cf. *TD* 45, 49; Wesleyan V:4; cf. Juarrero 2013:2.

[6]In addition, Polanyi distinguishes between the *mind* as a "from-to" experience and the subsidiaries of this experience as a bodily mechanism (LIS 238). If we take Polanyi's so-called correspondence thesis in the weak sense—where the structure of tacit knowledge is parallel to the structure of ontology—then Polanyi is saying that the mind and mental properties are on a higher level and emerge out of neurophysiological processes.

[7]Despite the dynamics of certain reactions being characterized as *endogenous*, these reactions nevertheless depend upon the environment in which they are enmeshed. The BZ, BR, and related chemical clock reactions operate until certain reagents get burned off and so the internal dynamics of these systems and the boundary conditions set by this kind of positive, mutualistic, runaway feedback is at least partly fueled by interactions *external* to its internal dynamics. All of this is to insist that when discussing whether the origin of complex entities is internal or external, the debate is not a genuine dichotomy. We are not dealing with a perpetual motion device or a Keely motor. The origin of complex entities depends importantly on (to use Juarrero's language) certain interfacing with the environment.

[8]For various accounts of Roux's famous "pricking" experiment, see Spemann 1938:18-21 and Allen 1975, 2005.

[9]See Spemann 1938, 298-299.

[10] See Allen 1975, 120.

[11]See Allen 2005, 268.

[12]For more on this, see Hamburger 1969, 1123.

[13]Polanyi saw embryological development to be a combination of mechanistic and regulative (organismic) principles. He writes that the "regulative principle of Driesch and the mosaic principle of Roux actually operate in combination" (*PK* 355). That development was directed by two principles "(1) Its division into areas of fixed determination lends it a machine-like structure; (2) the regulative powers which mutually adjust the several areas of fixed potentiality, and preserve equipotentiality within each area, represent, on the other hand, an organismic principle" (*TD* 43).

[14]In characterizing the so called equipotential interplay of all parts of a system, Polanyi is referring, on the one hand, to creative, skillful behavior and characterizes this not as an external control of the body (e.g., some kind of mental movement of the limbs to paint a picture) but as "an independent force operating *through* the body in combination with the existing machinery of the body" (*PK* 335). On the other hand, he is referring to the capacity of wholes to self-regulate and creatively adapt given alterations to its parts.

[15]Polanyi sees Spemann as accepting this type of parallelism for in a footnote in *Personal Knowledge*, Polanyi quotes at length (with some emendation) a passage in Spemann's *Embryonic Development and Induction* where Spemann writes that the field's behavior is "not a common chemical reaction" and is comparable to "nothing we know in such a degree as to those vital processes of which we have the most intimate knowledge, viz. the mental ones" (see *PK* 338 n. 4). In addition to the instance cited above supporting this synthesis, see also Polanyi 1951:109.

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Michael Polanyi and the Ecological Turn: Embodiment, Personhood, and Interdisciplinarity

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Key words: embodied cognition, personhood, interdisciplinarity, Michael Polanyi

ABSTRACT

Recent studies dedicated to exploring the relationship between cognition and the body have both yielded a rich variety of intriguing possibilities and introduced new questions and problems. Michael Polanyi's personalistic philosophy, enriched by insights from these studies, provides us with a means of addressing these challenges. In particular, Polanyi's account of the relationship between embodiment and personhood offers an expansive and integrative approach to the issues at the heart of this line of inquiry and thus provides a way of advancing these studies and bringing their insights to bear on other areas of analysis and reflection.

Introduction

One of the more interesting and potentially far-reaching lines of inquiry (both scientific and philosophical) in the study of the mind to have come into its own over the past several years involves analysis of the relationship between cognition and the body. Studies in "embodied," "embedded," and/or "extended" thought have raised a number of intriguing questions having to do not only with cognition but also with awareness, perception, action, and articulation. The various perspectives afforded by these studies, however, have also heightened certain familiar tensions (e.g., the question of how to correlate findings from disciplines as disparate as sociobiology, neuroscience, linguistics, and philosophy), and a heuristic framework capable of coordinating the research programs that define this field has not yet emerged.

The two principal sources that inform the argument of this essay include recent studies in embodied cognition and the personalistic philosophy of Michael Polanyi. I begin by expositing several distinct but related problems associated with the challenge of interdisciplinarity, a necessary first step in any attempt to coordinate findings from a range of disciplines. Next, I summarize Lawrence Shapiro's survey of various recent studies aimed at elucidating the extent to which the experience of embodiment conditions our apprehension, cognition, and articulation; I also provide a sketch of the wider intellectual milieu within which these studies should be situated. I then identify a number of themes in Polanyi's thought that both demonstrate Polanyi's contribution to our understanding of the nature of embodiment and its role in our experience as well as open up a particular approach to the challenges associated with interdisciplinarity. The final section describes this approach in greater detail, and proposes a way of addressing three distinct but related problems arising from attempts to coordinate different fields of inquiry. My overall argument is that a Polanyian reading of recent studies in embodied cognition helps us address the challenge of interdisciplinarity by situating embodied accounts of knowing within the wider, more integrative framework of personhood.

The Challenge of Interdisciplinarity

It has been more than one hundred years since Halford John Mackinder observed that the "bounds of all the sciences must naturally be compromises. Knowledge," he insisted, "is one. Its division into subjects is a concession to human weakness" (Mackinder 1887, 154). Despite Mackinder's helpful reminder, the relationship between distinct areas of formal inquiry continues to be a problem; indeed, it has become *more* of a problem today than it was in Mackinder's time.

We encounter this problem in a variety of ways, many if not all of which involve a sense that there is an apparently irreconcilable tension in our knowledge. Examples of this tension include the "daisy of dichotomies" recently enumerated by Esther Meek, such as objectivity and subjectivity, facts and values, reason and faith, theory and practice, freedom and authority, public and private, the personal and the impersonal, etc. (Meek 2011, 8-12). Similarly, Mark Johnson has noted the division of the conceptual from the perceptual, the rational from the imaginative, the cognitive from the emotional, and the *a priori* from the *a posteriori* (Johnson 1987, xxxv-xxxvi). The fragmentation of our knowledge has led to the fragmentation of our lives.

Such dichotomies, however, are not themselves the heart of the problem: they are instead symptomatic of a number of deeper and more fundamental issues that can themselves be characterized in a variety of ways. Meek includes the modern longing for indubitability, the preponderance of ocular metaphors for all forms of knowing and understanding, and the "substantivalist" tendency to identify things more or less exclusively in terms of that which individuates them as opposed to that which they share with other things (Meek 2011, 20-30). Johnson traces the origins of the problem to the modern bifurcation of "the bodily and the rational" first promulgated by Descartes, elaborated by Kant, and perfected by Frege (Johnson 1987, xxvi-xxxi). Similarly, Warren Frisina bemoans our dependence on "representational" accounts of language and knowledge and also faults our unwillingness to address "basic metaphysical questions" (Frisina 2002, 4-6).

Taken together, these factors present us with a range of distinct but related problems. For example, they make it difficult for us to account for the relationship between different domains of formal inquiry. We thus find it necessary to develop protocols for bringing different disciplines into "dialogue" with one another (e.g., by way of a presumably integrative rationality, method, language, or purpose). Oftentimes, however, such conversations result, not in the emergence of a more comprehensive and integrative horizon, but in a kind of perpetual negotiation between the disciplines in question (e.g., the on-going parley between the empirical sciences and theological studies).

