Review Essay on Faith and Science

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Aristotle's Revenge: The Metaphysical Foundations of Physical and Biological Science. By Edward Feser. Editiones Scholasticae, 2019. 515 pp.

Emergence: Towards a New Metaphysics and Philosophy of Science. By Mariusz Tabaczek. South Bend: University of Notre Dame Press, 2019. xxii+396 pp.

Essence in the Age of Evolution: A New Theory of Natural Kinds. By Christopher Austin. New York: Routledge, 2019. 144 pp.

Logos to Bios: Evolutionary Theory in Light of Plato, Aristotle, and Neoplatonism. By Wynand De Beer. New York: Angelico Press, 2018. 278 pp.

Finality in Search of Form

Three idioms of speculative philosophy have played a determining role in the history of Western culture: the Athenian visions of ancient Greece and their monotheistic interpretations, the rationalist systems of the Enlightenment, and the post-Kantian modes of evolutionary metaphysics, from Idealism and Romanticism, through vitalism, to process and emergentist thinkers. The second rose to prominence with Newtonian science and declined with it. The third has colored at times both evolutionary biology and contemporary physics, receding intermittently behind new variations of mechanistic materialism.

Talk about teleology has ebbed and flowed at roughly the same rhythm. While it is true that final and even formal causality never disappeared

entirely among the rationalists (e.g., Gottfried Leibniz), modern science eliminated both from the study of nature. With post-Kantian philosophy, final causality reappeared greatly transformed, broken out of its relation to a substantial form—teleology without a *telos*, as some Thomists jabbed at Henri Bergson. After decades of a neo-Darwinism fed by advances in molecular biology, one easily forgets the wide influence that something akin to Teilhard's cosmic finality of "complexity-consciousness" had at the time of the "modern synthesis." Though he was no friend to teleology, Stephen J. Gould began calling for an extended synthesis nearly fifty years ago, and evolutionary-developmental biology ("evo-devo") has of late put neo-Darwinism on the defensive.[1]

Now, it will not surprise Aristotelians that, as morphology and ontogenesis have become central to biology, teleology too has inevitably entered back into consideration, albeit mostly in the guise of downward causation, emergence, self-organization, or other terms associated with complexity sciences. In these same discourses, we find a groping towards formal causality as well, occasionally with reference to Aristotle himself. This essay will review some recent Aristotelian efforts to appropriate these trends, but any renewal of formal causality will have to confront the apparent conflicts between evolution and hylomorphism *and* respond to a range of philosophical alternatives that have remained much closer to the science.

Evolution seems hopelessly to blur any constant forms and the *telos* that guides them. So the explanatory functions of hylomorphism collide: ontogeny cries out for the formal cause, but phylogeny dissolves it. The becoming individual demands a determinate *eidos*, but evolution refuses fixed kinds. The relative success of post-Kantian philosophies of nature derives, in part, from their interest in consciousness (rather than form) as a point of departure; the diverse ways in which this interest can take up the scientific particulars of phylogeny, morphology, and neurology in exploring modes of consciousness; and the vague cosmic teleology into which those can be fitted. By contrast, Aristotelian notions of essence tend to blunt the

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[1] For an early variation of many such statements, see Stephen J. Gould, "Is a New and General Theory of Evolution Emerging?," *Paleobiology* 6, no. 1 (1980): 119–30. For a recent discussion of development and ecology in an "extended synthesis," see Kevin N. Laland et al., "The Extended Evolutionary Synthesis: Its Structure, Assumptions and Predictions," *Proceedings of the Royal Society B* 282, no. 1813 (2015), royalsocietypublishing.org/doi/10.1098/rspb.2015.1019. For a philosophical dissent, see Tim Lewens, "The Extended Evolutionary Synthesis: What Is the Debate about, and What Might Success for the Extenders Look Like?," *Biological Journal of the Linnean Society* 127 (2019): 707–21.

variety and contingencies of evolution (into eternal, unchanging kinds and ontological levels), to divide metaphysics sharply from any such atomistic explanation (and hence from science), and to rope off discussion of the human soul in particular from either set of considerations. If post-Kantian speculative philosophy has rediscovered finality in an aimless, empty cosmos, this *telos* still suffers perhaps from what Marjorie Grene called "eidophobia," lapsing into a lurching vitalism.[2] Hence the contours of a dilemma in natural philosophy that would have perplexed Aristotle: finality in search of form.

This review essay examines four recent Aristotelian interventions in philosophy of science and biology with an eye to their recovery of formal and final causes, emphasizing the particular role given to mathematics in each.

Structural Realism and Substantial Form: *Aristotle's Revenge*

Thomists come in all shapes and sizes, but only a certain sort willingly describes his philosophy as "scholastic." Edward Feser is—quite happily—that sort, and many readers of this journal will already know him as a veteran philosopher with a broad range of interests and a talent for crystalline (and sometimes biting) prose. *Aristotle's Revenge* is not a modest work. Its thesis is that Aristotelian-Thomistic metaphysics is "presupposed" not only by the scientific method that displaced it, but by quantum mechanics, relativity physics, and evolutionary biology. Feser rejects a weaker version of this claim, one that entails only the *compatibility* of autonomous science with certain metaphysical supports, asserting instead that the scientific method "could not possibly be deployed unless the natural world is more or less just as the Aristotelian says it is" (74). That is a bold statement.

