POLANYI'S FINALISM

by John F. Haught and D. M. Yeager

Abstract. Although Michael Polanyi's model of science and his construal of the nature of the real are usually thought to be congenial to religion and although Polanyi himself says that "the stage on which we thus resume our full intellectual powers is borrowed from the Christian scheme of Fall and Redemption" (Polanyi 1958, 324), theologians have given little attention to the model of God he presents. The metaphysical and theological vision unfolded in part 4 of *Personal Knowledge* is a thoughtful alternative to materialist versions of neo-Darwinism and provides a platform for revisiting four long-standing controversies at the interface of science and religion: whether life and mind can be completely specified in terms of physical analysis, whether nature can be adequately understood without appeal to final causes, whether natural selection adequately explains life's diverse forms, and whether knowledge can be fully objectified. Through an exploration of Polanyi's contribution to these discussions, we undertake to show not only that his treatment of God as a cosmic field is strikingly original but also that in reinstating activity as a metaphysical category, he reconstructs our understanding of our creaturely hope and calling.

Keywords: act metaphysics; commitment; Richard Dawkins; Daniel Dennett; field of force; final causation; formal causation; logic of achievement; Michael Polanyi; reductionism.

In the spring of 1996, there was a brief flurry of discussion on the Polanyi list[1] as to why theologians seem to have taken a special interest in Michael Polanyi. The consensus seemed to be that his theory of knowledge accommodates faith claims better than other theories of knowledge. No one suggested, however, that the interest of theologians could be explained by appeal to Polanyi's own discussion of religion or his reconceptualization of God. We will not deny that for most theologians the main value of Polanyi's work lies less in his explicit references

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to religion and God than in his theory of knowledge. Yet implicit in the "ontology of commitment" (Polanyi 1958, 379) that he works out in *Personal Knowledge* are the outlines of a powerful theological vision, and the closing paragraphs of both part 3 and part 4 of that work make clear the degree to which part 4 has been designed to unfold an account of God, or at least of the worship of God.

It is significant that much earlier in the book, in his discussion of religious doubt in chapter 9 ("The Critique of Doubt"), Polanyi remarks that "the rejection of religion was reasonable in view of the grounds on which religious doctrines were asserted at the time." He continues, "Today we should be grateful for the prolonged attacks made by rationalists on religion for forcing us to renew the grounds of the Christian faith" (p. 286). It is not far-fetched, therefore, to suggest that in part 4 of *Personal Knowledge,* Polanyi was intentionally undertaking a project of theological renewal. In spite of the undeveloped nature of the discussions of religion there and in his subsequent writings, Polanyi's attempts to join the hierarchical vision of traditional metaphysics to a cosmology of emergent evolution—as the framework for his "ontology of commitment"—testify to the depth of his interest in foundational theological issues and provide provocative resources for the reconceptualization of deity in a scientific age.

Why, then, have theologians been so careless of his explicitly theological efforts? Several options present themselves: Perhaps his enterprise of renewal is badly flawed and, having been tolerably well understood, has been unkindly assessed and dismissed as a conceptual blind alley not worth the trouble of going into. Marjorie Grene has said as much in a recent issue of *Tradition and Discovery*, condemning "the ontological dogmatism and the hopelessly anthropocentric evolutionism of the final chapter, as well as its closing Christian apologetic" (Grene 1995–96, 15). However, Grene confesses to an "agnostic if not atheistic frame of mind" (p. 14), so perhaps she is not the best judge. It may equally well be the case that Polanyi's "explorations into God" (the phrase is Christopher Frye's) have not yet been well enough understood or assessed to be either affirmed or dismissed.

In this article we will argue that in the suggestive theological proposals set forth in part 4 of *Personal Knowledge*, Polanyi has already outlined the heuristic structure of a fruitful religious metaphysics and that his contributions hold up particularly well when we view them in light of current issues in science and religion. Several of these issues are debated today as much as they have ever been:

1. Whether the reality of life and mind can be completely specified in terms of chemical analysis;

2. Whether final causal considerations are essential to an adequate understanding of nature;
3. Whether the regnant theory of evolution is adequate, a controversy that entails two separate questions:
    a. Whether the notion of natural selection provides an exhaustive explanation of creative novelty in evolution;
    b. Whether, or to what degree, the scientific appeal to the notion of accident really explains the origin of life and of evolutionary change;

and running through all of these,

4. Whether it is possible or desirable for science and philosophy to strive for the complete objectification of all knowledge.

Although some of us may have thought that Polanyi had already settled these issues, the recent flurry of scientific works claiming that a fully materialistic neo-Darwinism adequately integrates the natural sciences, and in some instances even the social sciences, invites us to take a fresh look at Polanyi's urbane alternative.[2]

We have chosen to focus on the last section of *Personal Knowledge* (part 4, comprising chapters 11 through 13) not only because it has often been dismissed even by sympathetic readers like Grene but also—and primarily—because it is here that Polanyi sets forth the core of his theological vision most substantively. After a preliminary examination of the metaphysical foundations of Polanyi's argument, we discuss Polanyi's contribution to the controversies surrounding appeals to final causation, the defensibility of scientific reductionism, and the adequacy of evolutionary theory (1–3 above). Polanyi is of course well known for his negative judgment with respect to the possibility of the complete objectification of all knowledge (4 above); commenting on this last issue *ambulando*, we will suggest that the intricate arguments that he marshals concerning the first three issues constitute his warrants for his passionate opposition to this dubious critical ideal.

1. Polanyi's Theological Metaphysics

Our position is that part 4 of *Personal Knowledge* outlines a significant theological metaphysics. On the surface, however, it might seem that Polanyi has no metaphysics at all. At the beginning of the last chapter of *Personal Knowledge*, he writes: "I have arrived at the opening of this last chapter without having suggested any definite theory concerning the nature of things; and I shall finish this chapter without having presented any such theory" (p. 381). In the contemporary antimetaphysical

climate, we might be wise to leave it at that. Nonetheless, despite Polanyi's assertion that he has been trying only to expose "the crippling mutilations" that have been imposed on human inquiry by the conventions of critical thought (p. 381), it is hard to see how *Personal Knowledge* could be read as anything but a critique of Cartesian metaphysics from the standpoint of something other than Cartesian metaphysics. The validity of the critique must therefore depend to some extent on the plausibility of the implied metaphysical alternative. Though Polanyi certainly offers no "general system of ultimate categories" (this description of metaphysics is Charles Hartshorne's), it is nonetheless possible to uncover or tease out some of the metaphysical principles that constitute Polanyi's "system of correlative beliefs" (p. xiv).