Similarly, we find ourselves wrestling with the question of how the perspectives afforded by particular disciplines correspond with what we might call the "transcendentals" (by which I mean something closer to the classic, Aristotelian sense of this word rather than the modern, Kantian sense). We are, for example, increasingly inclined to recognize the extent to which beauty plays an essential role in all forms of knowing, or the extent to which our knowledge is shaped by moral commitments (cf. Rolnick 2007, 137-143). But our ability to account for the extent to which particular rationalities are grounded in a more fundamental experience of the true, the good, and the beautiful has not kept pace with the proliferation of more specialized (and thus circumscribed) forms of awareness (cf. Fernández-Armesto 1997, 9-45).

Finally, the increasing formalization and hyperspecialization of knowledge and its concomitant fragmentation have left us with an anemic understanding of the intellective enterprise and the role of thought in social, political, and cultural initiatives. This tendency is manifest in the presumed dichotomy between "theory" and "practice," but it goes deeper than that. At its heart, this tendency reflects a pervasive sense of anomie, a ubiquitous estrangement manifest in our sense of connection to the world, to one another, and even to ourselves. In the absence of any possibility of an expansive and coordinated account of the world, we find ourselves adrift in a sea of apparent meaninglessness, pulled inexorably towards both the Scylla of fatalism and the Charybdis of nihilism (cf. Meek 2011, 14-15, 22-24).

Thus, the challenge of interdisciplinarity involves more than simply "harmonizing" disparate fields of formal knowledge. The attempt to elucidate the connections between the various modes of apprehension and understanding whereby we strive to make sense of our experience and our world can be seen as nothing less than a comprehensive form of therapy (cf. Meek 2011, 3-6). The purpose of such efforts involves not only finding a remedy to the various philosophical or conceptual problems that beset us when we are confronted by an array of apparently unrelated "facts," but (more importantly) identifying ways of employing our intellective capacities in the articulation of a worldview that fosters human flourishing (cf. Meek 2011, 49-56). It is these concerns that are at the heart of this essay.

Recent Studies in Embodied Cognition

In his recent book *Embodied Cognition* (2011), Lawrence Shapiro provides a thorough and incisive comparative analysis of various approaches researchers and scholars tend to adopt in their efforts to make sense of the relationship between the body and the mind. Shapiro's reading of these studies is sympathetic but by no means uncritical; he offers a number of trenchant observations aimed at clarifying the merits of both (in particular) the insights and proposals of specific research programs and (in general) this wider development in cognitive studies.

Shapiro organizes his survey by way of three interpretive frameworks, each of which represents a distinct approach to the question of the relationship between the mind and the body. These frameworks include the "conceptualization hypothesis" (Shapiro 2011, 70-113), the "replacement hypothesis" (114-157), and the "constitution hypothesis" (158-200).

The first of these (conceptualization) is organized around the idea that the nature and shape of the concepts employed by the mind are grounded in and constrained by the experience of the body. The second (replacement) proceeds under the assumption some forms of cognition traditionally ascribed to the activities of the mind should rather be understood in terms of patterns of embodied action. The third (constitution) suggests our understanding of the mind should include not only the brain and its activities, but should also recognize those features or dimensions of the body (and, in some cases, even the environment) that participate in acts of cognition. Taken together, these three frameworks thus evince a kind of spectrum: forms of the constitution hypothesis try to make a stronger case for the correspondence between mind and body than do forms of the replacement hypothesis, which in turn try to make a stronger case than do forms of the conceptualization hypothesis.

The conceptualization hypothesis, Shapiro suggests, tries to carve out a middle ground between the "chicken" of realism and the "egg" of idealism (54). Representative examples of projects aimed at advancing some form of the conceptualization hypothesis include the account of embodied cognition advanced by Francisco Varela, Evan Thompson, and Eleanor Rosch (52-56, 83-86), the analysis of the influence of embodiment on semantics, conceptualization, and articulation provided by George Lakoff and Mark Johnson (86-95), and the "indexical hypothesis" of Arthur Glenberg (98-103). The thing that unites these various projects is their shared commitment to the idea that the body both grounds and constrains our behavior, our awareness, and our concepts; hence, different forms of embodiment generate different forms of action, perception, cognition, and articulation. Shapiro finds this to be a helpful reminder, but does not regard it as being quite as revolutionary as some of its proponents suggest. Traditional cognitive science, he argues, is quite capable of accommodating many of the insights afforded by the conceptualization hypothesis (91-95, 104-106, 112-113, 202-206).

Because it goes one step further than the conceptualization hypothesis, the replacement hypothesis offers a more radical critique of traditional accounts of the mind; indeed, this perspective is the one "most self-consciously opposed to the computational framework at the core of standard cognitive science" (114). Representative examples of projects that advance some form of the replacement hypothesis include Timothy van Gelder's "dynamical hypothesis" (118-119, 144-149), Randy Beer's analysis of "categorical perception" (127-133), and Rodney Brooks's work in artificial intelligence and robotics (137-141). Those dedicated to the replacement hypothesis tend to share a commitment to the significance of dynamical systems theory; complexity, emergence, and coupling all play important roles in helping to describe the interdependence of the brain, the body, and the environment in acts of perception and cognition (56-61, 116-118). As with the conceptualization hypothesis, however, Shapiro finds the replacement hypothesis a bit lacking. In particular, he highlights the distinction between "description" and "explanation" as a way of probing the potential shortcomings of accounts of cognition that employ dynamical systems theory (133-137). He also recognizes the difficulties associated with attempts to clarify what does and does not count as a representation; these difficulties blunt the critique that replacement hypothesis theorists tend to level against traditional cognitive science (141-155). In the end, he suggests, replacement theory falls short of fulfilling its own ambitions, and although it may be a useful way of exploring *some* forms of cognition it is unlikely it can account for *all* of them (156-157, 206-208).

In some respects, the constitution hypothesis is more radical and potentially far-reaching than either the conceptualization hypothesis or the replacement hypothesis; at the same time, the constitution hypothesis is not necessarily as inimical to traditional cognitive science as the other two tend to be (159). By proffering a more expansive definition of the mind, the constitution hypothesis widens the boundaries of cognitive science without necessarily rejecting the expectations of a more computational or representational framework. Examples of projects aimed at advancing some version of this hypothesis include the sensorimotor theory of perception developed by Kevin O'Regan and Alva Nöe (164-170), the well-known elaboration of "extended cognition" championed by Andy Clark and David Chalmers (175-178, 182-191, 195-197), and Rob Wilson's description of "wide computationalism" (191-193). This approach, of course, is not without its detractors, and Shapiro gives equal time to the criticisms raised by Fred Adams and Ken Aizawa having to do with the failure on the part of constitution hypothesis theorists to distinguish between causality and constitution (161-163, 184-193). In the end, though, Shapiro seems to find the constitution hypothesis potentially the most fruitful of the three, not least because it does not necessarily compete with traditional cognitive science so much as it invites a reconsideration of the parameters of the discipline. The one caveat he offers is that the constitution hypothesis raises "vexing questions about personal identity and the nature of the self" (199; Shapiro quotes here from Andy Clark's *Supersizing the Mind* [2008]) and thus may harbor unacceptable "metaphysical consequences" for our understanding of persons (210).

Shapiro's analysis of these frameworks helps foreground the issues at the heart of this essay. He acknowledges that the conceptualization hypothesis, the replacement hypothesis, and the constitution hypothesis all may very well have something to say about the mind and its activities, but he also identifies various reasons for concluding that none of them are likely to supplant traditional cognitive science entirely (i.e., none of them will likely ever be able to account for the full range of human knowing). Thus, we find ourselves faced with the challenge of identifying a unified heuristic framework capable of accommodating both the insights of the studies Shapiro reviews as well as other forms of apprehension, understanding, and articulation that may not admit as readily to the kind of analysis made possible by these three hypotheses.