Since others have provided solid and readily available summaries of this book, this review will focus on a handful of critical issues.[3] I am skeptical that Feser makes good on this stronger claim mainly because his chosen philosophy of science—epistemic structural realism (ESR)—does not provide for the logical dependence between science and metaphysics that he clearly intends. But then the choice of ESR may rank low in Feser's priorities. His primary goal is to establish a certain relationship between science

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2 Marjorie Grene, "Aristotle and Modern Biology," in *The Understanding of Nature: Essays in the Philosophy of Biology*, ed. Robert S. Cohen and Max W. Wartofsky, Boston Studies in the Philosophy of Science 23 (Boston: D. Reidel, 1974), 88.

3 A quick search on Feser's blog turns up links to several good reviews. John Burghardt's review at *Thomistica* provides a fine critical overview, thomistica.net/book-reviews/2019/12/12/what-is-the-philosophy-of-nature-review-of-fesers-aristotles-revenge.

and metaphysics, determined by metaphysics. Here he reaches for Jacques Maritain's means of discriminating between modes of abstraction or degrees of knowledge, with mathematical judgment functioning as the boundary line between science and metaphysics (or philosophy of nature). ESR maps onto this scheme nicely to the extent that it is an essentially mathematical philosophy of science: citing Henri Poincaré, "equations express relations" (159). Having expressed relations in just this way, very little remains of the world science wishes to describe, and as Feser concedes, on ESR's account, science tells us almost nothing about nature in itself. That may leave a wide territory to metaphysics, but it is hard to see how science could then be said to "presuppose" *any* metaphysics whatever.

Feser's solution is to propose that structural realism is "perhaps best understood as simply an application, to the interpretation of mathematics put forward by physics . . . of general Aristotelian realism vis-à-vis universals, mathematical entities, and other abstractions" (170). He does not undertake that imposing task here, leaving open how he would handle the resolutely anti-metaphysical commitments of ESR's main exponents. Much of the anti-reductionist literature he cites to demolish scientism also sits uneasily with both ESR and metaphysics (Ludwig Wittgenstein furnishes a good example). Furthermore, ESR does little to explain the success of evolutionary biology *as a science*, and at least some aspects of what would appear to fall on the side of metaphysical abstraction (especially teleology) so belong to the basic phenomenal profile of living beings that paring them off from science—through mathematical judgment or not—seems unhelpful (to the metaphysician), if not impossible (for the scientist). His construal of teleology in animate substances may trouble these disciplinary and epistemic boundaries and perhaps also classical hylomorphism. If there were a mode of mathematical modeling more amenable to Aristotelian categories, to evolutionary biology generally, and to the dynamics of complex living systems in particular, it would fulfill Feser's interests far better than ESR.

All true substances are teleological, and he locates final causes at five distinct levels: (1) in the "bare pointing" of an efficient cause to its "characteristic effect" in even inorganic phenomenon, (2) in complex inorganic processes with "successive stages" (like the water cycle), (3) in the *unconscious* organic teleology of vegetative life, (4) in the *conscious* organic teleology of animals, and (5) in the *rational* teleology of humans (38–39). The salient question is to what extent these *teloi* are *continuous* and how substantial forms act in evolution—"whether one kind of substance can give rise to an irreducibly different kind of substance" (428).

Feser carves a parallel pair of distinctions between "mitigated" and

"universal" transformism and between "theistic" and "naturalistic" Aristotelian views of evolution (428–32). The first provides for substantial change between species only within certain phyla or perhaps across the ranks of animals, whereas a universal transformism sees substantial change occurring across the entire range of beings. Mitigated transformism requires "theistic" evolution in that God has to intervene at life's origin and possibly at other important evolutionary transitions. Universal transformism is naturalistic in the sense that it views nature as one continuous causal fabric across all cosmic change. Thomas Nagel defends a position of this kind, one ultimately compatible with theism.

Anyone taking the first stance has the weight of science against them, but Feser tilts in that direction. He argues for the ontological uniqueness of the human soul in a way that virtually necessitates theistic intervention, says that animals are strictly physical, and defends a three-level ontology of material, vegetative, and animal forms. The last piece may be compatible with a naturalistic stance, but the first two clearly are not. Feser does not feel compelled to sort the issue out, however, and he seems to think that a broad account of substantial change is enough to hold open the possibility. The contrast with Nagel is instructive. Like David Chalmers, Nagel takes seriously the combination problem—how the aggregation of apparently material elements (atoms to neurons) can yield a unified phenomenal consciousness. No evolutionary approach to consciousness can get around this, and one wonders what Feser would do with the "varieties of subjectivity" so artfully described in Peter Godfrey-Smith's *Other Minds* or Evan Thompson's neurophenomenology.[4] Consciousness in all its forms is contingent upon some underlying material configuration, and even if capacities like reason or self-consciousness are unified in ways that aggregation can never explain, human ontogeny recapitulates phylogeny so as to require a more continuous view of human evolution, which is difficult to imagine without a panpsychism or neutral monism like Nagel's. The intellectual—the rational—satisfaction of naturalism lies in these continuities.

