

Review of *Creative Nature* (part 2)*

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Abstract. The short monograph *Creative Nature* (Francisco Javier Novo, Rubén Pereda, and Javier Sánchez-Cañizares. 2018. *Naturaleza Creativa*. Madrid: Rialp. ISBN: 978-84-321-4916-0. 196 pp. Paperback, €14.25) is a welcome contribution to the philosophy of nature that arose from interdisciplinary conversations between authors who are both up-to-date in the scientific literature and deeply grounded in the western intellectual tradition. In this second part of our review essay, we offer three themes for further reflection: (1) seeing the whole: synergy between philosophy of nature and empirical studies, (2) boundary questions: philosophy of nature as a mediator of dialogue between science and religion, and (3) whether the book helps defend a natural philosophy of form and finality. In conclusion, we recommend this book as a way to bridge science and philosophy and as a point of departure for theological reflection.

Keywords: philosophy of nature; evolution; relationship to nature; boundary questions; form and finality.

* Francisco Javier Novo Villaverde, Rubén Pereda, and Javier Sánchez Cañizares. *Naturaleza Creativa*. Madrid: Rialp, 2018.

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Introduction

In the first part of this review essay, we summarized the main contours of the argument in *Creative Nature*, the recent monograph by Novo, Pereda, and Sanchez-Cañizares. We concluded that review by remarking upon the pedagogical possibilities of the book, particularly by using it as a common text for an interdisciplinary seminar among students of various specialities. In what follows, we offer our own interdisciplinary reflections upon four themes to which our attention was especially drawn when reading and discussing the book. We summarize them as follows: (1) seeing the whole: synergy between philosophy of nature and empirical studies, (2) boundary questions: philosophy of nature as a mediator of dialogue between science and religion, and (3) whether the book helps defend a natural philosophy of form and finality. We conclude that the book is a helpful new aid to progressing in that form of liberal education aimed at achieving wisdom about nature.

1. Points for deeper reflection

1.1. Seeing the whole: synergy between philosophy of nature and empirical studies

In *Creative Nature*, the authors' interdisciplinary perspective is facilitated by a unifying framework of philosophy of nature. Of course, they did not derive this framework from abstract axioms à la mathematical physics, but synthesized their humanities training with their own scientific activity. The framework they inherit and further develop enables the cross-pollination of physics and biology. The ambition of many mathematical physicists is to describe nature in terms of generalized equations, and the authors discuss the goal of unification at some length.¹ In the literature and in the working lives of some scientists there has been a clash of cultures between mathematical physics and biology. There has been an active debate about

¹ See the section "Systems" in the chapter "Nature" (Novo et al. 2018, 14–19).

this over the past century. Biology was criticized because it did not stand up to the rigours of mathematical physics – which has a particular style and approach. Biologists, naturally enough, took issue with this criticism.

What is the difference between biology and physics, and are they the same at a deeper level? In the late 1990s, the celebrated biologist Ernst Mayr wrote an essay about the autonomy of his discipline as an apologia for the particular methodology of biologists (Mayr 1996). Mayr, at this point a professionally accomplished biologist and sharing the wisdom of his years, argues that biology is just as much a science as physics and chemistry. But can anyone master all of contemporary science? Are disciplinary boundaries more of a limitation in our practical capabilities, rather than our diverse methodological approaches? To give a concrete example, will biology and physics be the same when we can calculate biological phenomena from fundamental quantum chemical equations? Mayr weighs in on these questions in multiple essays and books (Mayr 2004). He reflects on what is particular to biology, such as its focus on historical narratives and evolutionary causes working at time scales far removed from our human intuition.

The biology of proximate causations can indeed, to a large extent, be reduced to chemistry and physics. Yet nothing in the realm of physics and chemistry is equivalent to the evolutionary causations that are controlled by the genetic programs of all organisms. Simply to ignore a major determinant of all biological processes is both bad science and bad philosophy. (Mayr 1996, 104)

Biology and physics followed different historical paths, which makes sense because they were studying different aspects of reality and needed different frameworks to do so. In modern research universities, students are often taught them using different methodological frameworks, while their synthesis is covered in more advanced courses. Yet working scientists naturally develop their own mental movies that bridge between microscopic models and experimental observables. The textbook *Biological Physics: Energy, Information, Life* (Nelson 2013; first edition 2004, updated 2013) explores the apparent paradox of life and the second law of thermodynamics. Nelson resolves the apparent paradox through keeping track of system and envi-

ronment and their respective thermodynamics properties: entropy, total energy, and free energies. While the entropy of the entire whole has an overwhelming probability to increase, the entropy of a system can decrease while the entropy of the surroundings compensate by increasing even more. Depending on what properties are constant (pressure, temperature, volume, etc) different treatments (such as Helmholtz/Gibbs free energy, enthalpy) are more mathematically convenient and are equivalent to a net increase in the entropy of system *and* surroundings. While such treatments help us match biological phenomena with predictive equations, do they address the deeper questions? Why this phenomena? Why these equations?