Obviously, each of these three frameworks also engages a considerable range of questions and problems (albeit at times only implicitly): not only is each concerned with better understanding cognition, each also finds it necessary to consider the nature of intention, action, perception, conception, and articulation. Each framework is also (to varying degrees) concerned with the development of an ontology capable of supporting their respective accounts of the act of knowing. Thus, each framework finds itself to some degree or another (and consciously or otherwise) necessarily dealing with questions of an interdisciplinary nature. How, for example, does research in the empirical sciences (e.g., neuroscience) and information sciences (e.g., robotics) inform work in the human sciences (e.g., psychology), and how do these each in turn inform more philosophical forms of inquiry? How, too, do the kinds of assumptions and expectations amenable only to philosophical analysis help guide and shape research programs?

Thus, the net effect of Shapiro's analysis is that recent studies in embodied cognition cannot yet be said to be a unified movement, let alone a "well-defined theory" (2). What we see here is perhaps the beginning of a new, unified perspective, but one that has yet to coalesce in a fully integrated or productive manner. It is not hard to intuit how Polanyi's thought might be especially useful at this point: not only does his account of knowing potentially help further elucidate each of the three frameworks outlined above, his wider philosophical vision also provides a means whereby the interdisciplinary issues that emerge from these studies can be addressed. In other words, Polanyi provides us with exactly the kind of expansive, integrative philosophical framework capable of (first) accommodating many of the proposals of recent studies in embodied cognition while also (second) avoiding some of the narrowness of particular frameworks or research programs.

Before turning to a more fulsome account of how exactly Polanyi's work enables us to do this, I will outline in a rather cursory manner a number of developments that have been unfolding in several areas of study related to those Shapiro explores. Doing so will not only help contextualize studies in embodied cognition but will also help further highlight the challenge of interdisciplinarity and the potential contribution Polanyi can make to this conversation.

The Ecological Turn

One of the things proponents of the conceptualization hypothesis, the replacement hypothesis, and the constitution hypothesis all share is a commitment to the reconfiguration (or even, in some cases, the overthrow) of traditional cognitive sciences. However, it seems recent studies in embodied cognition represent more than just a reaction to a (ostensibly) moribund discipline. They also testify to a broader trend in Western thought, one that has been percolating for many years and has now emerged across a range of disciplines. Taken together, these developments signify a shift towards a more relational or ecological approach to questions having to do with awareness, understanding, articulation, identity, and reality itself.

Attending to the place of the body in acts of knowing and understanding goes back at least to Merleau-Ponty's *Phenomenology of Perception* (1945), but Walter Cannon's earlier *The Wisdom of the Body* (1932) is perhaps also relevant here. Some of the later work of Michel Foucault (e.g., 1975's *Discipline and Punish*) likewise represents an effort to examine the ways embodiment determines experience, knowing, and identity. Similarly, Elaine Scarry's *The Body in Pain* (1985) attempts to come to grips with the kind of knowing and being that arises out of the experience of subjugation, negation, and suffering. More recently, Samuel Todes has in his *Body and World* (2001) clarified the relationship between the line of inquiry initiated by Merleau-Ponty and earlier philosophical developments as well as extended its trajectory. Each of these rather disparate studies witness to a broader trend, namely, an increasing regard for embodiment and the way its shapes our knowing and being.

We see further evidence of this ecological shift in contemporaneous accounts of conceptualization and articulation. Mark Johnson has argued one can find an awareness of the correspondence between embodiment and language as far back as Samuel Taylor Coleridge's account of metaphor (Johnson 1987, 68-69). Whether or not awareness of this correspondence dates back quite that far is in some ways a moot point given the more recent efforts of Ludwig Wittgenstein, J.L. Austin, Benjamin Whorf, and others like them, each of whom in different ways provide an analysis of conceptualization and articulation that contributed to the gradual but inexorable conclusion that our embodied practices contribute at a rather primordial level to our acts of understanding and communication. More recently, Mark Rowlands (1999, 2006) has pursued this line of thinking in ways that draw out and capitalize on this correspondence. This preoccupation with the way the ecology of meaning (semantics, conceptualization, articulation, etc.) shapes our knowing and being further testifies to a wider intellectual shift.

Also closely related to the concern for understanding embodiment is a concern for understanding intentionality. This issue itself has generated a range of studies, from (first) those dealing with preconscious or implicit intentionality to (second) those dealing with conscious or explicit intentionality to (third) those dealing with unconscious or sublimated intentionality (often confused with but actually quite different from preconscious intentionality). Warren Frisina (2002) has argued this concern for the primacy of intentionality is evident in both the pragmatism of John Dewey and the process thought of Alfred North Whitehead. James Gibson's exposition of the role of action in visual perception inaugurated a rethinking of the nature of perception more generally, and his *The Ecological Approach to Visual Perception* (1979) is an important resource for many working in the area of embodied cognition (cf. Shapiro 2011, 28-37). The work of Stephen Turner (1994, 2014) and Harry Collins (2010; Collins and Evans 2007; Collins and Kusch 1998) has likewise helped define the shape of this field. A recent collection of essays demonstrates just how important action theory has become to contemporary studies in perception, learning, cognition, developmental psychology, and sociology (see Prinz, Beisert, and Herwig 2013).

There is one final development that bears mention at this point, namely, what Philip Clayton and Paul Davies have described as the "re-emergence of emergence" (see Clayton and Davies 2006). Earlier I noted (following Shapiro) the extent to which replacement hypothesis theorists in particular often depend on some version of dynamic systems theory; it is, however, not only those working in the area of embodied cognition who employ such models. The study of complex, nonlinear, adaptive systems has influenced a wide range of fields, including cognition and the mind (cf. Clayton 2004). We now recognize the "conceptual framework" of dynamic systems theory "has significant implications for the philosophical concepts of identity, teleology, cause, and explanation" (Juarrero 2002, 123). This is further evidence of the influence of Whitehead on late modern thought, and one could easily argue this tendency is also rooted in modern evolutionary theory.

The attentive reader will have noticed the preceding summaries of studies in embodiment, articulation, intentionality, and dynamic systems roughly correspond to the three frameworks Shapiro explores. This correspondence is of course not accidental and is intended to suggest the conceptualization hypothesis (with its concern for understanding articulation), the replacement hypothesis (with its concern for demonstrating the importance of intentionality and action), and the constitution hypothesis (with its concern for elucidating the interdependence of distinct forms or levels of activity) together represent the flowering of a number of trends that have been unfolding for some time now, all of which depend on the attempt to advance our on-going exploration of the importance of embodiment. Taken together, these trends signify what I believe we can call an "ecological turn" in late modern thought.

This "turn" represents a third option to the regnant traditions of (on the one hand) postmodern deconstructionism and (on the other) reductionistic materialism. Over and against the former, the ecological perspective provides a more holistic account of understanding by affirming the unity-in-distinction between knowledge and experience and our capacity to speak meaningfully of both (Frisina 2002, 156-159). Similarly, the ecological perspective does not require adopting a "hermeneutics of suspicion" when it comes to the reality and perdurance of the self (cf. Rolnick 2007, 91-120). The ecological perspective also evades the pitfalls of materialist reductionism, avoiding as it does the inconsistency of attributing the emergence of purpose and meaning to deterministic and mechanistic impersonal processes (Frisina 2002, 55-67; cf. Rolnick 2007, 63-90) and the tendency to associate cognition with brain states (Frisina 2002, 49-50). Contrary to both deconstructionism and reductionistic materialism, the ecological perspective affirms the possibility (indeed, the necessity) of developing a metaphysical account of action, meaning, understanding, and reality (Frisina 2002, 67-70, 177-192; cf. Rolnick 2007, 189-256). As we shall see, the question of the nature and reality of personhood is one of the more significant issues at stake in ecological studies.