1.1 Self-acting, Striving Centers. Polanyi's metaphysics, although by no means philosophically vitalistic, centers on the reality of living organisms. There are two dominant principles in terms of which he reads the core reality of life: participation and achievement. That he speaks, from time to time, of the "ontology of commitment" seems to suggest that he himself makes participation the supreme principle; however, the structure of part 4 of the book, proceeding from the "logic of achievement" (pp. 327 ff.) to the concluding image of "the awakening of the world" (p. 405), suggests the primacy of achievement. In fact, both participation and achievement can be gathered together as forms of action. Being is acting. Knowing (or at least knowing life) is acting-by-participating so as to understand acting-as-achievement.

In the notions of participation and achievement, then, Polanyi is setting forth the groundwork of what would become a lifelong opposition to the scientistic and materialist assumptions in which modern intellectual culture has sought to embed its understanding both of life and of knowing. Under the spell of René Descartes, modernity has pursued an ideal of "objective knowing" according to which "personal" experience is discounted as no longer part of the "real" world and is considered only marginal, even to the knower's own cognition. This "objectivist" expulsion of the knower from the world leads to the ironic consequence that the scientist, as the paradigm of objective knowing, is no longer a part of the known world but hovers detachedly and dispassionately outside of it. Correlative to the objectivist ideal of knowing, scientific thought, in its representation of living and thinking phenomena, has also purged them of all personal or centered initiative. It has envisaged their life as inert disconnected stuff moved inertially by efficient causes fully specifiable by the detached gaze of disinterested observers conceived as hardly more than passive recorders. Thus, while it is Polanyi's intention to reinstate thinking beings as "active centres"—as opposed to the receptive mirrors or isolated ghosts that critical thought gave us as the "subject"—he also

seeks to reanimate nonhuman creation, rehabilitating our intuition that the living systems that chemistry and physics treat as inert extended stuff are, in fact, complex centered systems of initiative and striving, ontologically distinct from the inanimate processes upon which they rely.

This picture of life clearly implies a robust metaphysics, and one that can explain natural occurrences, including evolution, much more holistically than can the scientific materialism that Polanyi seeks to displace. A careful look will show that the metaphysical suppositions embedded in Polanyi's "correlative system of beliefs" are boldly and unapologetically realist, personalist, dynamic, hierarchical, and teleological. There are defensible reasons for linking Polanyi's metaphysics with the act metaphysics of Thomas Aquinas, but equally defensible reasons for setting it against the background of G. W. Leibniz's philosophy. It was Leibniz, after all, who rewrote the notion of substance as force and who set in the context of modern science the notion of "spiritual" (we might say simply "vital") beings whose very nature it is to act. The differences between Polanyi and Leibniz are, of course, pronounced (particularly with respect to Leibniz's uncompromising atomism, his equally resolute separation of the monads from organismic or bodily being, and his supposition of unmediated knowledge), but still the affinity between Leibniz's individual centers of force—his simple, percipient, self-acting beings—and Polanyi's "active centres" is worthy of examination. What Leibniz called feeling or appetite on the part of the monads seems not to be greatly different from Polanyi's notion of directed striving. What is characterized as perception by Leibniz becomes participation in Polanyi. Both insist that it is activity that creates an individual as an individual, and both insist on graded levels of activity and perception/participation. There is a remarkable similarity between Leibniz's notion of the monad as microcosm and Polanyi's conception of "tiny fragments of the universe embodied in man" (p. 405) through learning and appropriation (which, significantly, take place in community—providing for Polanyi the "windows" Leibniz could not find for the self-acting centers). By means of this comparison, Polanyi might be made to seem less an inspired maverick of dubious credentials; instead, his reflections might thus be linked with a modern metaphysical tradition, one strand of which was diverted into the altering channels of "critical" thought, but another strand of which has constituted a continuous alternative tradition of "personalism." (E. S. Brightman, for example, identifies Leibniz as the origin of all contemporary forms of personalism [Brightman 1950, 342].)

Still the point is not so much to locate Polanyi on the map of metaphysical systems (a map drawn in remarkably divergent ways by different historians) as to bring out the distinctive features of his metaphysics, especially his ontological privileging of self-acting centers (sometimes

conscious but often not). This, after all, is the feature by which almost the whole of his work stands or falls. His staunch resistance to what he takes to be the incoherent project of rendering all of knowledge objectively explicit and bloodlessly dispassionate rests on the fundamental conviction that centered personhood in living beings is *real*, though unobjectifiable. Inasmuch as the modern assumption that we can purge personal subjectivity both from our acts of knowing and from the living natural world—so as to arrive at completely objective knowledge—lies at the root of central issues in science and religion, Polanyi's concerns should be of special interest to both scientists and theologians today.

1.2 The Divine Field of Influence. Polanyi's vision is not only metaphysical but also theological. The treatment of God in *Personal Knowledge* is oblique and elusive, but part 4 of the book culminates in the vision of "a cosmic field which called forth all [animate] centres by offering them a short-lived, limited, hazardous opportunity for making some progress of their own towards an unthinkable consummation" (p. 405). Perhaps the most significant feature of this conception of divinity (beyond the startling metaphor of God as *field*) is the sharing (or joint participation) of God and God's creatures in freedom and creativity—with the suggestion that this creaturely participation is itself the will of God. When this passage is set in the context of the entire book, we can note some affinities with the theological metaphysics of Karl Rahner, Bernard Lonergan, Wolfhart Pannenberg, and process theologians, all of whom think of God as the transcendent *telos* of all creaturely striving and as a power that wills the independence and initiative of the creatures called toward this end. Interestingly, Pannenberg has also employed the image of a cosmic "field of force" to represent the activity of the divine Spirit in relation to nature.[3]

Like other living organisms, humans are drawn or lured toward realities that to our way of knowing and being are initially tacit, "proximal," and focally ungraspable: we know more than we can say. We are perpetually restless and dissatisfied, creatures whose nature is to long, to adventure, and to reach. The metaphysical foundation of this reaching is the independent reality of a "cosmic field" that instigates, guides, and answers to that restlessness without ever setting it at peace (p. 199). For Polanyi this cosmic field is not an evolving God or an emergent deity only deficiently real or merely on its way to being. The divine powers do not depend on us; they visit us, call us, strew gifts in our way, but their regulative or organizing force or influence flows one way only. They seek the response of a world capable of but not coerced into emerging toward ever more intense degrees of commitment.

Polanyi is willing to allow the physical sciences to ignore any such field of influence—just as scientific method per se rightly ignores all final-

causal considerations. But a *comprehensive* understanding of nature must at some point include a metaphysical grounding of the field of novel possibilities that allow for genuine cosmic emergence. Here Polanyi would certainly approve of Alfred North Whitehead's strong insistence that possibilities "must be somewhere" (Whitehead 1978, 46). In order to be actualized, they must be rooted in something real, and in part 4 of *Personal Knowledge*, Polanyi seems to suggest that it is this transcendent source and promise that we acknowledge when we speak of God. Likewise, it is this transcendent source and promise that is the proper object of our worship.