Since Mayr's time, the discipline of biophysics has brought the objects of biology and physics closer together. It seems that life at a molecular level could be simulated by the equations of quantum mechanics, if we had computing power sufficient to the task. However, it also seems that we do not need to go to such a deep level of theory to understand the causal relationships in living beings. In fact, the difficulty to accurately simulate noise and dynamical fluctuations, the fragility of numerical calculating schemes to initial conditions, could lead one to prefer coarse-grained models (Kmiecik et al. 2016).

If we listen to noise we can hear what it has to say about nature. Noise can be seen in a much broader light than embarrassing error bars on an experiment. The areas of measurement theory, the distinctions between the Kennard, Heisenberg, and Robertson uncertainty relations,² mathematical models of random walks, and digital signal processing all influence the topic and provide fruitful tools and perspectives. As an example of the science of noise, we would like to point out a highly cited review from the early 1980s by Robert Shaw, a chaos theory pioneer (Shaw 1981).³ Shaw describes systems that create or consume information, from the vantage point of our knowledge of their state, and how this changes as time evolves. From this perspective one can raise all sorts of interesting questions about how we define the system and observer, and about what is happening globally. The authors of

² Rizzi 2018, 85–88, 240–241.

³ In 1988 Shaw was awarded a MacArthur Fellowship (also known as a genius grant) for his work in chaos theory in 1988 (MacArthur Foundation 2005).

Creative Nature are interested in where things are going globally and they make connections between these insights from physics and contemporary evolutionary biology. Contributions from diverse disciplinary methodologies can help us understand nature's deepest mysteries, such as life.

What does it mean to understand life? In *Creative Nature*, the authors philosophically reflect on contemporary science while not shying away from profound and perennial questions. To understand living beings as “*hierarchically organized systems, operating on the basis of historically acquired programs of information*” (Mayr 1996, 103), environmental context is critical. In fact, from an Eco-Evo-Devo perspective (introduced below), the intertwining of dependencies and communication can be so enmeshed and complex, that naive classification schemas of autonomous beings separated on the tree of life can hold us back from a nuanced and mature understanding of what is going on around us.

Alexander von Humboldt was a pioneer in the study of biological relationships in their environmental context. Humboldt was famous in his time and the young Darwin greatly admired him. Humboldt was known as the Shakespeare of science,⁴ and his recognitions by contemporaries are catalogued in encyclopedias (Wikipedia 2018). For instance the German physician and physiologist, Emil Du Bois-Reymond, wrote that “Every scientist is a descendant of Humboldt. We are all his family” (Walls 2009, ix). As Darwin sailed to the Galapagos, his constant companion was Humboldt's *Personal Narrative* (1819–1829, 7 vols.), which narrated Humboldt's own voyages to South and Central America half a century before. Moreover, long before Darwin's voyage on the *Beagle*, he had first encountered Humboldt's writings as a student and been drawn to the life of a naturalist explorer—even taking preparatory steps such as learning Spanish and approaching a merchant in London to inquire about ships (Darwin Online 2019). Who was this Prussian polymath, geographer, naturalist, explorer, scientist and philosopher that Darwin called the “greatest scientific traveler who ever lived” (Darwin 1881)?

⁴ 11 years after the death of von Humboldt, on the 100th anniversary of his birth, the American intellectual Robert G. Ingersoll said in a lecture that “He was to science what Shakespeare was to the drama” (Ingersoll 1869).