This admittedly perfunctory account of these trends and their correspondence is intended to do only two things: (first) to demonstrate in a very rough way how recent studies in embodied cognition fit within their wider intellectual milieu and (second) to help highlight the considerable range of interdisciplinary questions associated with such efforts. Both of these points are in turn intended to do nothing more than further anticipate what follows, wherein I introduce some of the ways Polanyi's thought can be brought to bear both on the distinct perspectives afforded by the conceptualization, replacement, and constitution hypotheses as well as on the more general question of how the insights of these distinct perspectives might be coordinated and integrated.

Polanyi and the Ecological Turn

Embodiment, intentionality, cognition, articulation, emergence: all of these are of course themes to which Polanyi devoted considerable time and energy. What is especially noteworthy about his efforts is the way he managed to coordinate his insights about these themes within a unified framework, one ultimately beholden to the reality of persons. This both accounts for the fecundity of his thought and makes him an ideal conversation partner for those engaged in the study of embodied cognition. Before exploring some of the possible directions this conversation might take, I will examine how Polanyi approached the major themes introduced by the three frameworks outlined above. How does his thought line up with the proposals made by recent studies in embodied cognition and fit within the broader ecological turn such studies signify?

Polanyi's work, unlike those Shapiro examines, did not begin with an exposition of the body and its importance; nevertheless, the significance (indeed, centrality) of embodiment emerged as a consequence of his analysis of other themes. The "logical structure of personal knowledge" and its "dynamic sources" lie precisely in our awareness of our bodies and the interactions of our bodies with and in our environments (*PK*, 60). It is the "intelligent [i.e., purposeful] use" of our bodies that gives us the ability to extend our efforts at knowing and being by simultaneously incorporating or interiorizing elements (both physical or conceptual) of our environment into ourselves and thereby indwelling them (*TD*, 16). Indeed, higher forms of life in some ways represent nothing other than higher, more complex forms of embodiment, wherein each element relies increasingly on the others that support it and thereby contributes to a life organized around "comprehensive governing principles of universal standing" (*PK*, 323). Embodiment is the locus at which knowing and being converge, the pivot on which turn our most primordial and most sophisticated strivings.

Any mention of striving, either primitive or sophisticated, takes us immediately to a consideration of the nature of intentionality. We do ourselves no favors, Polanyi argued, by trying to pass off purposeful action in terms of mere heuristic efficiency or explanatory "simplicity" (cf. *PK*, 15-17). Our actions are grounded in a range of passions, both private and public (*PK*, 171-174), that structure our subjective, personal, and objective forms of knowing. Despite their humble (some might even say ignominious) beginnings in the satisfaction of purely subjective appetites, our passions are what enable us to strive for the more sophisticated, responsible forms of commitment that define us as persons and even for the highly abstract, almost entirely impersonal accomplishments of "completely formalized experience" and thought (*PK*, 300-303). Not only do our passions exercise a "selective" influence on the affordances we pursue, they exercise a "heuristic" influence in our efforts to clarify and expand the affordances available to us (*PK*, 134-145). Together these strivings bear witness to a "logic of achievement" that accounts not only for human knowing but for the whole panoply of life (*PK*, 327-405).

Polanyi's use of *Gestalt* theory also bears mention at this point: his account of the role *Gestalten* play in perception and conceptualization is directly related to his account of achievement and thereby indirectly related to his account of intentionality. The apprehension of *Gestalten* signifies "the outcome of an *active shaping of the experience performed in the pursuit of knowledge*" (*TD*, 6, emphasis added). Polanyi thus made a significant and innovative contribution to the *Gestalt* theory of his day and anticipated the emphasis on action evident in the three frameworks Shapiro identifies. The mind, he suggested, is not a passive receptacle awaiting sensory impressions from the world; rather, the mind actively participates in the coalescence of meaningful patterns in the environment (whether that environment is physical, relational, or conceptual). This does not, however, result in an idealist epistemology: we entrust the "life and guidance of our thoughts to our conceptions" because we believe their "manifest rationality is due to their being *in contact with domains of reality*" and because we anticipate this correspondence will reveal an "indeterminate sequence of novel future occasions" whereby our understanding of reality will be further clarified and refined (*PK*, 104, emphasis added).

Each of these—embodiment, intentionality, apprehension—come together in Polanyi's analysis of the tacit dimension. Our more general and integrative but subsidiary awareness combines at all times with the more discriminatory and particular focal awareness we have of specific entities (*PK*, 55-56). Both subsidiary and focal awareness are decidedly functional: the former guides us out of ourselves towards an encounter with that which we apprehend by way of the latter, which in turn carries us even further beyond the encounter to the world (*TD*, 95-96). Likewise, the phenomenal, semantic, and ontological aspects of tacit knowing bear further evidence of the dynamic character of apprehension and cognition. The first has to do with our recognition that the meaningfulness of the elements of our subsidiary awareness lies in the relationships they share by virtue of their participation in the object of our focal awareness. The second has to do with the transposition or displacement of the meaning of these objects (both subsidiary and focal) away from ourselves. The third has to do with both our understanding of the comprehensive entity we thereby apprehend and our accreditation of the means whereby we apprehend that entity (*TD*, 10-13). Polanyi's exposition of tacit knowing clearly provides us with a dynamic account of the relationship between the knower and the known that avoids both the "chicken" of realism and the "egg" of idealism (Shapiro 2011, 54).

The expansive character of Polanyi's epistemology is perhaps nowhere more evident than in his account of language. Forms of expression are "conceptual frameworks" that afford distinct ways of understanding our experience and apprehending the world (*PK*, 104). Out of our inchoate experience emerge a variety of patterns of representation that bear witness to a complex range of meanings (and hence testify to a complex range of entities and degrees of reality). At a very general level, Polanyi distinguished between the "*ineffable domain*" (wherein the tacit predominates), the "intelligible" domain (wherein the tacit and the focal are coextensive), and the "*domain of sophistication*" (wherein the focal predominates); each of these is manifest in the patterns of conceptualization and articulation we associate with the "descriptive sciences," the "exact sciences," and the "deductive sciences" (*PK*, 82-95, emphases in the original). Similarly, Polanyi's later exposition of the differences between signs, symbols, metaphors, art, and myth attests to his determination not to allow different forms of meaning to be collapsed into one another (*M*, 66-148). It's also worth noting that Polanyi leveraged the correspondence between language and our knowledge of other minds: by dwelling in the forms of conceptualization and articulation of another, we recapitulate their experience in ourselves and thereby come to understand them (*M*, 48). Thus, Polanyi's understanding of the embodied, dynamic relationship between the knower and the known extends to his account of the relationships between persons. In other words, he provides us with an "ecological" account of interpersonal relations that is consistent with but that goes beyond the three frameworks outlined above.

Running like connecting threads through each of these themes (embodiment, intentionality, apprehension, cognition, articulation) are two additional concepts Polanyi employs: the first is emergence, and the second is personhood. Emergence is a recurring motif, one that shapes Polanyi's account of virtually every other theme he explores. The "operational principles" of complex, purposive entities exercise "marginal control" over the "boundary conditions" that delimit the nature of these entities (*TD*, 34-36, 40-45). Likewise, the distal elements of our focal awareness (i.e., those that testify to the operational principle of the objects of our awareness) supervene on the proximate elements of our subsidiary awareness in ways that enable us to recognize the former in and through the latter (*PK*, 59-61). Again, the significance of various forms of conceptualization and articulation harness the more rigid and narrow laws that govern languages (e.g., poverty, grammar, iteration, and manageability) and thereby facilitates the communication of an almost unlimited range of meanings (*PK*, 77-82). Polanyi's understanding of emergence and its ubiquity led him to suggest we should understand all of life as a "cosmic field" wherein a countless range of "centres" of purposive action pursue "short-lived, limited, [and] hazardous" opportunities "for making some progress of their own towards an unthinkable consummation" (*PK*, 405).