This image of a cosmic field of force may initially impress us as a fairly bloodless "image of the imageless" (the phrase is Martin Buber's) when compared with Martin Luther's divine horseman galloping on a lame creation, Buber's streaming eternal Thou, or even James Gustafson's cosmic deity bearing down upon and lifting up recalcitrant creation. Yet in the context of an evolving, emergent universe, it seems entirely appropriate, and it seems especially consonant with post-Einsteinian pictures of nature.

Originally the notion of an effective field of force comes from physics, but prior to the ascendancy of molecular biology, and in some cases even afterwards, a few influential biologists applied it analogously to the apparently hidden morphogenetic factors in embryogenesis and other aspects of biotic emergence. Throughout the whole chain of life, wherever vital processes are in play, powers or principles operate that confound the Cartesian metaphysics of disintegration and exclusively efficient causation. Things do not just pile up like waterworn stones, occasionally forming something useful; they are organized or molded functionally toward actions, even at very simple and primitive levels of life. According to Polanyi, the first to use the field concept to describe this phenomenon was Hans Spemann in 1921, followed by Paul Weiss, who in 1923 "introduced it for the study of regeneration and extended it (1926) to include ontogeny" (p. 356 n. 1). Polanyi recounts Spemann's experiments with newt embryos to establish the incontrovertible presence of an active organizing center present even in the gastrula stage of the embryonic salamander. A part of the embryo controls or regulates the development of the rest:

> If the embryo is cut up, any part of it in which this dominant region is included —or in which it is engrafted—will proceed to develop further, while in the embryonic tissue from which it is eliminated, individuation comes to a stop. Thus the dominant region, which is the seat of the organizer, molds a whole region under its control into one complete embryo, irrespective of any previously differentiated character of its several component cells, which respond equipotentially to the organizer's stimulus. The effect of this stimulus on the area under its control is ascribed to the organizer's *morphogenetic field*. (pp. 355–56; Polanyi's italics)

Polanyi, in spite of the careless accusations by Jacques Monod (1972, 27–28),[4] is not a vitalist (at least not in the sense in which scientists understand this term today), and he is careful to say that the notion of fields with organizing centers that control adjacent tissues is not in competition with the dominant models of mechanical function; it is complementary to them. Although Polanyi's project is not to displace and discredit the machine model, his recovery of what he believes to be the lost (or badly neglected) half of the more comprehensive account seems to compel some fairly radical changes in our thinking about life. Scientific understanding of the biological processes of development and of regeneration has, of course, made extraordinary progress in the years since *Personal Knowledge* was published; that Polanyi was wrong about the details of such processes does not necessarily mean that he was wrong about the structure. Just as Gestalt psychology has directed attention to our hidden powers of cognitive integration, so also the image of a morphogenetic field can bring into view dimensions of natural causation that inevitably escape the notice of a purely mechanistic modeling of life. In support of this point, Polanyi quotes Spemann's 1938 Silliman Lectures:

> Again and again terms have been used which point not to physical but to mental analogies. This was meant to be more than a poetical metaphor. It was meant to express my conviction that the suitable reaction of a germ fragment, endowed with the most diverse potencies, in an embryonic "field", its behavior in a definite "situation", is not a common chemical reaction, but that these processes of development, like all vital processes, are comparable, in the way they are connected, 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. (pp. 338–39 n. 4)

Although most philosophers and biologists would not dispute the teleonomic features of nature, most would deny the validity of extending the observed purposefulness of specific organs or of developmental biological processes beyond these local systems and beyond this rudimentary identification of purpose with biological function. Yet it is just this analogical extension that is central to Polanyi's hierarchically emergent levels of intensifying commitment in and complexity of self-initiated action. The morphogenetic field in which the developing tissues of the salamander embryo are integrated, according to operational principles that shape the material conditions of possibility to a living system of materially based but irreducible activities, is a simple and incontrovertible instance of structures common to all levels of living being. At the other end of the continuum of successively more powerfully integrative fields dominated by progressively more complex operational principles is the "cosmic field" under whose influence all of life is orchestrated by a telos no level of living being is competent to grasp. Polanyi's metaphysics is, however, a metaphysics of calling rather than of design, centralizing freedom rather than law, and change rather than fixity.

2. Polanyi's Alternative to the Materialism of Dawkins and Dennett

In view of his appeal to the metaphysical notion of a divine field of influence on the emergent universe, it is not surprising that Polanyi also strongly opposes the dominant alternative metaphysical claim—one that today is made more confidently perhaps than ever before—that Charles Darwin's theory of evolution by natural selection gives us an adequate account of evolutionary novelty. Recently the British ethologist Richard Dawkins, with the help of his American philosopher "bulldog" Daniel Dennett, has brought the ultramaterialist rendition of evolution a considerable amount of public and academic attention (Dawkins 1986; Dennett 1995). Dennett claims that Darwin and his neo-Darwinian interpreters have conclusively shown evolving life to be just an "algorithmic process," one capable of being completely understood in objective terms and without any appeal to such notions as inner-directedness, centeredness, subjectivity, or "personality" (1995, 266). The modest recipe for evolution consists of only three mindless ingredients: purely random events, the impersonal laws of natural selection, and enormous spans of time in which to experiment with different combinations of organic molecules. No supernatural skyhooks or morphogenetic fields are needed to account for evolution's prodigious creations. Through blind mechanical selection of adaptive changes in organisms over a period of several billion years, an impersonal evolutionary process can bring about all the morphic diversity of life, including sight and persons.

The exclusion of any personal dimension from our modern ideal of knowing is nowhere more evident than in this materialist dream—grown all the more exuberant since the birth of molecular biology fifty years ago—of explaining all of life and mind completely in terms of the physical and chemical processes upon which they rely and in which they dwell. Along with his opposition to the kind of extreme evolutionary adaptationism represented by Dennett and Dawkins, according to which the impersonal process of selection is sufficient to account for all the creative novelty in evolution, Polanyi also provides a logically crisp refutation of their attendant ontological reductionism. This is a critique that he begins to develop in *Personal Knowledge*, but that he later presents more clearly in *The Tacit Dimension*, *Knowing and Being*, and *Meaning*. (It is important, of course, to distinguish between *methodological reduction* and *ontological or metaphysical reductionism*. Polanyi does not oppose methodological reduction, and he acknowledges that it is part of the scientific method's specification of subsidiary particulars; what he opposes is the reductionism that maintains that science can grasp the full reality of living beings through such specification.)