Humboldt studied living beings in their ecological context. He had ventured halfway around the world, from Prussia to Venezuela to Washington DC, through wind and waves, to feel the crisp mountain air, the humid Amazonian jungle, and everything in between. By traversing such a lengthy journey, spanning half a decade, Humboldt could notice the large scale interconnections in and among ecosystems. Biographer Andrea Wulf writes that Humboldt

was the first to explain the fundamental functions of the forest for the ecosystem and climate: the trees' ability to store water and to enrich the atmosphere with moisture, their protection of the soil, and their cooling effect. He also talked about the impact of trees on the climate through their release of oxygen. The effects of the human species' intervention were already 'incalculable', Humboldt insisted, and could become catastrophic if they continued to disturb the world so 'brutally.' (Wulf 2015, 58–59)

Upon climbing 5800 meters to the summit of Mount Chimborazo, Humboldt beheld the flow of information, energy and life as a whole cosmos. Towards the end of his life, Humboldt wrote a multi-volume work entitled *Cosmos* with the goal “to recognize unity in diversity, to comprehend all the single aspects as revealed by the discoveries of the last epochs, to judge single phenomena separately without surrendering their bulk, and to grasp Nature's essence under the cover of outer appearances” (Humboldt 1864).

Humboldt paints a portrait of nature in *Cosmos*, his magnum opus. He first reaches into the depths of outer space from the Milky Way to the planets in our solar system. He descends to the earth and describes it at various scales in detail gathered from his first hand travel experience: volcanoes, mountains, jungles, hot springs, the snow-line, organic life, the universality of animal life, relationships of living and nonliving beings in ecosystems. He concludes with human beings in three sections: man, races [sic], and language. Humboldt emphasized the harmonious whole in contrast to competition/striving/violence—a Darwinian ‘survival of the fittest’—a contrast that has biographical and socio-cultural roots (Farooq 2016).

Humboldt's emphasis on interrelationships lives on. His seafaring adventure around the world, his expeditions into interior lands, and his and persevering dedication to systematic quantitative measurements was not in vain. While he passed away over a century and a half ago, and his fame has been eclipsed by Darwin and others, his "invention of nature"⁵ found admirers among poets, painters and politicians like Ralph Waldo Emerson, Edgar Allan Poe, Henry David Thoreau, Frederic Edwin Church, Walt Whitman, Susan Cooper, John Muir and George Perkins Marsh (Walls 2009, 301). His relationship to nature, steeped in lived experience, has surely touched many of us through these sources, even if unawares.

Has Humboldt influenced how we see the molecular cosmos? While Humboldt laid the foundations for studies on a geological scale (Thomson 2009), the technology and disciplinary methodology did not yet historically exist to explore the ecology of the inner lives of cells. In continuity with Humboldt, the Austrian pioneer of general systems theory, Ludwig von Bertalanffy (1901–1972) made major contributions to the study of living systems. Instead of picking a side in the vitalism vs. mechanism debate, von Bertalanffy proposed a theory that

allows for the study of interconnections among systems and accounts for the nature of 'open systems' which interact with their environments. General system theory introduced key concepts such as *open and closed systems*, stressing the role and importance of context and environment, *equifinality*, or the way systems can reach the same goal through different paths, and *isomorphisms* or structural, behavioral, and developmental features that are shared across systems. (Montuori 2011, 414)

Recent advances in scientific technology have enabled us to empirically study living beings from this systems-wide study. For example 'omics⁶

⁵ The title of Andrea Wulf's recent biography of Humboldt (Wulf 2015).

⁶ An English neologism that refers to disciplines that study whole systems and tend to end in -ome, as in genomics, proteomics, metabolomics. These are further refined, for example phosphoproteomics, epigenomics. The Oxford English Dictionary defined the -ome in the context of cell and molecular biology as "Forming nouns with the sense 'all of the specified constituents of a cell, considered collectively or in total'" (OED Online 2018).

technologies such as genome-wide DNA sequencing, RNA-Seq, and mass spectrometry allow us to capture information about the molecules that encode information and transduce it into dynamical structural change at a systems-wide scale. Recent advances that capture single cells allow us to deconvolute bulk and single cell measurements (Hwang et al., 2018). Single molecule microscopy and spectroscopy technologies⁷ are collecting sufficient atomic resolution information such that we can start to bridge mechanistic⁸ and systems perspectives.