In and of itself, however, emergence is not enough to account for knowing and being: it is only the concept of the person that ultimately enables us to make sense of the world and our experience therein. Joan Crewdson may have overstated the extent to which Polanyi's philosophy enables us to affirm some form of "mind" has been the "ordering principle … at work in the evolutionary process from the beginning" (Crewdson 1994, 19), but she was certainly right to say he understood the emergence and development of life as a series of "steps on the road to personhood" (Crewdson 1994, 206). I have elsewhere suggested Polanyi's account of the reality and nature of persons moves simultaneously in two directions, one "emergent" and the other "existential" (Grosso 2007, 64-71). Both have to do with the responsible pursuance of the affordances provided by the contingencies of human experience in ways aimed at achieving greater integrity, meaningfulness, and freedom. The former (emergent) has to do with the concrescence of the embodiment of a personal entity in response to "comprehensive governing principles of universal standing" (*PK*, 323). The latter (existential) has to do with the actualization of a vocation oriented towards the satisfaction of universal standards despite the "fiduciary hazard" involved in any such effort (*PK*, 213-214). Whether we're talking about knowing or being, the concept of the person lies at the heart of Polanyi's account of both (and thus at the heart of all his thought).

Embodiment, intentionality, cognition, articulation, emergence, personhood: for Polanyi, these were not only related but to no small degree interdependent. Polanyi recognized the correlation between knowing and being, between "understanding, believing, and belonging," early in his philosophical career (see Polanyi 1947), and this interdependence is yet another indicator of the ecological tenor of his efforts. Others have capitalized on this aspect of Polanyi's *oeuvre*: we hear clear echoes of this interdependence in William Poteat's (1981, 176) account of our "mindbodily being in the world" and in Charles Lowney's (2013, 20) use of the term "epistemontology" to describe the "interweaving of knowing and being." Polanyi thus enables us to recognize there is more than one ecology involved in perception, cognition, and articulation: we must account for both the range of informal ecologies manifest in (as) the relationship between the knower and the known as well as the series of more formal ecologies having to do with the dimensions of our awareness, cognition, and articulation (i.e., epistemology, phenomenology, axiology, and ontology). The reality that grounds, links, and animates each is that of the responsible person.

Interdisciplinarity: from Bodies to Persons and Back Again

Earlier in this essay I indicated one of my chief concerns would be to examine the question of interdisciplinarity and identify how a Polanyian account of embodied cognition can help us address this issue. I then identified some of the various ways the challenge of interdisciplinarity confronts us, outlined various recent efforts aimed at clarifying the relationship between embodiment and cognition and what these efforts suggest regarding the direction of late modern thought, and proposed various ways Polanyi's thought can further illumine the embodied character of all knowing. In this section, I demonstrate (albeit in a rather programmatic fashion) how the insights of the previous sections bear on one another.

First, to say explicitly what to this point has been mostly implied, Polanyi's thought accommodates (and, indeed, anticipates) all three of the frameworks Shapiro identifies; he is therefore an important conversation partner for those engaged in each of these research programs. This is so not least because his thought provides a way of accommodating the insights of each perspective while also facilitating the correlation of all three. In short, Polanyi enables us to recognize the extent to which the conceptualization hypothesis, the replacement hypothesis, and the constitution hypothesis potentially *complement* one another and need not *compete* with one another. All of them offer valuable insights and productive lines of inquiry. None of them, however, is able to provide an exhaustive account of human knowing. Thus, they all require a wider, more comprehensive philosophical framework capable of accrediting their particular insights. Polanyi's analysis of embodied knowing provides precisely this kind of framework.

Second, Polanyi's philosophical framework does more than simply provide another way of articulating the insights of the three frameworks Shapiro identifies; his thought provides the means whereby the ambitions of all three frameworks can be realized. This is so because Polanyi situates his account of embodiment and the role of the body in all knowing within the wider context of his understanding of personhood. He helps us recognize that, while the body plays an undeniably important role in all our ways of knowing, embodiment itself must be understood within the more comprehensive (i.e., more meaningful) framework of the purposeful strivings of responsible agents. Embodied knowing ultimately points to personal knowing.

Third, situating our understanding of the embodied character of knowledge within the wider context of the personal character of knowledge enables us to revisit the challenges associated with the question of interdisciplinarity. In the second section, I identified three particular problems associated with interdisciplinary studies: (first) the relationship between distinct areas of formal inquiry (e.g., empirical sciences, human sciences, fine arts, etc.), (second) the relationship between distinct areas of formal inquiry and what I called "transcendental" concepts (e.g., truth, goodness, beauty, reality), and (third) the correspondence between formal and informal experience. A Polanyian account of embodied cognition enables us to recognize these questions are not categorically equivalent; they each require a framework responsive to their particular demands, and we should not attempt to address any one of them through means more appropriate to another.

Relative to the first of these problems (i.e., the relationship between distinct areas of formal inquiry), Polanyi allows us to acknowledge the determinative role the body plays in all knowing while also enabling us to affirm that our knowledge cannot be entirely circumscribed by analysis of our embodiment. The dynamism and openness of the body is the way the body, so to speak, transcends itself (i.e., its contingent affordances) by cultivating ever-more complex and sophisticated forms of apprehension, conceptualization, and articulation. Thus, Polanyi provides us with a perspective on formal inquiry in some ways not dissimilar from that suggested by Michael Oakeshott in his *Experience and Its Modes*. Any formalized attempt to account for human experience (be it "historical," "scientific," or "practical") signifies nothing less than a whole world, one that draws on the unity of our informal experience and thus ineluctably seeks only one criterion of validation, namely, wholeness and coherence. Thus, formalized attempts to "harmonize" distinct disciplines cannot end in anything other than frustration or in an attempt (conscious or otherwise) to collapse one discipline into another.

However (and here Polanyi's thought enables us to go beyond both the frameworks Shapiro identifies as well as Oakeshott), this need not mean we are left without any chance of coordinating distinct fields of inquiry. What we need is a framework capable of subsuming the forms of apprehension, rationality, and articulation manifest in particular domains; here we pick up the second of the three problems of interdisciplinarity, i.e., the relationship between distinct fields of inquiry and "transcendental" categories. This is the point at which Polanyi's account of the supervenience of the person on the body becomes especially apropos: *it is within the more expansive and integrative horizon of responsible action that we should expect to adjudicate the relationship between distinct fields of formal inquiry*. Historical, scientific, and practical inquiry may each provide us with a world of concepts, rationality, and articulation, but none of them can or should be allowed to displace the higher, even more comprehensive logic of commitment and achievement.

This, then, takes us to the third problem with which we are confronted by the question of interdisciplinarity: how do we harmonize "theory" and "practice," how do we reconcile the formal and informal dimensions of our lives? Here the body again becomes important: when tempted (as it seems we always are) to lose ourselves in idealistic flights of fancy, it is our bodies that recall us to our vocations and hence to ourselves. In other words, *there is both a descriptive and an imperative dimension to our experience of embodiment*; when we lose sight of the latter, we find ourselves (both individually and collectively) suffering from the kind of moral and intellectual inversion that erodes any possibility of meaningful (personal) life. This is why the logic of commitment and achievement is so important: although our identity as embodied persons is in one sense a given and can be thought of very much as a gift (cf. Rolnick 2007, 144-185), there is also a sense in which neither embodiment nor a fully personal mode of living is guaranteed. Both require intense, sustained effort, the kind Polanyi suggested represents a "short-lived, limited, hazardous opportunity for making some progress … towards an unthinkable consummation" (*PK*, 405). And that, as Polanyi rightly noted, is exactly how one is placed when worshiping God.

