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Aristotelian-Thomistic Contribution to the Contemporary Studies on Biological Life and Its Origin

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Abstract: The phenomenon of life belongs to the most intriguing and puzzling aspects of reality, studied in various divisions of natural science, as well as in philosophy and theology. The purpose of this article is twofold. Firstly, it aims at bringing into the rich contemporary conversation on the nature, origin, and persistence of life a deeper and more thorough insight coming from the classical Aristotelian-Thomistic philosophy of nature and metaphysics. Secondly, in reference to the theological aspects of the debate, the article presents the two contrasting positions on the necessity of a direct divine intervention in the origin of life and analyzes them from the same Aristotelian-Thomistic perspective.

Keywords: Aristotle; Aquinas; definition of life; divine action; hylomorphism; origin of life; primary and secondary causation; principal and instrumental causation; teleology; transient and immanent causation

> In biology, nothing is clear, everything is too complicated, everything is a mess, and just when you think you understand something, you peel off a layer and find deeper complications beneath. Nature is anything but simple.
>
> Richard Preston

1. Introduction

The phenomenon of life, its origin and persistence, belong to the most intriguing and unfathomable phenomena in the universe. The complexity of even the most rudimentary forms of life and the vast variety of the possible patterns and configurations of living beings make it difficult to define. The questions of whether life can be explained in terms of the non-living, whether its definition should be grounded in a detailed biochemical and molecular description or rather in a more abstract functionalism, and to what extent it should take into account borderline cases—make the precise characterization of life even more complicated. When entering the meta-level analysis of the studies on the nature, origin, and persistence of life, we encounter not only the epistemological puzzles raised by the complexity of the many interacting sciences involved, but also the challenges of contrasting reduction and emergence, relating biology and chemistry, and specifying the limits of the naturalistic explanation offered by science, which—in turn—opens the way to theology and the vexing question of whether the origin of life required a direct divine intervention.[1]

The purpose of this article is twofold. Firstly, it aims at bringing into the rich contemporary conversation on the nature, origin, and persistence of life a deeper and more thorough insight coming from the classical Aristotelian-Thomistic philosophy of nature and metaphysics. Secondly, in reference to the theological aspects of the debate on life, the article presents the two contrasting positions on the necessity of a direct divine intervention in its origin and analyzes them from the same Aristotelian-Thomistic perspective.

The article consists of ten parts. Sections 2 and 3 enumerate the properties (characteristic features) of living things and categorize a variety of definitions of life based on the

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list of these properties. The following Section 4 enters the meta-level of the analysis of life definitions. The remaining two sections of the first part of the article are dedicated to the puzzling questions concerning the theoretical and methodological aspects of the research on the origin of life, and the meta-level of this interdisciplinary scientific research program. The first section of the second part of the article recalls the most important aspects of the classical Aristotelian notion of life. It is followed by the analysis of three possible contributions of the Aristotelian account to the current attempts at defining life—offered in Section 8. Next, Section 9 addresses the challenging issue of the principle of proportionate causation as applied to the origin of life. Moving to the third part of the article, Section 10 presents the two contrasting positions on the necessity of a direct divine intervention in the origin of the first living being(s). The last section presents some crucial arguments in favor of both views and analyzes them from the point of view of the classical Aristotelian-Thomistic tradition of philosophy and theology. A short conclusion closes the entire study.

2. Properties of Life

On the one hand, an attempt at defining life faces many challenges and has become one of the most discussed topics and a bone of contention among biologists and philosophers of biology.[2] On the other hand, our current scientific knowledge grounds a relatively good and advanced grasp of the characteristic features of things we tend to classify as being alive. Beginning from the latter, more positive approach, we may join Mark Bedau who—following Tibor Gánti—lists the hallmarks of life, which are commonly regarded as neither necessary nor sufficient, yet typical of living systems:

(1) *Holism*. An organism is an individual entity that cannot be subdivided without losing its essential properties. An organism cannot remain alive if its parts are separated and no longer interact.
(2) *Metabolism*. An individual organism takes in material and energy from its local environment, and chemically transforms them. Seeds are dormant and so lack an active metabolism, but they can become alive if conditions reactivate their metabolism. For this reason, Gánti makes a four-part distinction between things that are alive, dormant, dead, or not the kind of thing that could ever be alive.
(3) *Inherent stability*. An organism maintains homeostatic internal processes while living in a changing environment. By changing and adapting to a dynamic external environment, an organism preserves its overall structure and organization. This involves detecting changes in the environment and making compensating internal changes, with the effect of preserving the overall internal organization.
(4) *Active information-carrying systems*. A living system must store information that is used in its development and functioning. Children inherit this information through reproduction, because the information can be copied. Mistakes in information transfer can "mutate" this information, and natural selection can sift through the resulting genetic variance.
(5) *Flexible control*. Processes in an organism are regulated and controlled so as to promote the organism's continued existence and flourishing. This control involves an adaptive flexibility, and can often improve with experience. (Bedau 2011, p. 457) (after Gánti et al. 2003)[3]

Bedau notes that Gánti classifies the aforementioned criteria as "real" and distinguishes them from "potential" criteria that refer not to a single living entity, but to groups of organisms across generations:

(1) *Growth and reproduction*. Old animals and sterile animals and plants are all living, but none can reproduce. So, the capacity to reproduce is neither necessary nor sufficient for being a living organism. However, due to the mortality of individual organisms, a population can survive and flourish only if some organisms in the population reproduce. In this sense, growth and reproduction are what Gánti calls a "potential" rather than "real" life criterion.

(2) *Evolvability*. "A living system must have the capacity for hereditary change and, furthermore, for evolution, i.e., the property of producing increasingly complex and differentiated forms over a very long series of successive generations" (Gánti et al. 2003, p. 79). Since what evolves over time are not individual organisms but populations of them, we should rather say that living systems can be members of a population with the capacity to evolve. It is an open question today exactly which kinds of biological populations have the capacity to produce increasing complexity and differentiation.

(3) *Mortality*. Living systems are mortal. This is true even of clonal asexual organisms, because death can afflict both individual organisms as well as the whole clone. Systems that could never live cannot die, so death is a property of things that were alive (Bedau 2011, pp. 457–58).[4]

3. Definition(s) of Life

The list of properties characteristic of living beings seems to provide a suitable background for an attempt at defining life. As Mariscal notes, much of the current interest in providing such a definition is motivated by the most recent science and technology, including not only studies on the origins of life and astrobiology, but also artificial life, synthetic biology, and various biotechnologies—especially those related to the beginning and the end of human life, human enhancement, transhumanism, and posthumanism (with ethical, legal, and political aspects of these developments).[5]

Mariscal and Bedau both suggest some criteria that may help organize a vast number of proposed definitions of life, which in most cases emphasize one or more of the phenomena mentioned above.[6] Bringing their accounts together, we may list the following meta-categories:

(1) Matter and energy-related definitions of life—they take a more mechanistic (thermodynamic), chemical and biochemical (metabolism-, catalysis-, and biosynthesis-related), or wholistic (function- and purpose-related or emergentist) approach.[7]

(2) Structure-related definitions of life—they take a more reductionist, cell-related (where a single cell is treated as a central feature of life), or hierarchical (and emergentist) approach.[8]

(3) Environmental interactions-related definitions of life—they refer to the micro/macro environment, mutualisms and properties necessary for relating with surroundings and other living beings.

(4) Evolution-related definitions of life—they are based on the categories of heredity, variation, mutation, adaptation, speciation, etc.

(5) Information-related definitions of life—they take either a minimalist or genetic approach. The former strives to specify the least amount of information to demarcate life from non-life. The latter takes genes, their expression, and variability (more recently also epigenetic modifications) to be the origin and basic features of life.

(6) Miscellaneous definitions—they include (i) cybernetic approaches (trying to incorporate computer-based artificial life); (ii) generalist approaches (broad, obscurantist, purposefully vague); (iii) vitalist approaches (grounding life in an as-yet mysterious force); and (iv) parametric approaches (identifying one or more relevant properties of life).[9]

In conclusion of his classification, Mariscal proposes his own definition of life in which he describes living systems as:

> those that are: (1) composed of bounded micro-environments in thermodynamic equilibrium with their surroundings; (2) capable of transforming energy to maintain their low-entropy states; and (3) able to replicate structurally distinct copies of themselves from an instructional code perpetuated indefinitely through time despite the demise of the individual carrier through which it is transmitted (Mariscal 2021, sct. 1.2).