Accepting a universal, naturalistic transformism has far-reaching consequences for teleology and substantial form. The coincidence of *telos* and

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[4] On the combination problem, see David Chalmers, "The Combination Problem for Panpsychism," in *Panpsychism: Contemporary Perspectives*, ed. Godehard Bruntrup and Ludwig Jaskolla (Oxford: Oxford University Press, 2016), 179–214. For Godfrey-Smith's materialist but still phenomenologically rich account of these issues, see "The Varieties of Subjectivity," *Philosophy of Science* 87, no. 5 (2020): 1150–59, and *Other Minds: The Octopus, the Sea, and the Deep Origins of Consciousness* (New York: William Collins, 2016).

eidos in Aristotle was limited to a single being. Nagel's universal teleology, by contrast, runs somewhat spasmodically through the whole course of cosmic evolution, with its billions of years and trillions of galaxies. The primary potency it actualizes is for consciousness or mind. That suggests a drastic reconstruction of teleology, including teleological arguments for the existence of God. Feser has a lot to contribute here, and not just his excellent skewering of intelligent-design theorists (I doubt that anyone else has so thoughtfully distinguished *design* arguments from *teleological* arguments proper).[5] It is unclear how substantial forms would fit into a universal transformism of this kind. Nagel speaks as if material structures trail behind the actualization of consciousness and are explained by the combinatory possibilities of preceding configurations, which limit the expression of a latent cosmic potency. Substantial forms may give rise one to another, but Aristotle realized that one substantial form turning to another is usually a matter of decomposition and that the birth of a new kind from another is a rare and terminal affair (as with mules). What a universal transformism or naturalistic metaphysics of evolution would seem to require is a deep embedding of all possible *eidoi* in the most primitive, unfolding through a flexible, radial teleology that responds to the contingencies of phylogeny, development, and environment, what Stuart Kauffman called the "adjacent possible."[6]

Another mode of mathematical modeling may offer an exit from several of these problems. René Thom's structuralist topology had roots in pure mathematics but also in morphogenesis and embryology, for which his catastrophe theory developed descriptions of possible transformations and the events characterizing their pathways. Not only do these models extend to biology in a way that ESR does not and attempt to capture the dynamics of morphological change with an eye to form and end, but Thom eventually worked out his models as a detailed interpretation of Aristotle, though more as a phenomenology than a metaphysics. Thom regarded his modeling practices and theorems as instances of a general philosophy of science never completed, one that would displace reductionism and atomism with a renewed attention to the peculiar fact of structurally stable forms. Science would then not merely describe nature, but once more seek to *understand* it.[7]

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5 See *Aristotle's Revenge*, 37–39 and 432–42, but also Feser, "Between Aristotle and William Paley: Aquinas's Fifth Way," *Nova et Vetera* (English) 11, no. 3 (2013): 707–49.

6 Stuart Kauffmann, *At Home in the Universe: The Search for Laws of Self-Organization and Complexity* (Oxford: Oxford University Press, 1995).

7 For an excellent overview of the development and reception of Thom's ideas, see David Aubin, "Forms of Explanation in the Catastrophe Theory of René Thom: Topology,

Whether this kind of structural realism would better satisfy Feser's ambitions is an open question. If he chooses to revisit and expand the eclectic philosophy of science presented here, we may hope to find out. A book of this size and scope is inevitably programmatic, and it would be perverse to criticize the author for not covering more ground when the focus of this review has been so narrow.[8] The reviewer should also acknowledge the difficulty of fairly assessing the full range of Feser's arguments in such a short space, when Feser submits this as a companion volume to his *Scholastic Metaphysics* (2014) and has written at length on many of these topics elsewhere. Pointing to a few significant challenges (particularly concerning universal transformism) and resources (particularly Thom) does not lessen the fact that this is a wide-ranging, stimulating piece of philosophy.

Emergence, Fields, and Formal Constraint: *Emergence*

Thom never specified an ontology for his topological reflections. C. H. Waddington, the pioneer of theoretical biology, pleaded with him to do so and ultimately interpreted their mutual work on morphogenesis in terms Alfred North Whitehead's organicist metaphysics. Waddington linked Thom's topology to Paul Weiss's theory of morphogenetic fields as the causal agency in embryonic development, healing processes, and even the radial energy of adaptive change. Michael Polanyi took up Waddington's morphogenetic fields (but without Thom's topology) in his theory of emergence. Polanyi formulated his ideas during the high tide of neo-Darwinism, and when emergence theories returned on the scene in the 1980s, the field concept had been displaced by self-organization or similar ideas. Among the most influential of these recent emergentists is Terrence Deacon, who developed his theory with explicit reference to Aristotelian notions of final and formal causality.