Conclusion

William Poteat, it seems, was not exactly one for underplaying his philosophical hand: he suggested we are engaged in nothing less than a "disciplined, arduous, relentless, painful, and patient process of seeking a post-Cartesian intellectual equilibrium, working at every point against the grain of our entire culture" (Poteat 1993, 42). He established this new equilibrium with his account of our "mindbodily being in the world," whereby he sought to demonstrate the radical interdependence of our knowing and our being (Poteat 1981, 176). All of our formalized efforts to elaborate a meaningful account of the world and our place therein depend on the skillful performance of an expansive hierarchy of actions, coordinated and guided at every level by our sense of ourselves as responsible agents. This perspective enables us to understand our lives as the place, the "*room*" wherein we engage in the "liturgical shaping" of our experience in the effort to "comprehend love and death" (Poteat 1993, 35-36, emphasis in the original).

Poteat rightly discerned the reality at the heart of Polanyi's vision is that of the person, engaged in the risky but exhilarating enterprise of leveraging the contingencies of life in an effort to achieve an integral and perduring identity. This enterprise is not just *grounded* in our experience of embodiment; *it is itself the form of our embodiment*, the concrescence and actualization of our commitments. The challenge of interdisciplinarity thus simultaneously orients us both "down" and "up," down toward the primordial dimensions of knowing and being and up toward the affordances that call us out of ourselves and grant us the possibility of meaningful, purposeful lives open to a transcendent horizon of unimaginable promise.

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REVIEWS

Dru Johnson, *Biblical Knowing: A Scriptural Epistemology of Error*. Eugene, OR: Cascade Books, 2013. Pp. xxi+242. ISBN 13:978-1-61097-726-5. $29.00.

Dru Johnson's *Biblical Knowing* challenges sedentary thinking about epistemology within theology. The book is unique because its diachronic approach (emphasizing a *through time* process of knowing) dares to object to the synchronic approaches (emphasizing *point in time* justification) typical of analytic philosophy. Trained in analytic philosophy and theology, Johnson is just the person to help to initiate this healthy turn in theological epistemology.

Johnson's stated goal is to "lay the groundwork for a biblical theology of knowledge—how knowledge is broached, described, and how error is rectified within the texts of the Protestant Christian canon" (xv). And yet, modestly, he admits that this book can only be a "pry-bar, a tool to open the lid on the neglected idea that Christian Scripture might be developing robust descriptions of knowing that can direct us today" (xvi). The idea that Scripture itself presents a "robust" description of knowing seems a bit implausible on the surface, especially given the diversity of perspectives within the Christian canon and seemingly anachronistic notion that ancient Near Eastern people were concerned with such matters. But he sees "significant points of contact" within the canon which are "fundamentally consistent with each other" (xvi).

Johnson begins his analysis with some preliminary comments on knowledge and error. Helpfully, he speaks of error not as insufficient information or superficial mental mistakes, but rather deeper patterns "in embodied performance." Further, Johnson makes the contentious claim that "we can discover a *general* theory of knowledge that is persistent in the minds of the authors of Scripture" (16). I will comment briefly below on the success of this endeavor.

Chapters 2 through 6 form the core of Johnson's argument. Here he guides the reader through various kinds of errors made by people in Genesis 2-3, Exodus, Numbers 12 and 16, Deuteronomy 13 and 29, as well as various passages in Mark, Luke and John. His treatment of Genesis 2-3 is notable in that he sees the passage as an epistemological process whereby the knower is led by God himself to discover his own mate. From this text, Johnson emphasizes that knowledge is social, learned by differentiation, situated, embodied, diachronic, and reliant on authoritative, accredited guides. The influence of Michael Polanyi on this scheme is pervasive. Further, his account of error in Genesis 3 relies on the idea that the woman listened to an illicit authority, the serpent. He states that "we should conceive of knowledge and error as two types of epistemological outcomes, so that error is a form of knowledge—erroneous knowledge—contingent upon which authorities we heed" (47).

Johnson continues his development of the importance of an accredited authority by demonstrating two types of errors in Exodus: failure to listen to the accredited authority (first order error) and failure to embody the authority's instructions (second order error; 65). In Exodus, knowing is not *brute seeing*, but rather *understanding* what has been *seen*. But the error in Exodus goes beyond the first order task of listening to the proper authority; error is also possible in "failing to participate in the instruction to the degree required" (72).

In addressing Deuteronomy, Johnson takes up the question he raised in his treatment of Exodus, by what means is a prophet authenticated as an authoritative guide? He admits that "authentication of the prophetic voice who speaks on behalf of YHWH will always require special means of authentication" (85). But, he argues, the situation for Israel is no different than our own in this regard. He says, "For Israel (as for us today), epistemological ventures inherently involve risk, even ventures of divine communication with special authentication" (87). In Deuteronomy, listening and obeying are important prequalifications for being able "to see."

Next, Johnson investigates the disciples' knowing in Mark, Luke, and John. The gospels present a picture of them "getting it wrong" quite often and being dull of seeing and hearing (98). "Brute *looking* and *hearing*" cannot rescue the disciples, but only listening to Jesus as their authoritative prophet.

In Chapter 6, Johnson turns especially to the work of Michael Polanyi, offering insight as to why his book makes use of Polanyi's epistemology. Particularly advantageous to the theologian are Polanyi's notions of embodied participatory knowing and its inter-personal elements. Among the highlights of this chapter is Johnson's discussion of maximic language (aphorism) which "only attains meaning in praxis" (140). He cites wisdom literature and Ephesians as examples of maximic instruction that becomes clear through participation. To summarize, Johnson has woven the following topics into his discussion: authority, authentication, embodiment, participation, and maximic direction (149).

Finally, in Chapters 7 and 8, Johnson challenges the assumptions about reality of analytic philosophers and theologians, especially concerning the role propositions play in knowing. He criticizes analytic theology's emphasis on propositional knowing in particular, arguing that a proposition is simply a tool for coming to know broader external reality. "There is no informational content to a proposition" (160). In other words, "[A sentence's] significance is only between the human knowers and the role it plays as a transparent tool in epistemological process" (161). In light of this, Johnson argues for a phenomenological approach to epistemology, rather than an analytic one. A phenomenological approach recognizes creaturely limits and better reflects how knowing is *described* and *prescribed* in Scripture. In this way, Scripture is allowed to be "the epistemological guide for our theological prolegomena" (200).

Johnson does a good job of uncovering clear Scriptural epistemological themes which have been overlooked. Moreover, Johnson enacts his theory of knowledge by being the reader's authoritative guide in *seeing* the epistemological framework that is in the text. His use of Polanyi is sufficiently *ministerial* in that it illumines the text, rather than *dominates* it. There are clear coherences between Polanyi's scientific epistemology and biblical knowing.

And yet, while Johnson claims that his account is *general* in the sense that it accounts for all varieties of knowing, the *special* elements that are still present in his scheme are significant. He says that "the constitutive factors [of epistemology] remain the same," but the objects of knowing are different (17). And again, while the process of knowing is *general*, "the prophetic authentication is often *special*" (17). These differences seem significant enough to chasten any possible grand apologetic hopes in positing a *general epistemology*. In other words, for those who think religious belief is irrational in some sense, the problem of a special epistemology finally remains.

But, in the end, Johnson probably does not have these grand apologetic aims. As a necessary corrective to recent thinking on epistemology within theological studies, this volume is a valuable contribution.

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Menachem Fisch and Yitzhak Benbaji, *The View from Within: Normativity and the Limits of Self-Criticism.* Notre Dame, IN: University of Notre Dame Press, 2011. Pp. xiii+394, ISBN 10: 0-268-02904-0. ISBN 13: 978-0-268-02904-3. $50.00.