Recently, systems perspectives of development and ecology have enriched an evolutionary theory that synthesized natural selection and Mendelian genetics. A wealth of seminal empirical studies, groundbreaking syntheses, reviews, and books are incorporating developmental symbiosis and plasticity into evolutionary theory. A recent review summarizes the field of Eco-Evo-Devo:

The newly discovered, interactive, world of holobionts⁹ and instructive environments is a nature that is different from the biomes seen through the lens of the modern synthesis. Animals are not individuals by the traditional anatomical, physiological, immunological, genetic or developmental accounts. Rather, developmental symbiosis generates holobionts, organisms that are composed of numerous genetic lineages the interactions of which are crucial for the development and maintenance of the entire organism. Moreover, the environment is not merely a selective filter. Developmental plasticity transforms the environment into an active agent in shaping the phenotype. With these changes comes a shift in how we think evolution works. Natural selection may function at the level of the holobiont, genes can sometimes be considered

⁷ For example single particle electron cryo-microscopy, atomic force microscopy, x-ray crystallography, micro electron diffraction, nuclear magnetic resonance spectroscopy, small-angle scattering and other techniques used in structural biology of biomolecules (Worldwide Protein Data Bank 2019).

⁸ I use mechanistic as it is commonly used in structural biology: how one biomolecule interacts with another biomolecule at a quantum / semiclassical level of theory.

⁹ A holobiont is defined in the article as “The eukaryotic organism (host) plus its persistent symbionts. The cow, for instance, is a combination of the mammalian body plus the symbionts, the enzymes of which allow it to digest grasses, and so on.” (Gilbert et al. 2015, 612). Metaorganism can be considered a synonym.

followers, not leaders of phenotypic evolution, and developing organisms can modify their environments and then be modified by them. Documenting, comprehending, and understanding the ramifications of these phenomena are the areas of ecological evolutionary developmental biology. (Gilbert et al. 2015)

If we have a snapshot of the ‘movie of life’ at a microscopic level, *and* an Eco-Evo-Devo lens to interpret these data, perhaps we can start to further refine and update traditional concepts in philosophy of nature and deepen our philosophical wisdom. When we make further distinctions and nuances we do not invalidate prior conceptual frameworks. Why? Because we are seeking to hold onto the core truth contained in concepts that have been passed on from generation to generation and separate the grain from the chaff. Much of scientific knowledge is like this: contextual, partial, but valid (López Ruiz and Woollard 2016). General philosophical frameworks can be a firm walking stick to guide us through the tangled brush of messy empirical studies. For instance, St. Thomas emphasized the importance of relationships against autonomous, isolated substances popular in the toy models of undergraduate physics courses: “Any creature whatsoever subsists in its own being and has a form through which it is determined as to its species *and has an order to something else*” (Aquinas 1888; *ST I*, q. 45, a. 7, c., Leon., 4: 476; emphasis added).

To be more specific, how does an Eco-Evo-Devo perspective challenge and perhaps enrich Aristotelian-Thomistic definitions of substance and accidents? A concise scholastic definition of substance does not synergize with our scientific reasoning if we cannot point to something concrete and confidently say, “this is a substance” and “that is pile of ‘em”. In order to avoid philosophical stagnation, it is critical to be able to connect the perspectives of the philosophy of nature with empirical studies. Otherwise would we not merely be doing “archaeological philosophy”: learning rules of systems of language rather than enriching our grasp of reality? Charles De Koninck warned against seeking a philosophical system as a final end, getting “trapped in verbiage”, “indulg[ing] in endless acrobatics within our heads, regardless of awkward fact”, and becoming “divorced from what we

really know before inquiry” (De Koninck 1964, 16–17). In contrast, a living philosophy can give us new analogies and refine categories that shape how we study the relationships among living beings and the interconnection of causes over time. With the deluge of data from scientific instrumentation captured by digital recording, calm and cool philosophical reflection will set our sails to reach promising new lands. We therefore heartily recommend *Creative Nature* as a commendable example of living philosophy.

1.2. Boundary questions: philosophy of nature as a mediator of dialogue between science and religion

In *The Mind of the Universe*, the scientifically trained philosopher and theologian Mariano Artigas calls upon philosophy to build bridges between science and religion. He emphasizes that each discipline has a way of using language, a particular methodology, and that it is we, the scholarly community, who must build bridges between science and religion.¹⁰ Although the authors of *Creative Nature* do not engage in theological discussion proper, this book is a wonderful point of departure for those souls eager to brave the high seas of theology. The language and examples developed can be further considered from theological perspectives, perhaps with further help from a robust contemporary metaphysics.¹¹ While reading *Creative Nature*, some readers may find themselves at the boundaries of their familiar empirical perspectives and pose questions fitting to such boundaries: What is the source of natural creativity? Does this book just engage how we, as a scholarly community, can relate to and know reality in itself? Is our experience strolling through the park authentic? Can it lead me to its divine source?