Marius Tabaczek's *Emergence: Towards a New Metaphysics and Philosophy of Science* aims to reconcile Aristotelianism with these emergentist

Morphogenesis, and Structuralism," in *Growing Explanations*, ed. M. N. Wise et al., (Durham, NC: Duke University Press, 2004), 95–130. For a sample of Thom's reading of Aristotle, see "Les intuitions topologiques primordiales de l'aristot´elisme," *Revue thomiste* 88, no. 3 (1988): 393–49. For a recent assessment of Thom's philosophical significance with reference to Thomas, see Morier Clément and Bruno Pinchard, "René Thom et la Réhabilitation des Formes Substantielles," *Philosophica* 24, no. 47 (2016): 125–40.

8 For an excellent discussion of key issues related to the chapters on space-time (ch. 4) and matter (ch. 5), see the articles in *American Catholic Philosophical Quarterly* 94, no. 3 (2020).

approaches to science (especially biology) by way of dispositionalist metaphysics. A lengthy introduction traces the rise and decline of Aristotelian categories and their recurrence in emergentist notions (e.g., downward causation) of the last century. Part I surveys the basic concepts of emergentism (ch. 1) and several classical emergentist approaches to science and causality (ch. 2) before exploring in detail Deacon's dynamical-depth model as the strongest iteration of such theories (ch. 3). Both the classical and the dynamical versions he judges ontologically underdetermined. The first share the concept of downward causation, ascribed variously to laws or regularities, boundary conditions, constraints, patterns of organization, processes, or entities, whereas Deacon reduces constraints to the "mathematical formalizations of a phase space," none of which have the ontological standing to operate as causes (74). The same goes for the causal efficacy of Deacon's constitutive absences, so that his "teleonomy" is conjured out of mechanistic processes by an ontological sleight-of-hand. Part II has a parallel structure, surveying a half dozen theories of causality in analytic philosophy (ch. 4) and isolating the analytic metaphysics of powers as the most coherent and relevant (ch. 5). The synthetic work is accomplished in the last two chapters, which interpret dispositionalism in terms of more "orthodox" hylomorphism (ch. 6) and apply this neo-Aristotelian position to the ontological vacuum in emergentism (ch. 7).

This is an excellent book. A massive swath of philosophical literature is presented carefully and judged fairly, with steady, neat ordering towards an original synthesis. It is probably the best available tour of recent work on causality by an Aristotelian philosopher. One will find very little to argue with in the surveys of hylomorphism, emergentist thinkers, analytic theories of causation, or dispositionalism, and the neo-Aristotelian reading of dispositionalism in terms of hylomorphism is well-situated in a rigorous field of debate. If the last chapter disappoints, it is only because the reader is led to expect a serious confrontation between hylomorphism and emergence, yielding a higher synthesis—a *new* metaphysics and philosophy of science. A reassertion of "orthodox" hylomorphism is the somewhat anti-climactic denouement.

Moreover, if Tabaczek's project is to shore up deficits in emergentism using dispositionalism, it is not clear what is left of either once they are reduced to a traditional hylomorphism. The criticisms of classical and dynamic emergence and of theories of causation in analytic philosophy all strike their targets; the critical edge of this book does its work gently but decisively. Constructively, formal and final causality do appear to fill the bill, once these deficits are revealed, but the *conflicts* between emergence

and hylomorphism are glossed over almost without comment. Perhaps the conceptual tensions between more orthodox and dispositionalist Aristotelianism are not so great; Anna Marmodoro is very close to Tabaczek already (228–29). But it remains unclear why the *orthodox* hylomorphist really needs dispositionalism to approach emergence at all.

Reconstructing an episode from the history of emergence theories exposes some of these conceptual rifts. Tabaczek criticizes Polanyi, among others, for attributing causal force to "boundary conditions" or constraints while leaving them ontologically ambiguous. The complaint of causal or ontological underdetermination cuts into many emergence theories, but the misrepresentation of Polanyi here is telling. It is morphogenetic *fields*, not boundary conditions, that bear causal efficacy; boundary conditions only specify quantitative operating ranges for the fields.[9] Waddington borrowed the morphogenetic field concept, grafting Thom's topology on top and Whitehead's metaphysics underneath. Both drop out in Polanyi's account, with boundary conditions replacing Thom's topology and Teilhard eventually replacing Whitehead. Ultimately, Tabaczek may be correct, insofar as Polanyi punts the question of why just *these* boundary conditions are actualized to a vague theological teleology, relying on Teilhard, yet this is not so ontologically underdetermined, even if it fails to give a sufficient explanation for form.

But the conflict between hylomorphism and emergence becomes evident at precisely this point. Polanyi identified the structure of living things in the interplay of higher-level boundary conditions imposed on lower-level physico-chemical conditions, on analogy with the blueprint of a machine. His theory of emergence amounts to a complex, hierarchical nesting of higher boundary conditions. The Aristotelian element in his philosophy is evident in the following thesis (with a modest gloss) from his "Life's Irreducible Structure" essay: "The structure [formal cause] of machines and the working [end] of their structure are thus shaped by man, even while their material [cause] and the [efficient cause] forces that operate them obey the laws of inanimate nature."[10] Polanyi never commented on Aristotle directly, but his collaborator, Grene, laid bare the gulf between Aristotle and evolution or emergentism. Aristotelian species are not simply eternal, whereas evolutionary biology knows them to be transitory, but

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9 On morphogenetic fields and boundary conditions, see Michael Polanyi, *Knowing and Being* (Chicago: University of Chicago Press, 1969), 219–21 and 233–35. Admittedly, Polanyi sometimes speaks as if boundary conditions were doing the causal work, but the morphogenetic field is the causal agent.