The View from Within begins with the view now current in analytic philosophy that rationality and its frameworks are inherently normative in character. The authors then inquire into what this view implies about learning from critical discussion. To what extent can one distance oneself from one's norms in order to be innovative and improve the thought of one's self and one's community by way of *critical interchange*?

First, the authors argue that differences in culture ("Normative Diversity") imply the incommensurability and incomparability of cultural standards or norms ("Comparative Irrealism"). Second, the authors argue that Normative Diversity and Comparative Irrealism imply that rationality can either provide no effective grounds for critically evaluating the norms of a framework, since rationality can only operate within a framework, or at the most, only provide grounds for rationally fine-tuning the norms of a framework. For the authors admit, along with other analytic philosophers, that the framework cannot be evaluated holistically so as to include the norms inherent to the framework: all internal arguments about norms must already presume our *normative commitments.* Even though we can evaluate the thoughts of other cultures, we can only understand them within our own ongoing *normative commitments* (327, n. 32). "The problem of rational norm revision…is a major one, deemed by most insurmountable" (21). However, the authors claim to provide a means within analytic philosophy to substantially improve the norms of one's framework *through critical interchange*.

The authors' style of philosophizing is polemical. They point out the failings of their "rivals" both as a launching point for developing their theory and as a "remedy to the failings" of their "rivals."

The first two parts of the book present the context of the book. Philosophers influenced by Wittgenstein or his disciples, such as Rorty, Walzer, Kripke, Brandom, Kuhn, Friedman, and others, are discussed at varying lengths with a singular upshot: they do not solve the problem of rationally changing frameworks, norms and standards. Those influenced by Wittgenstein have failed to see that the speech-act of criticism performs the function of "rebuke:" "all criticism, even the most technical, involves an inherent and defining element of rebuke, an element of *normative* criticism, if you wish; a call, not merely to mend or abandon the system in question but also to *amend or abandon one's ways*" (221). Given that one's reasoning is anchored in certain normative commitments, how can rational self-transformation take place?

In Part III of the book, the authors develop their novel theory of internal criticism largely through a polemical discussion of Harry Frankfurt's work, exploring the self-transformative effect of self-criticism on the level of the individual. The authors also polemically discuss the transformative effect of self-criticism on the level of the community by examining the philosophy of science of Michael Friedman and Peter Galison. However, I hope I can enhance and sharpen the book's theory of internal criticism by making explicit some of its Polanyian aspects.

The irony of self-criticism is that we need others, a *trusted* friend, a *mentor,* to help us see our flaws. Once our mentor points out our flaws, then four questions emerge, the last two of which are the most difficult to answer. First, why do we not just ignore the mentor's critical remarks, especially if they call into question some of our norms? Second, on what basis can we use those critical remarks to transform ourselves? Third, while we typically seek as mentors those who are members of our own community, how can we find a mentor who is able to make critical remarks about the shared framework and norms of our community? Fourth, how do a few critics get a whole community to change its frameworks and norms?

I think the book solves all four problems with its theory of internal criticism. We should seek trusted mentors who themselves are ambivalent about the frameworks and norms of our shared community because they have gone outside the bounds of the community and explored other communities. When their ambivalence is spread to those who trust them, eventually the framework and norms of the home community shifts. In other words, internal criticism creates ambivalence within the individual and community when those we trust reveal their ambivalence to us through communicating to us their experience and understanding of the norms and standards of a different community. "Individuals can be transformed at home, from within, by members of standing and voice whose work not only reflects their own personal ambivalence, but is taken seriously enough within the community to have a corresponding ambivalating impact on a critical mass of their colleagues"(293).

Whom should one trust in a community comprised of those in a scientific discipline structured by specific assumptions? This is where the terminology of Polanyi's theory of personal knowledge can provide some clarity. Those persons who function as mentors must be those who have been granted an *authoritative* role in a scientific community, as Polanyi suggests in speaking of the importance of apprenticeship and authority in science. More generally, usually only the criticisms of the "sages" of our communities are accorded the power to transform the frameworks and norms of our communities. No individual and no community can transform frameworks and norms holistically. Rather, we make transitional steps with the help of piecemeal changes until entire frameworks and norms are transformed, without anyone really noticing this during the stage of transition. The complete transformation occurs by sliding our changed frameworks and norms into our *tacit knowledge*, while the old frameworks and norms become the focal point of critical discussion from the internal point of view of the new *tacit knowledge*.

In their critique of Karl Popper's approach to scientific procedure, the authors seem to take a position close to Polanyi's attention to the limits and inadequacies of frameworks:

> With regard to normative commitment, the truly transformative moment of rationality…is not one of bold conjecture or keen refutation but one of disturbing, destabilizing ambivalence; a moment characterized by indecisive dithering—a state of mind not usually considered the most inspiring and motivating and therefore, not usually associated with rationality. But if there is any truth in our analysis, then the creative individuals initially responsible for rationally transforming a field are to be sought among those who were lucky to be exposed to the ambivalating challenge of trusted external critics—real or imagined. (292)

The "trusted external critics" are those authoritative mentors from outside our home community who have influenced our own authoritative mentors ("creative individuals") if and when they open themselves to insights from outside communities or outside disciplines. The "trusted external critics" interpret their frameworks and norms to our authoritative mentors, who become intermediaries for us of the frameworks and norms of the outside communities and disciplines. When our authoritative mentors return to lead and teach us, we follow, though hesitantly and sometimes rebelliously.

In sum: the authors of this book take a viewpoint of criticism generally consistent with Polanyi's emphasis upon tradition and authority, yet also acknowledge the need to break out of constricting frameworks. To make any change with the use of internal criticism, a person needs to become enmeshed in a network of *authoritative* thinkers, being especially attentive to those open to outside influences. By *indwelling* the terminologies of alternative traditions and frameworks and merging those terminologies with their own terminologies, *creative individuals* create hybridized terminologies that modify various normative outlooks and expand various traditions and frameworks. In other words, only by being acknowledged as an authoritative speaker in different communities, can you too hope to have your internal criticism taken seriously so that you can contribute to making piecemeal changes to the current frameworks and norms of your community.

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Stenmark, Lisa L., *Religion, Science and Democracy*: *A Disputational Friendship*. Lanham, MD: Lexington Books, 2013. Pp. 230. ISBN 978-0-7391-4286-8 (cloth); ISBN 978-0-73911-4288-2 (electronic). $70 (£ 44.95).

Stenmark's book is an analysis of and prescription for the current state of "the science and religion discourse (SRD)" (2), a public conversation in which some participants (e.g., Ian Barbour, John Polkinghorn, John Haught) have taken Polanyi to be a thoughtful resource. Stenmark does not mention or draw on Polanyi in any way, but her book is an interesting if at times dense, convoluted, and not altogether convincing discussion. Her argument has both critical and constructive elements, which unfold in eight chapters. To this reader, Stenmark's critical perspective on the SRD is more illuminating than her constructive argument, which calls for expanding the scope of SRD interests, drawing into the conversation a broader range of topics and some resources she thinks have been underutilized. She proposes essentially to democratize the SRD and create what she calls "a disputational friendship" between science and religion.

The current SRD is largely academic discourse configured in a way that resembles the model of so-called democratic discourse promoted by John Rawls. Stenmark call this a "doctrines and discoveries" (2) approach that focuses on truth claims as a way to discern areas of agreement and establish a firm foundation for the relationship between religion and science. The presumption of this approach is "that there are 'hard facts' and 'objective knowledge'—as opposed to embedded and subjective knowledge—which can help us adjudicate our disagreements" (2). It, in short, presumes a dualistic framework and this works out in practice for scientific reasoning-giving to trump religious reason-giving; this merely increases conflict between partisans for religion and science.