¹⁰ See the section “Boundary Questions” in Artigas 2001, 13–20.

¹¹ For an introductory discussion to such a metaphysics, see Rizzi 2004, for many examples of philosophical distinctions that help to begin untangling apparent paradoxes and contradictions in contemporary science, especially topics in modern physics (special relativity, quantum mechanics). Robust metaphysics was recovered and developed by many notable philosophers during the previous century. See Maritain 1995, Simon 1970, De Koninck 2008, Wallace 1996, Weisheipl 1961. One should also consult more recent work by Robert Koons, Alexander Pruss, David Oderberg, Edward Feser, the collection edited by Simpson, Koons, and Teh (Simpson et al. 2017), as well as work by Jacob Klein, Hans Jonas, Leon Kass, Richard Kennington, and Richard Hassing.

In this section and the following we do not base our speculations merely on the image of God based on reason and our ordinary experience of nature—that is, a self-subsistent and perfectly full Being. We also explore the bridge between *Creative Nature* and the most profound revealed mystery of God articulated in the Catholic Christian, biblical doctrine of the Holy Trinity.

Recent papal teaching has shone the light of faith on “the world, created according to the divine model” and highlighted its composition as “a web of relationships” (Francis 2015, 240). In the encyclical letter *Laudato Si’: On Care for our Common Home*, Francis addresses the global community and reminds all of us that our ability to notice and articulate a link between the Creator and creation is challenged by the wounds of our fallen state. Thankfully the light of faith illuminates our gaze, “so partial, dark and fragile” (Francis 2015, 239), so that we can penetrate into new paradigm and draw reason to formulate a synthesis (Francis 2015, 63–64). Faith leads to new paradigms, completely consistent with reason “by preventing research from being satisfied with its own formulae and helps it to realize that nature is always greater” (Francis 2013, 34). And what is the new paradigm for natural creativity and its synthesis with Trinitarian theology? Humboldt was not the first to emphasize relationships, and Christian writers in antiquity (St. Augustine)¹² and the middle ages (St. Bonaventure)¹³ write about the of the cosmos like a divinely composed poem, where each part is beautiful in sight of the whole. Through the Pontifical Academy of Sciences, the Holy See

¹² St. Augustine explains the difficulty we have seeing the beauty of the whole, as we are just a part and see from a particular perspective. “An individual syllable in a living poem would be unable to grasp the beauty of the whole poem, if the individual’s life-span were restricted to the duration of each recited syllabic sound” (Casarella 2006, 487), citing Augustine’s *De musica*, VI.17.58.

¹³ See St. Bonaventure’s prologue to his handbook on theology, the *Breviloquium*: “And so this entire world is therefore described by scripture as proceeding from beginning up to the end by a very well-ordered course in the mode, so to speak, of a very beautifully composed *carmen* [poem or song]. Here one can observe in accordance with its temporal course diversity, multiplicity and equality, order, rectitude, and the beauty of many divine things that proceed from God’s wisdom governing the world. And just as no one can see the beauty of such a *carmen* unless his gaze is directed to the whole verse, so to no one can see the beauty of order and governance of the universe unless he observes it and its entirety.” Translated in Casarella 2006, 488.

dialogues with recent advances in science, many of which were unglimped in Humboldt's time, such as the following workshops which have happened subsequent to the publication of *Laudato Si'*: "Cell Biology and Genetics" (Pontifical Academy of Sciences 2017), "Biological Extinction" (Pontifical Academy of Sciences & Pontifical Academy of Social Sciences 2017) and the "Power and Limits of Artificial Intelligence" (Pontifical Academy of Sciences 2016).