10 Polanyi, *Knowing and Being*, 225.

rather both *eidos* and *telos* vacillate in the play of genetic, developmental, and environmental forces, such that all becomes flux and flow, between forms but also among the material and formal causes.[11] One need not follow Grene towards Maurice Merleau-Ponty's ontology to accept the gauntlet she sets down. The metaphysical perplexities that arise from the interlacing of causalities, upper and lower, formal and material, in the relation of genome and morphogenesis were noted by Polanyi, but also in frankly Aristotelian terms by Fran O'Rourke.[12]

Aristotelians must confront these problems more squarely. Polanyi's field-oriented ontology is preferable to Deacon's self-organizing materialism and blunts at least some of Tabaczek's criticism. If Thom's topology is reinscribed in Polanyi's morphogenetic fields, this is no mere skein of form as *morphe*, but a rich and consciously Aristotelian vision of form as the dynamic, unfolding functional pattern of life, worthy of the title *eidos*. The "gradient" character of the morphogenetic field, coupled with Thom's topology, also seems to avoid certain problems associated with classical hylomorphism, even if it lingers, as phenomenology, at the threshold of metaphysics. Tabaczek's other writings, especially on divine ideas and Augustine's *rationes seminales*, need a hearing at this point, but could any adherent of Aristotelian metaphysics seriously countenance these moves?[13]

Theoretical Morphology and Eidetic Plasticity: *Essence in the Age of Evolution*

It so happens that Christopher Austin, in his *Essence in the Age of Evolution*, has made use of topological models to reconstruct both *eidos* and *telos* in ways that come quite close to this. While Feser and Tabaczek are adept at identifying Aristotelian vacancies in the life sciences, Austin surpasses both in articulating the basic conflicts between evolution and hylomorphism. His neo-Aristotelian theory of biological natural kinds essentialism leans heavily on a dispositionalist metaphysics (not unlike those criticized by Tabaczek), so much so that one may wonder what is left of the *eidos* in his account.

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11 Grene, "Aristotle and Modern Biology."

12 Fran O'Rourke, "Aristotle and the Metaphysics of Evolution," *Review of Metaphysics* 58, no. 1 (2004): 3–59.

13 See his remarks on divine ideas in Tabaczek, *Divine Action and Emergence: an Alternative to Panentheism* (South Bend, IN: University of Notre Dame Press, 2021), 192–97, and then Tabaczek, "The Metaphysics of Evolution: From Aquinas's Interpretation of Augustine's Concept of *Rationes Seminales* to the Contemporary Thomistic Account of Species Transformism" in *Nova et Vetera* (English) 18 no. 3 (2020): 945–72.

The first chapter defines natural kinds as repeatable structures marked by a "set of properties *p* where any entity *x* belongs to a kind if and only if *x* possesses *p*," provided that (ontologically) the set is "sufficiently natural" and "mind-independent," as well as (epistemologically) "inductively rich" enough to ground a "wide variety of inductive generalizations" about that kind (5). Because essentialism is a more contested notion, Austin distinguishes it from natural kinds with two criterion, both of which concern "modality" (8). The "necessary set" component stipulates that a member cannot lose a particular, kind-defining set of properties without ceasing to exist as a member of that kind, while the "modal fount" component grounds this range of "permissible and prohibited properties" in the essence of a kind (8–9). Significantly, he argues for a certain "looseness of fit" between the nominal (kind-defining) and real (essential) properties that will serve his metaphysical rendering of plasticity. A sketch of the hylomorphic distinction between form and matter likewise distances the "morphological profile" of a being from its form, while granting that, for Aristotle, forms are "incapable of variation" (14–15). A neo-Aristotelian dispositionalism will overcome this limitation.

Austin then guards his theory against a possible misunderstanding (ch. 2). Acknowledging that essentialism has to play two basic roles, one ontological (explaining ontogenesis), the other epistemic (explaining kinds), he is careful to avoid the "conflation of *taxon* and *telos*" by confining essence to the function of "taxon-membership" rather than "taxon-category" (28–29). In short, the question of essence entails identifying which properties mark out *belonging* to a particular species rather than how properties *constitute* a species *per se*, bypassing an infamous question in the philosophy of biology.

Chapters 3 and 4 set out the core of the book's proposal by supplying a dispositionalist interpretation of ontogenesis and locating the site of those dispositional properties in the genetic regulatory networks (GRNs) of developmental modules within organisms. Austin characterizes these "morphomodulary" or "μ-dispositions" as "multiply realizable" by different organic systems, teleologically oriented to goal-states, capable of reaching that goal by multiple routes within a system ("pleonastic"), and in this way able to overcome perturbations in development ("persistent") (39–41). Dispositional properties are "functionally differentiated" or identified by their playing just this orthogonal role in development, but they are also responsive to the (organismal and environmental) flow of information. Austin expends great effort to show that these GRNs are the "ontologically privileged" locus of his dispositional properties by attending to the "precise causal structure of the developmental pathways that begin in the undifferentiated embryo," pathways that are "modularized" in distinct subsystems (44).