2.1 An Alternative Concept of Life-as-Machine. The first step in such a critique, and one that may not immediately seem promising from a theological point of view, is to grant the value of considering organisms on the analogy of machines. Polanyi's point, however, is that, contrary to prevailing thought, to consider an organism on the model of a machine is not necessarily to reduce it ontologically to a determinate mechanism that can be exhaustively analyzed in terms of its material components—for an analysis of chemical constituents can never disclose the presence of a machine, let alone define its functions: "*complete knowledge of a machine as an object tells us nothing about it as a machine*" (p. 330; Polanyi's italics). A machine is an object designed to serve a purpose, and the purpose it is designed to serve is *superadded* to the material constituents: "We identify a machine by understanding it technically; that is, by a participation in its purpose and an endorsement of its operational principles" (p. 330). A machine can be understood only if it is understood normatively; it cannot be understood simply descriptively, that is, by specifying the physical components and processes out of which it is constructed. It also has operational principles, "rules of rightness" (pp. 328–31) which are logically extraneous to the subsidiary laws of chemistry and physics, but which define its possible success as the machine that it is. The material substratum is, of course, necessary, but it is not sufficiently determinative of the machine's identity. It provides the wherewithal and limits, but it cannot provide the "comprehensive feature" in light of which the machine is what it is and functions as it does. "The parts can *fulfil* their functions" only under certain "material *conditions*" (p. 331; Polanyi's italics); and occurrences within these subroutine conditions can also explain the failure of a machine to achieve its designated function. However, no appeal to the subordinate material conditions can ever explain the *success* of a machine. Success or achievement is an attribute introduced only through the logically distinct level of operational principles that determine the boundary conditions left open by the material substratum. Operational principles of machines are embodied in the machine's performance or *actions* (p. 331 n. 1), and as actions they can succeed or fail. But since success and failure are concepts completely inapplicable to the subordinate material routines, the machine itself cannot adequately be understood even by the most sophisticated knowledge of the laws of chemistry and physics.

The analogy of the machine is especially significant in Polanyi's critique of biological reductionism, for it has become a standard scientific model of the living cell and even of the organism.[5] Thus, the point of Polanyi's argument is that if even a machine cannot logically be reduced to its chemical and physical constituents, then it is likely that the living, goal-oriented realities for which it stands as a theoretical model cannot

either.[6] It appears that the modernist habit of thinking of organisms as machines is, in a sense, stood on its head by Polanyi's careful statement of the nature of machines. But Polanyi is not yet done.

2.2 The Differentiation of Organisms from Machines. Machines, however inscrutable they may be when viewed strictly in terms of their "material topography," are indeed determinate, whereas organisms are not. Animals, for example, have some machinelike aspects, but they also display organismic functions. Machines operate specifiably; their powers are formalizable—that is, their functions "operate ideally by fixed structures" (p. 342). Organisms, however, operate unspecifiably and have "unformalizable powers" (p. 336).

Polanyi introduces the term *equipotentiality* to name the powers of organismic life to achieve a purpose or carry out an action in a variety of ways by a "process of spontaneous adaptive reorganization" (p. 338). Organismic life lays over its machinelike functions "an equipotential integration of all parts in a joint performance" (p. 342). If there is a spontaneous integration guiding or "regulating" an action, then there must be "an active centre" that does the integrating. The appearance of (and recognition of) "an active centre" corresponds with the appearance of (and recognition of) individuals (pp. 343–44).

> . . . a living individual is altogether different from any of the inanimate things. . . . it has a *centre*. The focus of our comprehension is now something active, that grows, produces meaningful shapes, survives by the rational functioning of its organs; something that can behave and [in more complicated organisms] acquire knowledge, and at a human level, can even think and affirm its own convictions. (p. 344; Polanyi's italics)

Now it might seem that this notion of the active center introduces into Polanyi's argument as a given precisely the reality whose presence it is his responsibility to demonstrate. By thus taking for granted the reality of an integrating active center of initiative, he would appear, at least to philosophers like Dennett, to beg the essential question of how *objectively* to account for such subjective experience. However, the point of Polanyi's work is to demonstrate that there can be no objective representation that adequately thematizes what it is to be an acting or knowing subject.[7]

Not only does the organism exercise "unformalizable powers," but the very notion of an organic system implies organizing interests. Machines are designed by engineers for some purpose; machines do not rise out of the slime spontaneously. In the case of machines, the interests served are external to the system that functions to serve them. In the case of living organisms ("living machinery": p. 360), the interests are, as it were, internal to the system that serves them: "Organs and their functions exist only

in their bearing on the presumed interest of the living individual" (p. 360). This is the reason that "every living being is acknowledged as an aim in itself" (p. 360); every living being functions in its own interest —which is at least to say that it functions in order to perpetuate the system that it is. This gives direction to the action of the initiating, organizing center, and from this Polanyi develops the motif of "directed striving." This turn of the argument is also crucial to the development of his "ontology of commitment," since the interests of the organism anchor it in a field of value.

According to Polanyi, commitment in its broadest definition signifies simply an agent's "act of seeing things in one particular way" when it might see them otherwise (p. 363), for such seeing is, however primitive, an act of appraisal in light of some sense, however inchoate, of "rightness" or, we might say, value. In vegetative being, the level of commitment is "primordial"; it is simply commitment to "function and growth." Although some might balk at this usage of *commitment* precisely because it elides conscious intention, Polanyi holds it to be a justifiable use because (1) he has shown that "function and growth" require an organizing center that controls a field of change so that the changes pursue a direction that is not inherent in the material undergoing the change (in Spemann's experiments, the organizing tissue produces the developmental changes in any tissue onto which it is grafted, and no tissue pursues the developmental changes absent the organizing tissue); (2) any stable system involves a pattern of influences and reliances among its components. Thus, "in a generalized sense commitment may be acknowledged even at the vegetative level, since it is of the essence of a living organism that each part relies for its function, and for its very meaning as part of the organism, on the presence and proper functioning of a number of other parts" (p. 363).[8]

The level of commitment intensifies (or perhaps we might use the language introduced on p. 366 to say that acts of commitment become more emphatic) but does not change in nature as we turn our attention from the vegetative to the animal kingdom, and within the animal kingdom, from organisms that are active and perceptive but not thoughtful (that is, organisms that perceive and act in light of rules of rightness that they do not generate) to organisms that are capable of conscious deliberation (that is, organisms that are capable of generating an additional stratum of rules of rightness according to which they perceive and act—and in light of which they may succeed or fail). At this last level, we may speak of responsibility and, therefore, of personhood—though significantly, Polanyi's concept of the person is not restricted to *Homo sapiens* (part 4 contains multiple references to the persons of animals, and on p. 373 he speaks of "rising levels of personhood").

"Directed striving" remains, however, an ambiguous concept. There seems to be some considerable difference between the relatively uncontroversial notion of a telos as a sort of embedded program of change according to which an organism or system develops until it achieves the stability that represents the realization of its potentiality, and the notion of a telos as something future and hidden toward which the organism reaches or is drawn in acts of self-disposition. The first remains machine-like (possessing what some biologists refer to as *teleonomic* properties); the second elicits agency (an ability to respond appropriately or fail to respond appropriately) and freedom (a capacity for discovery and innovation). This latter notion plays an exceedingly important role in *Personal Knowledge* as a fundamental feature of Polanyi's notion of heuristic vision, in which we somehow apprehend "hidden rational relationships" (p. 366) long before we can say anything explicitly about what those relationships are. It seems appropriate, then, to turn to the question of the place of final causes in Polanyi's understanding of life.