Laudato Si' is not a scientific document, speculative treatise, or theology handbook. It is a magisterial encyclical that interprets, guards, articulates, and develops the true and authentic meaning of supernatural revelation, entrusted to the Catholic Church. Francis makes an analogy between Creator and creature through communication and relationships, citing three questions in St. Thomas Aquinas' *Summa Theologiae*:

The divine Persons are subsistent relations, and the world, created according to the divine model, is a web of relationships. Creatures tend towards God, and in turn it is proper to every living being to tend towards other things, so that throughout the universe we can find any number of constant and secretly interwoven relationships. [Cf. Thomas Aquinas; *ST* I, q. 11, a. 3; q. 21, a. 1, ad 3; q. 47, a. 3.] (Francis 2015, 240)

In these questions St. Thomas is examining the diversity of creatures (q. 47), God's justice and mercy (q. 21), and God's oneness (q. 11). When we look around us we experience diversity and multiplicity, and q. 47, a. 3 examines how exactly things are united. In the body of the article, Thomas cites q. 11, a. 3 and q. 21, a. 1 as having established that "all the things that come from God have an ordering both with respect to one another and with respect to God" (Aquinas 1888, *ST*, I, q. 47, a. 3, c.).¹⁴ He points out the consequences of different worldviews, different cosmologies, such as "Democritus, who said that this world and infinitely many others had been made from the convergence of atoms" (*ibid.*). Although this perspective is ancient, perhaps it will re-emerge if we don't ground our speculation in the oneness of God

¹⁴ This and subsequent translations of the *Summa* are those of Freddoso 2019.

as St. Thomas does: “There must be just one first being that brings all things into a single ordering. And this is God” (ibid., q. 11, a. 3, c.). A world view that claims that “chance—and not any ordering wisdom—is the cause of the world” leads to positing “many worlds” in contrast to a single interacting and communicating totality, ie. a single world (ibid.).¹⁵

Chance, in the sense of stochasticity and random draws from a probability distribution, certainly plays a leading role in our contemporary understanding of nature, certainly at a microscopic level. However, chance is not the ultimate source and ground of being. The scientific enterprise yields knowledge of “the nature of each thing in its own proper order and with its own proper powers” (ibid., q. 21, a. 1, c.). Thomas links this diversity of things with the distributive justice of God, who, like a team leader entrusted with oversight, “gives what is appropriate to all things according to the worthiness of each of the things that exist” (ibid.). Furthermore, this analogy has some caveats: “God is a debtor to no one,” (ibid., obj. 3) and as Creator everything receives the richness of its being as a gift. The transcendence of God knows no bounds and does not distance him to an *astral plane* but instead enables him to be imminent in the deepest and most material structures of reality (Stoeger 2012). “The order that conforms to the measure of His wisdom” (Aquinas 1888; *ST I*, q. 21, a. 2, c.) is the very structure interrelating the whole totality of reality; and science seeks to know this order. There is a marvelous unity within diversity and precisely *this* is a trace of the Trinity. We can stroll through the garden with a smile on our lips and a skip in our step, aware of the presence of its gardener, and in communion with Him.

1.3. Natural philosophy of form and finality?

In light of its promotion of a dynamic systems perspective on nature, the most salient philosophical point that *Creative Nature* raises, and provides resources to articulate more clearly, is the recovery of form. Much contemporary philosophical discourse in the academy characterizes the

¹⁵ Note that arguments from the *a posteriori* perspective are also possible. See (Juarez 2017).

order displayed by nature in Humean terms or through a quasi-Platonic approach to laws as universals enforcing nomic necessity upon events. Yet a growing body of Neo-Aristotelian philosophy of science is defending the reality of powers and dispositions that not only characterize natural objects but underlie our talk of the laws and behaviors exhibited in the course of nature.¹⁶ This interest about dispositional or power ontologies has slowly been gathering strength during recent decades. Dispositionalists offer an alternative to neo-Humean views of causality. As their name implies, they maintain that the properties of natural objects must include dispositional properties: those which are disposed to, ordered to, or prone to manifest or actualize certain other properties, features, or behaviors. The fragility of glass, the solubility of a salt, or other abilities in the non-living and living domains are typical examples.

In considering the contributions made by the authors of *Creative Nature*, we should also keep in mind, as they do, recent debates about reductionism (whether ontological or semantic), as well as emergentism—sometimes associated with talk of “top-down” or “downwards” causality. Taken together, the philosophical discussions of dispositional ontology and the scientific and philosophical considerations of emergentism and top-down causality provide an ambit where *Creative Nature* makes welcome contributions in an approachable and far less technical fashion, thus making these topics available to a wider audience than philosophical specialists. Two examples come prominently to mind: the first concerns the old philosophical notion of form or essence (see Chapters 4 and 6), and the second concerns the equally venerable topic of purpose in nature (see Chapter 5).