The critical move in Austin's book is to model these developmental pathways using a variation on Waddington's epigenetic landscapes. Constructing a morphospace—a hyperspace of possible pathways and end states—helps to visualize the constraint and privileging of certain modes of development. By adding a gradient of stability and defining a topological map with peaks and valleys or "attractor basins" (Thom's term), Austin prepares the way for his singular insight (56–59). The fact that varying morphologies can result from the same genetic base within populations—phenotypic plasticity—would seem to do away with the stable *eidos* that Aristotelians have appealed to in explaining morphogenesis and kinds. By reconstructing morphology around morphospaces and topological landscapes, he reconstructs teleology as an environment-sensitive, pluriform energy, directed to no particular token instance or collection of GRN expressions, but *without* falling into an eidophobic vitalism. These bounded morphospaces give definition to the *eidos* without confining it to a too-specific morphology—what we might call "eidetic plasticity."

This allows him in the next chapter (ch. 5) to head off the "no such set" objection that the properties he wishes to designate as essential are too "anatomically and eidonomically diverse" to sustain that role. He also reworks hylomorphism here, assigning (somewhat counterintuitively?) *form* to the GRNs and *matter* to the abstract morphospatial topology of development. The last chapter (ch. 6) argues that many of these evolutionary objections to essentialism derive not from evolution per se, but only from its neo-Darwinian, adaptationist interpretation, and he underscores the easy compatibility of his metaphysics with evo-devo.

Austin's book has yet to receive the notice it deserves. It may rankle orthodox Aristotelians, and of course essentialism is hardly mainstream in the philosophy of biology, but the promise of his middle course is not without its perils.

The book's main weaknesses all stem from the near-identification of dispositional properties (as essences) with GRNs.[14] First, defending the causal primacy of GRN's creates a small wrinkle in Austin's account of evolutionary theory. His allegiance is to evolutionary-developmental biology as the prime candidate for an extended synthesis, but he vigorously attacks the turn away from genetics in a virtually neo-Darwinian tone (67–68). Reemphasizing the primacy of GRNs within a developmentalist framework

[14] Austin would have done well to settle this question before the last chapters, since his language in earlier parts of the book suggests such an identification, and a more precise summary of the whole argument, which has its share of intricacies, would have been a great help to the reader in the introduction.

may be perfectly coherent and a useful corrective, but some biologists may regard it as backtracking, and a deeper plunge into the science here would have helped his case. Second, and more importantly, assigning dispositional properties to so limited a biological locus produces an artificial confusion of causalities. Austin's intuition is right: metaphysics needs to explain, in detail, why things work the way they do. That means sticking close to the science, as have emergentist philosophers, but the placement of powers with GRNs starts to resemble the structural hylomorphism that Tabaczek acutely critiqued as verging on materialism. Once those powers are cut loose from GRNs later in the book, they begin to lose all ontological mooring.

This points, third, to a problem with his interpretation of essence in terms of powers. Austin has gone in for the "pure" powers version of dispositionalism, according to which powers may float free of substances. Anna Marmodoro (with whom he has jointly published) has articulated well the pure powers position.[15] This appears homuncular, a kind of occult energy known only by its manifestations, which need not be too precise. Austin admits that "painstaking" empirical research will be required to properly draw the boundaries of these properties, but without that empirical work, his reconstruction of essence is in doubt. Many Aristotelians will resist endowing *properties* with the kind of causal force Austin grants them. Properties belong to substances, and the substantial form is the metaphysical cause of the properties which together demarcate the form. Granted, he gets to eidetic plasticity only by giving up substantial form in the traditional sense, and he has given good reasons for doing so. So, if substantial forms are too discrete, and pure powers not discrete enough, is there another way to hook up morphological identity conditions to their metaphysical underpinnings?

Following George R. McGhee, Austin might trade in the morphospaces and topologies of *developmental modules* for those of *whole morphologies* and *adaptive landscapes*. Morphospaces in this case place definitive morphological features in gradients along multiple axes, so that the boundaries between possible and impossible and between actual and merely possible forms become visible. Morphospaces can be converted into adaptive landscapes by adding a third dimension that measures the adaptivity, in peaks and valleys, of specific forms against specific environmental conditions. McGhee's version of these models also incorporates development, stochastic extinctions, and other prominent elements of contemporary evolutionary

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15 Anna Marmodoro and Erasmus Mayr, *Metaphysics: An Introduction to Contemporary Debates and Their History* (Oxford: Oxford University Press, 2019), see ch. 2 and especially 77–89.

science into a potential general theory of biology, what he has termed a "periodic table of life."[16]