3. The Controversy concerning Final Causation

There can be hardly any doubt that Dennett would consider Polanyi's appeal to inner directedness, commitment, achievement, and morphogenetic fields to be the pathetic residue of prescientific thinking about life. He would insist that if we look at evolution objectively, we no longer need the superfluous religious metaphysics to which Polanyi appeals at the end of *Personal Knowledge* and in later works. As Dawkins himself has put it, maximization of the "utility function" of *DNA survival* is sufficient to explain all the products of evolution (1995, 95–133). Thus, nature has no need for any nonmechanical influence to move life along or to give it its various forms. The same impersonal force that governs the stars and the atoms also rules the relentlessly selfish units of evolution. An utterly meaningless momentum to survive at all costs and by whatever clever ploys are available will even cause genes eventually to invent intelligent beings as vehicles who unknowingly carry them on to subsequent generations. According to Dawkins, Darwin has thus given atheism the firmest intellectual foundation it has ever had (1986, 6).

Polanyi's response to this hyper-Darwinist version of evolutionary materialism, however, would probably not be substantially different from the one he offered in *Personal Knowledge* and clarified in subsequent writings. He in no way discounts the exciting discoveries of evolutionary science, nor does he deny that natural selection has explanatory value. However, he is led by simple logic to deny that purely materialist readings of Darwinian science can ever adequately account for emergent novelty. Selection alone, moreover, cannot fully explain the rise of life out of

lifelessness, of sentience out of the insentient, or of personal self-awareness and capacity for ethical commitment out of less intense forms of life.

As we have seen, Polanyi believes that the defining mark of living beings is their capacity to strive and to succeed in terms of "rules of rightness" (p. 330) that are systematically unspecifiable in physical or chemical terms. The "logic of achievement" is importantly asymmetrical: Chemical and physical processes "establish the material *conditions* under which the parts [of a mechanism or an organism] can *fulfil* their functions and which will *explain* their occasional *failures*" (p. 331; Polanyi's italics), but the performance that constitutes rightness or fulfilled function or successful action can be neither identified nor explained by reference to material conditions. Physical and chemical processes happen as they inevitably must (and in that sense, there is no logical space to speak of success or failure at the purely physiochemical level), but life processes are equipotential processes (pp. 337–38) which can move to a given outcome in any number of ways. In the domain of life, "indeterminate means" are "utilized" instrumentally "for achieving a comprehensive feature" that in lower forms constitutes right function and in higher forms constitutes an even more elusive sort of "rightness" (p. 340). Life *is* heuristic effort. Any and all life-forms organize and reorganize "available means for a predetermined end" (p. 339). Life is indistinguishable from "the capacity for coherent and resourceful action" (p. 339). In Polanyi's view, it is not, therefore, possible to speak coherently of life without speaking in terms of the ends toward which life organizes itself. A science that deals with living things is therefore "logically different from a science dealing with inanimate things" (p. 344):

> All physiology is teleological and in this sense we may speak here also of reasons and causes. We say that the *reason* for having valves in the circulatory system is to prevent the regurgitation of the blood; while we ascribe the *causes* of any regurgitation, occurring in spite of these, to an insufficiency of the valves owing to malformation or disease. Physiology is a system of rules of rightness, and as such can account only for health. Accordingly, we do not enquire into the causes of health —any more than into the causes of a mathematical proof; but we do enquire into the causes of disease. (p. 360; Polanyi's italics)

Only our own existential experience of achievement can put us in touch with this distinctive feature of life. It is only because we ourselves are striving centers of initiative, that is, *persons* capable of reaching toward goals and also able to fail in such attempts, that *we* can truly *know* the goal-oriented *reality* of other living beings. A completely impersonal, detached, "objective" recorder of natural occurrences (in other words, the ideal "knower" that has been posited by modern intellectual culture) could not possibly register the emergence of life (or of mind and ethical

aspiration) as anything more than just a special application of impersonal chemical processes. Life, sentience, and personal commitment can be called *emergent* only because of their additional capacity for success and failure. This quality, though immediately obvious to *personal* knowers, would completely escape any hypothetically impersonal method of gathering data about nature. Physical and chemical processes considered only in themselves are aimlessly "algorithmic"—they are systems "to which no distinction of success or failure applies" (p. 381). Consequently, a method which by definition looks at life and evolution *only* through the filtering screen of chemical and physical occurrences, and which abstracts totally from the *act* of striving to achieve that is life's defining feature, can hardly pretend to know life or the emergent levels of striving that as persons we can clearly make out in the evolutionary story.

Hence, a more comprehensive accounting is required if we are to explain the gradient along which emergent levels of striving and achievement become actual. Since mechanistic science by definition leaves such explanatory features out of its field of vision, only a vision of nature proportionate to the logic of achievement can provide them. Accordingly, Polanyi introduces and defends a variety of "finalism" which in no way conflicts with *science*, but which he certainly knows to be quite out of step with *scientism*, the peculiarly modern and historically provincial ideology that treats objective, impersonal knowing as the only legitimate cognitional avenue to the real.

However, any hope Polanyi has of rehabilitating "finalism" in this age of scientism depends on the success of his more fundamental epistemological attempt to reestablish the cognitional stature of personal knowing. This, of course, is the point of Polanyi's entire project in *Personal Knowledge*, and it is an argument too large for us to present here. However, it is one to which we must eventually give our consent if we are also to make room for any final-causal factors in the emergence and evolution of life. Only a crediting of our own personal experience of striving to achieve goals could ever conceivably allow us to integrate into our knowledge of the world the kind of clues that might also give us the sense that the cosmos is bounded by an ungraspable divine field of meaning.[9] So long as we relegate the personal aspect of knowing to the epistemological fringes and persist in our modern obsession with the ideal of completely objectifying knowledge, we will also exile any inklings of evolutionary goals and cosmic meanings to the realm of wishful thinking.

4. The Inadequacy of Dominant Evolutionary Theory

The explanatory adequacy of Darwinian and neo-Darwinian evolutionary theories must be evaluated not only because they are sometimes accompanied by relentlessly materialistic presuppositions, but also in

terms of their alleged power to explain what they claim to explain: not only the rise, persistence, and diversification of life-forms but also the rise of sentience and the development of sentience into self-reflexive consciousness. Conventional evolutionary theory offers us the linked mechanisms of random genetic variations sifted and selectively preserved by natural selection or reproductive advantage (over millions of years). Polanyi argues that these mechanisms, while they do usefully explain certain variations within species in the natural world, are manifestly inadequate to explain not only the "coming into being of life itself from inanimate origins" (p. 383) but also the passage of life through five pivotal stages: (1) the change by which "ultramicroscopic, virus-like specks of living matter gained standard shapes and sizes," producing individuality; (2) "the appearance of a nucleus within a bed of protoplasm [indicating] an increased complexity of internal organization" and marking "immensely augmented self-control"; (3) "the aggregation of protozoan-like creatures to multicellular organisms" and the initiation of sexual reproduction; (4) the awakening of consciousness; (5) "noogenesis," the appearance of the distinctively human through the invention of language, which made possible "a lasting articulate framework of thought" (pp. 387–88). Each of these stages represents the appearance of "novel modes of operation" (p. 383), and Polanyi denies that "entirely accidental advantages can ever add up to the evolution of a new set of operational principles" (p. 385).