First, as to essence or form. As mentioned, our authors discuss in Chapter 4 a range of ways in which evolutionary adaptations are limited, having discussed in Chapter 3 the range of nature’s evolutive mechanisms. They adopt the framework popular since the work of Sewall Wright (Wright 1932) and utilize the analogy of the topography of a landscape to model the fitness of a population for survival (height) against a range of attributes (modeled

¹⁶ See Simpson et al. 2017; Groff and Greco 2013; Jacobs, 2017. Consider also Austin 2018; O’Rourke 2016.

in the plane). This adaptive landscape helps to capture in a graphical model why not just any evolutive leap is possible. However, they note a spectrum of ways that populations search the possibility space of this landscape for “solutions” to the problem of survival (Novo et al. 2018, 108–112). They note that “on our landscape of adaptations or evolutionary solutions, some are visited more frequently because it is easier to achieve them,” whereas other adaptations are rarer achievements due to extreme conditions demanding survival, and “these are the steep, rarely visited peaks” (Novo et al. 2018, 112). Outside this range between the frequent to the infrequent lie the “mythical heights, the Mount Olympus of our landscape” which “is formed by all those ‘possible’ evolutions about which we can be sure they could never occur” (Novo et al. 2018, *ibid.*).

In view of the form of living things, we can hear in their discussion echoes of the Aristotelian *dictum* that nature acts always or for the most part. In this case, evolution possesses its own natural contours that are captured by the model of the adaptive landscape. Further restrictions upon a putative “pure” or “unbridled” evolutionary sequence of mutations are provided by what a population traversing the landscape is able to attain. The authors note the frequent and adaptively advantageous structural homologies between various organisms (Novo et al. 2018, 118), whose adaptations are retained precisely because they work—a sort of reverse evolution is not observed: “a turnabout is tremendously difficult: once a path is chosen, it cannot be re-traced to try out a new possibility” (Novo et al. 2018, 119). This robustness with plasticity (Novo et al. 2018, 141) is explained through the variability of the genetic networks that underlie, but are not sufficient without environmental pressures to explain, the evolutionary process. Thus, the philosopher might ask the scientist at this juncture: Have we in these pages a modern account for formal causality? The authors seem to think so in this sense, once one includes the discussion of emergence from Chapter 6: “Top-down causality functions just like that which philosophy has traditionally called the formal cause” (Novo et al. 2018, 176).

This consideration of formal causality captured in the language of top-down causality and fitness landscapes naturally raises the topic of order and

purpose in nature, or teleology. As noted above, our authors open Chapter 5 with a discussion of biological mechanism that adverts to the possibility that science's search for reasons and explanations or causes only sometimes arrives at the necessary and sufficient conditions for a phenomenon. Theirs is a broader approach to what counts as a cause, which they define "as neutrally as possible" as "all that happens depends upon something; the dependence in existence is called causality, and designates a type of relation between elements of reality" (Novo et al. 2018, 128). This opens up the space for their discussion of function and purpose. They note that "function" can have weaker senses that apply to much more mechanical processes which can "serve for" or "be there for" something else, such as what the weather or volcanoes provide to an ecosystem. They focus on the question of whether or not organic functions exhibit a stronger sense of "purpose" or whether this is merely a human projection. After all, talk of a population searching the possibility space of biological solutions by exploring an evolutionary landscape, or its success in hitting upon adaptations with positive functions, is talk shot through with purposive-sounding language.

Their discussion centers around two non-favored contending explanations before settling on their own preference. The first option, familiar to cosmologists, is an appeal to the anthropic principle and the multiverse. They cast aside such explanations of the apparent existence of order and purpose in nature as circular and scientifically insufficient. (They also discuss the Boltzmann brain problem, that a multiverse hypothesis where all possibilities actually occur in some universe makes non-evolved life more probable than evolved life.) The second option, familiar to students of the history of modern biology, is the design-type, extrinsic teleology frequently attributed to Paley's Watchmaker. Utilizing Mayr's distinction between teleonomic and teleomatic natural processes, both exhibit order, but only the former, biological processes exhibit the stronger case of intrinsic natural purposiveness (as opposed to an extrinsic sort of design). Again, the authors helpfully note that even physical (non-biological), teleomatic processes can exhibit order to an end in a certain way; they provide the historically fascinating case of the principle of least action as an example.