McGhee employs geometrical and functional constraints, along with more typically accepted phylogenetic and developmental ones, to understand why evolution converges on similar morphological solutions to similar adaptive pressures. These mathematically defined constraints are "extrinsic"—abstract, universal, and *formal*—rather than "intrinsic," or concrete, particular, and *material*.[17] Here again, we have an example of Waddington's landscape concept being appropriated without reference to the topological models of Thom or the ontological implications of fields. Between the mathematical models of McGhee and Thom there are important differences but more impressive convergences, making them ripe for an Aristotelian interpretation. McGhee has squarely denied, however, that these formal constraints are anything more than the "laws of physics and geometry" in order to exclude teleological readings of convergence. Yet his argument plausibly confirms just the opposite, once his confusion over the meaning of teleology is mended.[18]

These conceptual tools could return Austin's essences to the wholeness of substantial forms. For the *eidos* is a *whole*. That bears repeating. But I pause over his account of powers as recurrent *properties* (i.e., the modal source of morphological *parts)*, for it is often just these "properties" that are the stuff of evolutionary convergence.

Convergence, Consciousness, Form: *Logos to Bios*

Evolutionary convergence remains almost entirely neglected in the philosophy of biology, and not just by Aristotelians.[19] Wynand de Beer's intrepid *From Bios to Logos* hopes to restore final and formal causes by linking a

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16 George R. McGhee, *Convergent Evolution: Limited Forms Most Beautiful* (Cambridge, MA: MIT Press, 2011), 260–63.

17 See McGhee, *Theoretical Morphology: The Concept and Its Applications* (New York: Columbia University Press, 1999), 273–77, and esp. ch. 7 of *The Geometry of Evolution: Adaptive Landscapes and Theoretical Morphospaces* (Cambridge: Cambridge University Press, 2007).

18 See ch. 8 in McGhee, *Convergent Evolution*, and McGhee, "Can Evolution Be Direction without Deing Teleological?," *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 58 (2016): 93–99.

19 The only monograph on the subject of which I am aware is Russell Powell, *Contingency and Convergence: Toward a Cosmic Biology of Body and Mind* (Cambridge, MA: MIT Press, 2020). For one of the few direct philosophical responses to McGhee, see ch. 4 of

Hellenistic *logos* of number to directed, convergent evolution by way of Wentworth D'Arcy Thompson's mathematicized study of morphology. The first four chapters summarize the roots of a metaphysical concept of evolution (ch. 1) as the unfolding of being in Hellenistic cosmology (ch. 2) and biophilosophy (ch. 3), with an interlude on Thompson's theory of transformations (ch. 4). The last four chapters survey the "modern synthesis" up to Gould (ch. 5) and forward a conception of evolution as law-bound (ch. 6), directional (ch. 7), and convergent (ch. 8), explaining the orthogonal character of evolution in terms of Hellenistic categories. Lev Berg's theory of nomogenesis anchors the back half of the argument, with Simon Conway Morris's work on convergence serving as an expansion of Berg's theory.

De Beer's is an adventurous and suggestive book but comes up very short of its goal. Too much of it reads as brisk summaries of complex and conflicting ideas, both in ancient philosophy and in modern science, with far too little attention to primary sources or subsequent fields of debate. The joints in the argument never materialize. His metaphysical concept of evolution as the unfolding of the "divine subject" along a geometrized path of being is problematic even by the standards of ancient philosophy, but to treat Thompson's morphology as if it were straightforwardly teleological and easily elided with this notion (and with no reference to his essay on Aristotle!) simply begs too many questions. Similarly with Berg's theory of nomogenesis, no criticism of which by biologists even enters into consideration. Scrutiny of the footnotes raises concern. Long stretches of the book appear to summarize secondary sources of questionable provenance and cite obscure or non-expert authors or websites more than any reputable sources in the relevant fields.

There are also missed opportunities, above all McGhee's work on formal or geometric constraints and convergent evolution, which gives Thompson's theory a massive upgrade by way computational models pioneered by McGhee's mentor, David Raup. Morris is widely recognized as the signature biologist of convergence, but McGhee's work is more detailed and comprehensive, though not as speculative and concentrated, making it less attractive to philosophers and theologians. If De Beer's interest is freed from a kind of linear emanationist perspective, the connections he traces do hint at an alternative history of evolutionary theory worth fully reconstructing, but that will require far more attention to details both philosophical and scientific.

Convergence is frequently associated with two philosophical themes

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James Maclaurin and Kim Sterelny, *What Is Biodiversity?* (Chicago: Chicago University Press, 2008).

and occasionally with a third: teleology, consciousness, and universals. Convergence, which differs from parallelism and homoplasy only in the temporal and phylogenetic degrees of separation, is the recurrence of similar adaptive solutions to similar environmental pressures. Favorite examples include complex, highly specified organs like the camera eye or broader but niche-specific morphologies like the fusiform body of dolphins, sharks, swordfish, and ichthyosaurs, as well as more seemingly common convergences and evolutionary canards that turn out to share isomorphic but anatomically heteronomous elements put to similar uses. The fact that the number of possible successful morphologies or capacities is so limited, as against the enormous hyperspace of impaired forms or certain failures, and that evolution seems to navigate this space of possibilities with surprising precision, speed, and reduplication across wildly different itineraries, is why convergence is often thought to demonstrate a cosmic teleology in evolution. Such arguments typically rely on the vast improbabilities of escalating complexity.