He notes that, ironically, the features of nature that the mechanism of natural selection actually explains superbly are just the variations that have no importance in the long-range pattern of changes that constitute the achievement of new and more complicated levels in the multiplying strata of life. The hereditary changes we can actually observe are, Polanyi suggests, a kind of biological static, interfering with or "swamping" our vision of the process of change. The "comprehensive operations of evolution," its action, is discernible only retrospectively. Polanyi does not dispute the fact that in identifying and tracing the influence of reproductive advantage in accounting for biological diversity the busy Darwinian biologist has perfected a highly laudable power of comprehending and manipulating certain kinds of changes. The difficulty is that these kinds of changes are, in Polanyi's judgment, unrelated to the line of evolutionary change that is the object of concern. Indeed, these genetic variations actually function to obscure and even conceal the line (or lines) of evolutionary emergence. The theory of selection by reproductive advantage is a powerful explanatory device, but it does not explain evolution.

4.1 Stable Open Systems. The argument to be made with respect to the theory that random mutations suffice to account for the emergence of "novel modes of operation" in the realm of organismic life is rather

different. Polanyi's discussion of our ability to recognize the formal- and final-causal factors in life—at a level above and beyond the restricted region of efficient and material causation—is pivotal to his critique of accounts of evolution that rest on random variation, and it may also help us to place in perspective the allegedly causal role in evolution attributed to contingency, accident, or chance by neo-Darwinian biologists. There is considerable debate among evolutionary scientists today over how far to extend the explanatory role of contingent events in accounting for the diversity of life. Some prefer to locate the accidental factors that provide the material for selection primarily in the molecular region of genetic mutations, while others (notably Stephen Jay Gould) emphasize the importance of environmental contingency in the larger arena of natural history (exemplified in climatic shifts, plate movements of the earth, meteorite impacts, and so on) as the dominant engine of change. In either case, however, a prominent explanatory role is given to accidental events, that is, to happenings that appear, at least at the level of biological understanding, to be devoid of any intelligible explanation themselves.

To biological science, microscopic mutations are random and hence unintelligible natural contingencies, but they can unpredictably change the whole course of evolution. The accidental extinction of the dinosaurs 65 million years ago opened Earth's ecology for mammals that eventually would evolve into humans. Some evolutionary scientists now make a great deal of the exquisite sensitivity the shape of life today has to such past contingencies, claiming that if we rewound the tape of evolution, it would never produce the same results a second time. Of course, biologists also recognize the ordering influence of law and "necessity" whereby contingency is kept within bounds, but the explanatory role given to random events, which by definition have no intelligibility, is especially problematic. Once again Polanyi's typical strategy of evading an either/or choice by devising a both/and solution proves to be provocative and productive. Unpatterned, unpredictable, contingent events are necessary but not sufficient, important but not explanatory. He suggests that only if we supplement our knowledge of efficient causation with a consideration of formal, "morphogenetic" causation (a point that Polanyi later unfolds in terms of the notion of information: Polanyi [1968] 1969, 227–30) and final causation will we have a scheme of intelligibility sufficiently rich to account for life and emergence.

Polanyi harmonizes the distinct roles of efficient causation, on the one hand, and formative and final causation, on the other, by way of his argument that open physical systems can "stabilize" and preserve "the highly improbable fluctuation of inanimate matter" that creates the circumstances within which an innovation may arise; in this sense, open systems make "the improbable probable" (p. 384). A stable open system

is impossible apart from a sustaining configuration of material stuff, but the ordering principles of the system, rather than the sustaining material itself, constitute the *identity* of the system. The sustaining material does not produce the operating principles but is the condition of their concrete actualization. The material conditions have the power to *release* the action of operational principles, and among the conditions that allow them to become actualized are events that appear to us to be completely random. An example taken from the inorganic realm is a flame that can be ignited by a variety of random fluctuations in the "physical or chemical topography" (p. 384). But such accidental fluctuations are not identical with the flame itself, nor can they even be said to be its adequate cause. A random event may be the occasion or triggering circumstance that allows certain formative stabilizing principles to come into play, but it would make little sense to derive the full intelligibility of natural systems from events that we simultaneously acknowledge to be inherently unintelligible. The operational principles of a flame act upon the material substrate to stabilize any accidental configuration that established the conditions of the system: "The atomic configuration which ignited a flame keeps renewing itself within the flame. It is a fundamental property of open systems . . . that they stabilize any improbable event which serves to elicit them" (p. 384). In this sense, the action of the operational principles is at once dependent and self-sustaining (p. 394).

What is true of inorganic systems like flames is no less true of living systems. We cannot really understand organisms without also appealing to the notion of formal operational principles that lie ontologically at a level hierarchically distinct from that of the continuum of efficient and material causes in which evolutionary scientists have long sought to find the exhaustive explanation of life. In Polanyi's view, the neo-Darwinian attempt to explain life and evolution by giving thick causal status to accidental events occurring within this continuum is self-contradictory: it is logically unthinkable for accidental advantages to produce new operational principles. At the same time, however, Polanyi agrees that evolution cannot be understood apart from careful attention to the accidents of mutation and unlooked-for reconfigurations of contingent factors. Unpredictable mutations and adventitious changes in circumstances play a highly important role, but "their proper status [is that] of merely *releasing and sustaining the action of evolutionary principles* by which all major evolutionary achievements are defined" (p. 385; Polanyi's italics). In the actual formation of living beings, we must acknowledge the complicity of operational principles that systematically pattern the (otherwise unintelligible) dynamic and material constituents of life.