Here we should recall the discussion of the priority of form or function. Our author's solution defends a contemporary definition of "function" in terms of those selected by the evolutionary process: "The function of any structure is that for which evolution has selected it; the evolutionary 'reason' due to which this structure possesses such a form" (Novo et al. 2018, 136). However, we should note that this contemporary definition, at least in the manner in which they defend it, relies upon the prior existence of the potentially functional or dispositionally functional organ or structure:

Perhaps initially there were organs or structures that had—among other things—the *potentiality* to pump blood, or to detect sound waves or photons, and it was precisely these—or at least some of these—structures that little by little were modified over the course of evolution, adapting itself better and better every time to realize this specific function. Consequently, there are authors who prefer to think that a function is, in reality, a *disposition* to act in a specific way depending on a concrete context. (Novo et al. 2018, 135)

Here, then, we have precisely defined for us a classical question in the philosophy of nature and indeed in classical metaphysics. To resolve the debate of the priority of form or function, our authors have appealed to a certain priority between act and potency, or what actually is and what potentially could be. In their approach, it is potency which has the priority, as they indicated above. That is, it is not a need for some function (an activity with its own purpose) that demands a certain form, but rather there already exists a form of life with certain potencies or dispositions (to pump blood, to detect sound waves, etc.). However, isn't this a case of passing the buck? Perhaps it isn't, for the reason that this notion of function depends upon a certain conception of what counts as "nature" or the intrinsic, non-anthropocentric causes in the universe. According to our authors' viewpoint, the nature of life is to be defined by the process of evolvability. Thus, life as a type of natural principle is not itself the last word. One must look to the constitutive elements of the universe which permit the possibility of an evolutionary process. In this sense, the biological tale must curtail itself. It cannot answer in what sense there are potentially adaptable organs, at

whatsoever scale or stage of development. It must presuppose that there are such dispositions available in nature as “natural resources” for evolution.

However, this forces us to ask about “nature” in a broader sense than the complex of causes that sustain the evolvability of living things. The natures of things within the universe as a whole must admit of sufficient order, or sufficient disposition to, such evolvable systems. The parts of the cosmos at a larger scale—do *they* possess natural finality? It is here that our authors’ discussion about teleology suffers needlessly. This discussion, and the distinction between an order in nature that is intrinsic to nature as opposed to an order extrinsically imposed upon nature’s processes, bears the flaw that the *latter* is given the name “teleology,” when it is historically the *former* that takes that name. Let the latter take the name “design” in an anthropomorphic sense. Classical theistic arguments such as St. Thomas Aquinas’s “Fifth Way,” by contrast, take their start from the former and not the latter sense of order in nature. In turn, it is this tradition of arguments that ultimately resolve the question of priority of potency or act, of function (in the sense of purpose) or form, in definitive favor of act and purpose, or finality. Indeed, our authors allude to this traditional position regarding the cosmological problem of apparent design in their discussion of self-directed natural processes (Novo et al. 2018, 66–67). The full quote they allude to is from St. Thomas Aquinas’s commentary on Aristotle’s *Physics*:

Nature is nothing other than the reason of a certain art, namely the divine art instilled into things by which the things themselves are moved to a determinate end: as if the shipbuilder were able to bestow upon timbers such ability that they were to move of themselves so as to take on the form of a ship. (Aquinas 1884; *In Phys.*, lib. 2, lect. 14, n. 8; Leon, 2: 96)

This illustrates the understanding of *teleology* in a sense different than that meant by our authors. By Aquinas’s argument, the order in nature is not imposed from without (intelligently designed like a watch’s parts by a watchmaker), but that order is imbued from within in the very same metaphysically creative act that constitutes the being of natural things. Aquinas therefore argues that an entirely intrinsic order that characterizes

the natures of things in the cosmos is not incompatible with their being derived from a source of order outside the cosmos. The joint discussion of the order within nature, its functionalities and purposes, and the biological vs. ultimate explanation of their origin would have been better served by clarifying the contemporary debate in light of these perennial ideas.

2. Philosophical Possibilities in Conclusion

It is frequently observed that a liberal education is the beginning of wisdom. As a part of a larger curriculum in the liberal studies, philosophy, or the sciences, *Creative Nature* is the sort of book that contributes to heightening the student's awareness of the unity and intelligibility of the natural order. At the same time, it outlines the great extent to which one must be willing to go if wisdom about the true nature of reality is really one's aim. The natural sciences continue to allow us to listen to nature's secrets, and this book, eschewing the specialization that strangles a sapiential, synoptic view of the whole, encourages its readers to take up that aim.

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