Stenmark clearly recognizes that such a dualistic framework is not acceptable (and she notes that early SRD figures like Barbour said just this) and she proposes moving away from it. This move includes broadening the SRD conversation—i.e., moving from a largely academic conversation to a more public kind of discourse, which is not so fixated on truth claims and which considers a broader range of issues. Part of this move is to put to work resources whose appropriateness to the SRD have not been recognized, especially the thought of Hannah Arendt. Stenmark proposes that "the range of Arendt's writings ultimately covered all of the relevant issues relating to the role of religion and science in public life . . ." (3). Arendt, Stenmark contends, has a method that shows "she wanted to find a way to achieve a critical position, and a mode of discourse, that did not privilege any particular authority or tradition," a mode of discourse that valued plurality and "did not attempt to substitute itself for public judgment. But instead enhanced it" (3). Arendt thus promises to be a resource that puts science and religion on an equal footing in public discourse about public life "without sacrificing their particular commitments" (3). And the Arendt-based model for the SRD that Stenmark proposes is, as I have noted, what she discusses in the final chapters of her book and identifies as "a disputational friendship."

I find much of Stenmark's discussion of the problems with the current SRD in her early chapters to be insightful. She shows how increasingly pluralism draws the conversation between science and religion into the culture wars; she makes plain how the model for discourse in a pluralistic context is scientistic. She calls for a new understanding of discourse which is grounded in a different understanding of authority in public discourse. She wants to link authority to belief, action and tradition and show that tradition provides both stability and a ground for growth, innovation and change. Stenmark makes some use of Arendt's ideas in this discussion but she could, as any Polanyian will see, make her case adeptly with Polanyi.

The fourth chapter turns to a large scale explication of Arendt's account of different spheres of human experience and activities; most of the succeeding chapters are also occupied with explaining in some detail Arendt's positions and their relevance. Arendt's distinctions and categories are quite complicated, and unpacking them was, to this reader, confusing. Especially this was the case because Stenmark draws into the discussion some of the criticisms and varied interpretations of Arendt's scheme. Clearly, the author is a sophisticated Arendt reader attuned to many of the discussions in secondary literature, but her interest in the SRD sometimes gets lost in the extended discussions of Arendt. She at times seems very much engaged in shoring up Arendt, that is, in transforming Arendt's ideas into something more useful. Stenmark intended to make a case that Arendt offers a nuanced account of politics and public life, but I don't find this case clear.

In her fifth chapter, Stenmark, following Arendt, contends that since politics focuses on judgment and opinion, religion and science as truth-oriented, "need to be excluded from political discourse, except in limited circumstances…when people unthinkingly cling to a single truth or deny truth altogether" (141). It is clear that Stenmark wants to curtail dogmatism and premature closure in public conversations. She wants both to protect politics from truth and protect truth from politics as she later suggests. Nevertheless, is it sensible to in any way de-emphasize truth-seeking in science and religion or even politics in this postmodern, digital culture? Stenmark's alternative is to promote storytelling as a strategy to explore disagreement in the SRD and to generate new stories. In sum, I found myself wishing

Stenmark had taken a more metaphysical turn in her exploration of the problem of politics, science and religion, arguing perhaps, like Polanyi, that truth-seeking, fallible inquirers make contact with reality and come to understand reality but do not at any given time exhaustively grasp the depths of reality. Reality has indeterminate future manifestations.

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SUBMISSIONS FOR PUBLICATION

Articles, meeting notices, and notes likely to be of interest to persons interested in the thought of Michael Polanyi are welcomed. Manuscripts normally will be sent out for blind review.

Articles should be sent to Paul Lewis at lewis_pa@mercer.edu

Book reviews should be sent to Walter Gulick at wgulick@msubillings.edu.

All manuscripts should be submitted as a Microsoft Word file attached to an email message (.doc or .docx) and formatted as follows:

- double-spaced
- with 1" margins
- in a reasonable typeface (Times New Roman 12 is preferred)
- with paragraphs indented 0.25"

As to other matters of style:

1. *Spelling*: We recognize that the journal serves English-speaking writers around the world and so do not require anyone's "standard" English spelling. We do, however, require all writers to be consistent in whatever convention they follow.

2. *Citations*: We recognize that Polanyi's work connects with scholars who work in diverse disciplines and typically use different style guides such that we are "fluent" in different conventions for citations, capitalization of titles, and so forth.

- Our preference is for Chicago's parenthetical/reference style in which citations are given in the text as (last name of author year, page number), combined with bibilographical information at the end of the article.

- Endnotes should be used sparingly and be placed before the reference section.

- To the extent that our software allows, we will, however, accept other styles (e.g., APA or MLA) so long as the author is consistent and careful in following it. The main point, of course, is to give the reader enough information to locate and engage your sources.

- We do encourage one exception to this practice. Polanyi's major works may be cited parenthetically: for example: Polanyi argues that …. (*TD*, 56). Full bibliographical information should still be supplied in the references section since many of us may work with different editions of his works. If you take this option, please using the following abbreviations (note that abbreviations are italicized):

CF	*Contempt of Freedom*
KB	*Knowing and Being*
LL	*Logic of Liberty*
M	*Meaning*
PK	*Personal Knowledge*
SEP	*Society, Economics, and Philosophy*
SFS	*Science, Faith, and Society*
SM	*Study of Man*
STSR	*Scientific Thought and Social Reality*
TD	*Tacit Dimension*

Deadlines:

- For Number One of a Volume (October): 1 July
- For Number Two (February): 1 November
- For Number Three (July): 1 April

WWW Polanyi Resources

The Polanyi Society web site (polanyisociety.org/ or polanyisociety.com/) provides information about Polanyi Society membership and meetings. The site also contains the following: (1) digital archives containing all issues of *Tradition and Discovery* and its predecessor publications of the Polanyi Society going back to 1972; (2) indices listing *Tradition and Discovery* authors, reviews and reviewers; (3) the history of Polanyi Society publications; (4) information on *Appraisal* and *Polanyiana*, two sister journals with special interest in Michael Polanyi's thought; (5) a link to the "Guide to the Papers of Michael Polanyi," which provides an orientation to archival material housed in the Special Collections Research Center of the University of Chicago Library, Chicago, IL 60637; (6) photographs of Polanyi; 7) links to a large selection of primary material, including (a) Collected Articles and Papers of Michael Polanyi (the 1963 Gelwick microfilm collection of more than 100 items); (b) Polanyi's 1940 film Unemployment and Money; (c) unpublished texts of Polanyi's Gifford Lectures (1951-1952), Duke Lectures (1964) and Wesleyan Lectures (1965), (d) audio files for Polanyi's McEnerney Lectures (1962), Ray Wilken's 1966 interview of Polanyi (audio and text), and Polanyi's 1966 conversation with Carl Rogers (audio and text).

Electronic Discussion List

The Polanyi Society supports an electronic discussion group that explores implications of the thought of Michael Polanyi. Anyone interested can join. To join yourself, go to the following address: http://groups.yahoo.com/group/polanyi_list/join. If you have difficulty, send an e-mail to James van Pelt (james.van-pelt@yale.edu) and someone will see that you are added to the list.

Dues and Contributions to the Polanyi Society

The Society offers the following ways to support its work: (1) ***dues*** ($35 for individuals, $25 for libraries, and $15 students), (2) ***the Travel Assistance Fund,*** and (3) ***the Endowment Fund*** Those living in the United States should send a check with the fund designated in the memo line to Charles Lowney, Dept. of Philosophy, Baker Hall 124, Washington and Lee University, Lexington, VA 24450. Those living outside of the U.S. should use the Pay Pal payment option on the Polanyi Society membership web page (http://polanyisociety.net/register/join-renew.php).

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