On the basis of Polanyi's clear distinction between operational principles and triggering circumstances, it becomes possible to give proportion

to the dramatic claims by many contemporary biologists that life came about purely by accident, perhaps in the chemical equivalent of Darwin's "warm little pond." Polanyi is exceptionally sensitive to how such a notion, which may be innocuously and trivially true at a certain level of causal analysis, may be taken as scientific substantiation of nihilistic modern suspicions that nature and life therefore have no inherent meaning or value. Thus, while he is completely open to the possibility that *historically speaking,* random events were involved in the causal chain that led to the emergence of the first living cell, he also insists, and this is a distinctive mark of his metaphysics as well as his evolutionary theory, that in order for life to have a chance of coming into existence at all, *nature must already be ordered* in such a way that random events can be stabilized into enduring open systems constrained by organizational principles whose presence cannot be accounted for by one more evasive appeal to the notion of chance. In light of recent developments in the physics of chaos and the new sciences of complexity and self-organizing systems, Polanyi's proposal no longer sounds as mystical as it may have only thirty years ago.[10]

4.2 Accounting for Evolutionary Novelty. Nevertheless, it is inevitable that Polanyi's thought will sound mystical and vitalistic to his neo-Darwinian adversaries. After all, they would complain, who has ever seen or felt the intangible operational principles that adventitiously appear on the stage of evolution when the triggering circumstances are right? Why do these causes not show up within the matter-energy continuum where we can discern more *visible* traces of the purely *material* conditions that led to life and mind through a process of pure improvisation? Any attempt to explain life and evolution in terms of nonenergetic morphic principles will certainly be greeted with the same distaste with which his objectivist critics have typically treated Polanyi's appeal to the mystifying idea of personal knowing—an appeal treated as an intellectual atavism, a reversion it is difficult to credit at a time when, as Dennett claims in his book *Consciousness Explained*, we are at last allegedly in a position to give a completely materialist account of even mental activity. Moreover, Polanyi's explanation of emergent evolution, wherein "higher levels have in fact come into existence spontaneously from elements of . . . lower levels," which requires the release of successively more subtle "operational principles" (p. 393), intensifies rather than lays to rest the question, "How can the emergent have arisen from particulars that cannot constitute it?" (p. 393).

The exposure of fallacies in a widely accepted argument has independent value, and the validity of the critique does not depend upon the critic's success in fielding a plausible alternative. Yet the reader can hardly be faulted for expecting Polanyi to offer an account that succeeds where

he has shown the received account to fail. His discussion of this topic—localized in section 4, "The Logic of Emergence," of chapter 13 (pp. 393–97)—is among the most cryptic and elusive in the already generally difficult part 4. In the second paragraph of the section (p. 393), Polanyi focuses on the "unfolding of the noosphere" and identifies three possible solutions to the problem of the emergence of novel operational principles from particulars that only occasion, but cannot constitute, such principles: (1) "improvisation of the anthropogenic process" (p. 393); (2) divine intervention, described as the "continuous intensification of an external creative agency" (p. 395); and (3) the inscription of all the works of evolution and of the human mind "invisibly in the configuration of the primeval gases" (p. 393) "predetermined from the start" (p. 395). By "improvisation" he probably refers to the neo-Darwinian solution that he has already shown to be flawed.[11] Principles 2 and 3, the conventional theistic explanations, he fuses into a sort of indissoluble antinomy:

> Looking back on this process of emergence, it seems clear enough what has happened. The passionate urge to fulfill self-set standards will appear *completely determinate* if we too accept the same standards as real and valid; but it is also seen to be *quite indeterminate*, for it is achieved by a supreme intensification of uniquely personal intimations. Such is the logic of self-compulsion with universal intent. Action and submission are totally blended in a heuristic communion with reality; determinism and spontaneity mutually require each other when embodied in the universal and the personal poles of commitment. (p. 396; Polanyi's italics)

Within the framework of Polanyi's logic of achievement and its corresponding ontology of commitment, one can embrace both the scientific notion of physical continuity or causal determinism (even agreeing with mechanists that the material conditions of life are inexorably fixed) and the notion of genuine emergence in which wholly new sets of operational principles seem, inexplicably, to appear out of nothing. Put otherwise, Polanyi sees no contradiction between the traditional hierarchical metaphysics, which posits an *ontological discontinuity* between matter and life, and modern evolutionary science, which highlights the *physical continuity* between nonliving processes and their reliable functioning within living organisms. Unfortunately, materialist neo-Darwinists such as Dawkins, Dennett, and Gould have mistaken the obvious physical continuity in natural history for an *ontologically* uninterrupted plenum in which life is reductionistically absorbed into the sphere of lifeless matter. Reactionary theists have likewise assumed that evolutionary science's uncovering of the historical, genetic continuity in the life story is a threat to traditional valuing of living organisms and conscious persons as ontologically distinct kinds of being.

Much of the misunderstanding on the whole issue of God and evolution today could be eliminated, however, if we would agree that the two

levels can logically be held together in a more comprehensive and richly explanatory synthesis than either materialist evolutionism or antievolutionist metaphysics can envisage. Such a union is possible, according to Polanyi, because there are, as it were, "two forms of existence" (p. 394), and in the emergence of life or individuality, a maturation or intensification can occur at the level of physical processes that brings about the release of unprecedented novelties. Within the framework of the ontology of commitment, the physical continuity and the ontological novelty are not at all contradictory. "Difficulties arise only when we look at the fragments of the commitment non-committally" (p. 396); in that case, it seems that it has to be one way or the other.

Polanyi may seem to be left, then, in the unlikely position of embracing the neo-Darwinian notion that emergent evolution occurs as the result of random, meandering improvisation. In a sense, he can accept this option, since at the level of efficient-causal analysis—where science abstracts from any considerations of commitment and achievement—this is all that objectifying knowledge will be able to see. However, once we allow that achievement and commitment are inherently real aspects both of human knowers and of the living beings they seek to know—and we have already seen that Polanyi believes that it would be self-contradictory to deny this—then a whole new vista opens up. Then our "committed" sense of the ontological discontinuity between the living and the nonliving levels is in no sense contradicted by the scientist's sense of physical continuity elicited by a noncommitted method of examining the material constituents of the life process.

In *Personal Knowledge*, Polanyi's reasoning on this point is as intricate as any we find in the book—and a good deal more condensed. Whether or not his argument is finally persuasive, we do not think Grene is correct to criticize it as fallaciously anthropocentric. If any individuals were to trace their ancestors back in a continuous chain of begetting to the point at which the inorganic gave rise to the organic, they would behold at that point a universe "still dead" but with "the capacity of coming to life" (p. 404). As a means of understanding that capacity, Polanyi proposes once again the construct of a generalized field of energy or forces, a morphogenetic field:

> Morphogenesis, operating under the direction of a morphogenetic field, is a somatic process of the same kind [as the somatic process accompanying comprehension], but following *morphological rightness* [Polanyi's italics] as its standard of achievement. Yet it may be described as equilibration, to distinguish it from the operation of a machine-like framework, and also to illustrate the *inexhaustible resourcefulness* [our italics] shown by the morphogenetic process. (p. 398)

As is the case with other, more familiar, sorts of fields, the action of biotic fields transforms potential into actual energy. It does this along

"gradients of phylogenetic achievement" (p. 402) ordering the action of "a field of centres" (p. 404).