If teleology needs a *telos*, consciousness usually stands in as the goal. Morris's two major books on convergence have subtitles like "Inevitable Humans in a Lonely Universe" and "How the Universe Became Self-Aware," and he traces in great detail the convergent evolution of distinct modes of sensation and locomotion, eusociality and natality, consciousness, problem-solving, music, and play.[20] Nagel's metaphysics fits smoothly with this picture, though Teilhard was privileging consciousness *and* convergence a century earlier. Nagel and Morris both give a central role to atomism as an explanatory strategy, assuming that the routes to consciousness are a function of combinatory possibilities inherent in the nature of things. Nagel seems to think that morphology will vary widely while the neural base of cognitive functions will be functionally the same, but Morris suggests the exact opposite: the morphologies supportive of something like human cognition will be tightly constrained while similar (prehuman) cognitive functions can derive from the most various neural platforms. In describing these possibilities and the material features that subtend them, Morris turns to the philosophical language of "properties" and even "universals," but without much definition.[21] All of this presents both challenges and opportunities to de Beer's

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20 Simon Conway Morris, *Life's Solution: Inevitable Humans in a Lonely Universe* (Cambridge: Cambridge University Press, 2003) and *The Runes of Evolution: How the Universe Became Self-Aware* (West Conshohocken, PA: Templeton, 2015).

21 See Morris, *Runes of Evolution*, 17–18, and "Evolution and Convergence: Some Wider Considerations," in *The Deep Structure of Biology: Is Convergence Sufficiently Ubiquitous to Give a Directional Signal?* (West Conshohocken, PA: Templeton, 2008), 46–67.

argument, but he addresses none of it. To the extent that Morris's account of convergence steers towards Nagel's reconstruction of teleology, McGhee's emphasis on formal constraints (and not simply material constraints or improbabilities) presents a powerful touchstone for an Aristotelian theory of formal causes in convergence, emphasizing as it does the mathematically precise "engineering" conditions that govern the success of evolutionary experiments.

Conclusion

This review has surveyed some recent Aristotelian retrievals of final and formal causality in dialogue with philosophy of science and biology. In doing so, it has pointed to the relative strength of certain strains of metaphysics that resemble Teilhard's cosmic teleology of complexity-consciousness and have precedent among some notable biologists.[22] Reference to such positions has been primarily heuristic, underscoring the difficulties a continuous transformism of this kind poses for substantial forms, traditionally conceived. Aristotle's hylomorphism was a metaphysical naturalism, an effort to overcome the ontological and causal "gap" in Plato's exemplarism by locating the engines of development within organisms themselves. This generated its own impasses, since compounded by evolutionary biology. I have only gestured at the possibility of relieving these impasses by construing formal causality as the cascading, emergent boundary conditions of morphogenetic fields, mathematically specified by Thom's Aristotelian topology and McGhee's theoretical morphology. I anticipate this would comport well with an Aristotelian theory of universals, while resolving persistent nominalist complaints like multiple exemplification.

The fact that Thom's legacy has been channeled primarily into phenomenology rather than metaphysics (principally by his student, Jean Petitot) may, however, confirm suspicions that the questions to which formal causality was the answer are still on the table. It is by no means obvious that the field concept can generate a consistent ontology which is applicable to contemporary biology. Nor is it clear that a theory of divine ideas, like Tabaczek's, could ground either this ontology or the nascent theory of mathematicals it presupposes.[23] The transcendental Thomists will be worth reconsidering

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[22] Waddington, Theodosius Dobzhansky, Christian de Duve, Harold Morowitz, Stuart Kauffmann, Brian Goodwin, and Rupert Sheldrake would top a very partial and philosophically heterogeneous list.

[23] Paul DeHart's recent work on a "non-Platonic" theory of divine ideas presents some fascinating potential connections to these themes; see *Creation and Transcendence:*

here, as will the work of E. J. Lowe and Lorenz Puntel. This much does seem clear: philosophy of science and philosophy of biology is opening onto an Aristotelian moment that is simultaneously emergentist and Romantic. These two streams will not succeed in displacing the prevailing empiricist and materialist philosophy of science without a concerted alliance. The works reviewed here demonstrate that such a dialogue is well under way—and has a long way yet to travel. N·V

Theological Essays on the Divine Sublime (London: T & T Clark, 2021), see part III, esp. ch. 10, "Improvising the Paradigms: The Divine Ideas as Anti-Platonic Ontology" (241). DeHart's essay "What Is Not, Was Not, and Will Never Be: Creaturely Possibility, Divine Ideas and the Creator's Will in Thomas Aquinas," *Nova et Vetera* (English) 13, no. 4 (2015): 1009–58, makes for a compelling comparison with McGhee, "Exploring the spectrum of existent, nonexistent and impossible biological form," *Trends in Ecology and Evolution* 16 (2021): 172–73. DeHart also points to the significance of James F. Ross's work in this arena.