> Just as mechanical forces are the gradients of a potential energy, so this field of forces would also be the gradient of a potentiality: a gradient arising from the proximity of a possible achievement. Our sense of approaching the unknown solution of a problem, and the urge to pursue it, are manifestly responses to a gradient of potential achievement; and when we identify a morphogenetic field, we see in it in fact a set of events co-ordinated by a common gradient of achievement. (p. 398)

However, biotic fields are not so much fields of mechanical force or preformed pattern as "fields of opportunity and of a striving directed towards this opportunity" (p. 404) along the gradients of energy ("pathways": p. 402) by means of which the centers of action are affirmed and supported in their approach toward novel achievement before the nature of the achievement can be apprehended.

This is an account that supposes final causes and active, responsive centers. Any account of life that fails to acknowledge the operation of final causes or the reality of self-acting biotic centers even at the level of single-celled life-forms will necessarily be, in Polanyi's view, incoherent. We must remember, though, that Polanyi has taken the position that it is precisely our modernist inability to think in this fashion that constitutes the "mutilation" worked on our intelligence by several centuries of the epistemological equivalent of Mandarin foot-binding practices. Polanyi holds that anyone who is not impaired in mind can see that "the rise of human personhood . . . demands the assumption of finalistic principles of evolution" (p. 402).

This, then, represents Polanyi's "kind of finalism." Though he himself rather truculently announces that he is prepared to be counted a vitalist (p. 390), we think his argument ought not to be considered vitalistic in the term's usual sense. Polanyi does not propose that we believe in some intelligent spiritual power that is fundamentally separate from material reality. He does not suggest that some adventitious vital entity miraculously animates dead matter. What he does do is undertake to reinstate activity as a metaphysical category and agency as a feature of the real. The myriad self-acting centers, being uncaused (though not unconditioned), are all first causes or prime movers, however primitive they may be; most are influenced by more comprehensive centers under which they are "consolidated." These more comprehensive centers represent a succession (both temporally and morphologically) of steadily more comprehensive fields of final causation which open the trajectory along which the self-acting centers may achieve the potential intrinsic to them.[12] Polanyi "attributes to certain achievements—whether self-centered or aiming at universality—the power to promote their own realization," though not with "unlimited scope" or "unbounded resourcefulness" (p. 399). The

striving of the centers toward these achievements is the striving of each center after its own good, toward which it is "prompted" and for which it has "innate affinity" and in relation to which it may succeed or fail. Thus, beyond all the biotic fields, "we may envisage then a cosmic field," and whatever else we religious may be doing in our worship of that which we name as God, we are placing ourselves in relation with that "First Cause and Ultimate End" that calls activity out of a dead universe, endows agency with a restless longing for the good, and answers to that longing.

NOTES

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1. The Michael Polanyi electronic discussion list was established in 1994 and is moderated at St. Bonaventure University by John V. Apczynski. The address is Polanyi@sbu.edu. For information about access to the list archive, contact apczynski@sbu.edu.
2. The most notable of such neo-Darwinist arguments are in the works of Richard Dawkins (see, for example, Dawkins 1986, 1995).
3. Pannenberg 1993, 13–14, 37–40, 58. It should be noted, however, that Pannenberg may be attributing a causal power to the divine "field of force" that is not directly implied in the mathematics underlying physicists' use of the metaphor. As Polanyi employs the image, however, it is more in the sense of formal than efficient causation.
4. Monod also characterizes Polanyi's arguments as "oddly lacking in strictness and solidity" (1972, 28).
5. Jacques Monod, for example, says that living beings are "chemical machines" and defines the organism as "a self-constructing machine" (1972, 45–46).
6. In later writings, Polanyi shows in more detail how the DNA molecule functions as a source of the ordering principles in the development and activity of organisms. Francis Crick was so impressed by the role of complex molecules in the formation of life that he proclaimed the reducibility of "all biology to chemistry and physics" (1966, 10). Polanyi, on the other hand, is impressed not only by the chemistry but also by the *specific sequence* of the nucleotides A, T, C, and G in DNA, for it is not so much in the chemistry itself as in the informational patterning of the nucleotide "letters" that the formative features of life are embodied. Although A,T, C, and G are indeed purely chemical, their *specific sequence* in the cell's DNA is extraneous to chemistry (See Polanyi [1968] 1969).
7. In chapter 12, "Knowing Life," Polanyi does more than just blithely assert the reality of such centers. His preemptive reply to his critics has two major components. The first is his innovative use of field theory (see § 1) to ground a thoroughgoing reconsideration of what constitutes an organism. The second is an extended appeal to the witnessing presence of the scientist. This latter argument is essentially an attempt to expose a contradiction between the philosophical account of science and the actual practice of science. While theoretically denying the reality of integrative centers, biologists can operate as biologists only to the degree that they recognize and assume the reality of such organizing powers. In this sleight of mind, "we meet with the typical device of modern intellectual prevarication. . . . Knowledge that we hold to be true and also vital to us, is made light of, because we cannot account for its acceptance in terms of a critical philosophy. We then feel entitled to continue using that knowledge, even while flattering our sense of intellectual superiority by disparaging it. And we actually go on, firmly relying on this despised knowledge to guide and lend meaning to our more exact enquiries, while pretending that these alone come up to our standards of scientific stringency" (p. 354).

8. The quoted passage cross-references this text from p. 323: "My body may be said to be alive to the extent to which its parts are functioning as elements in a joint operation and these operational principles are rational. Life is a stratagem, in which each element must rely on it that the other elements will support it, and each consecutive step in a sequence is taken in the expectation that the next will suitably continue it."

9. Polanyi's later work, especially that summarized in *Meaning* (Polanyi and Prosch 1975), provides a rich account of how such religious meaning is embedded in symbol, myth, and metaphor.

10. In fact, Polanyi has much to contribute also to these recent scientific discussions (many of which are still implicitly reductionist and materialist) because his clear, logical distinction between self-organizing systems that operate automatically and more centered living systems that act and achieve is a distinction that is still missing from this literature.

11. Structurally, it seems odd that he would revisit an option he has already dismissed. It is possible that *improvisation* is rather meant to represent his own religiously weighted alternative, which he means to contrast with the more conventional theistic explanations that are the focus of his consideration in this section. If this interpretation were developed, *improvisation* would be understood not as the blind and wasteful groping by which certain life-forms are thrown up by chance and preserved amid tremendous loss by a differential death rate; rather, improvisation would be understood as the extemporaneous performance of a resourceful center organizing its field of influence in unpredictable ways toward ends that it may only dimly and inchoately sense as transcendent possibilities. On this interpretation, improvisation would be introduced here as a conceptual bridge between the pivotal argument concerning the equipotentiality of all life-forms and the book's closing image of creatures accepting "a short-lived, limited, hazardous opportunity for making some progress of their own towards an unthinkable consummation" (p. 405). This is not, however, the interpretation that we have adopted for the remainder of our discussion, and it will not be pursued here.

12. The relation of his notion of comprehensive centers to biotic fields is one of the obscurities of the argument that we have not yet resolved to our satisfaction.

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