Bedau, for his part, does not offer a conclusive definition of life. Rather, he enters a meta-level of reflection, concluding that all the discussed definitions have, one way or another, an essentialist flavor. They all strive to capture the network of characteristic features and flexible processes in matter that distinguish animate from inanimate systems. He also suggests that:

> [S]cientific essentialism about life might be true, even if contemporary science has reached no consensus about life. Scientific essentialism is a philosophical view about the method by which life's essence would be discovered—it is not a view about the particular content of that essence. The details of the scientific essentialist definition of life might need to await further scientific progress.[10]

4. Meta-Analysis of Life's Definitions

That we do not have one precise and non-controversial definition of life is a well-known fact among both practitioners and theoreticians of life sciences. It is most likely one of the tasks of the latter to explain why this is. In order to do so, a philosopher might try to deepen Bedau's meta-reflection on the nature of the definition we are looking for.[11] As notes Mariscal (2021, sct. 1), traditionally both biologists and philosophers of biology—when searching for a definition of life—aim at providing sufficient and necessary conditions for a given system to be called alive. He suggests to classify such definitions as "real," "ideal," or "philosophical." One might add that they are also essentialist, as their proponents believe in the possibility of specifying one unequivocal notion of life as a natural kind.

While this approach is the most ambitious and profound one, it faces some challenges. It turns out to be impractical and fragile to counterexamples, especially vague (marginal) cases that are hard to classify and some non-living things and phenomena that might be inappropriately included as alive under a given definition. Concerning the former, one might think about viruses and prions (protein products of living beings that can fold other proteins in a way that allows for cumulative evolution) that self-replicate and spread without having an independent metabolism, dormant seeds or spores, and bacteria or insects that are frozen. The latter include fire (on the definition of life as an energy processing phenomenon) or populations of microscopic clay crystallites, growing and proliferating, and capable of undergoing natural selection.[12]

Consequently, one could argue that "real" or "philosophical" definitions set up too rigid a standard. Following this criticism is a list of other possible types of definitions that may potentially be promising in the context of the search for an unambiguous demarcation line between animate and inanimate things (see Mariscal 2021, sct. 1):

(1) Wittgensteinian family resemblance definitions—replacing the rigid requirement of listing necessary and sufficient conditions of a given phenomenon with a cluster of properties that share a family resemblance (they might be useful in sorting out marginal cases).
(2) Operational (working) definitions—based upon the practical study of concrete living beings and their characteristics, favored by scientists yet philosophically shallow, as they are usually narrow in scope.
(3) Nominal (lexicographer or dictionary) definitions—based on the analysis of the usage of a given term (they might be less useful in sorting out marginal cases).
(4) Demonstrative or ostensive definitions—derived from a shared observation and access to natural kinds (they might be less useful in sorting out marginal cases).
(5) Stipulative definitions—introduced and defined by fiat (they may be not specific enough, e.g., the definition of swans as white birds with long necks allows for classifying many cranes as swans and excluding black swans).[13]

The main line of division in defining life separates philosophical and operational approaches. Facing the fact that the vast literature on the definition of life proves to be repetitive and utterly inconclusive, some philosophers of biology show definitional skepticism. They express it either in the epistemological conviction that, due to the diversity

of life, we will never arrive at its general definition or in an ontologically rendered claim that the category "life" is heterogenous and thus not a natural kind. Some researchers go as far as to say that the distinction between living and non-living systems is a human kind—a distinction that is not natural and changes with the development of science and technology (see Keller 2002). Moreover, embracing a more pragmatic attitude, they claim that defining life is pointless as it does not change the scientific practice.

5. Questions Concerning the Origin of Life

Scientific and philosophical struggles in defining life find reflection in similarly complex debates over its origin.[14] Griesemer brings together and lists some of the most vexing questions raised by the researchers in this field:

> (1) did life begin with metabolism, a bounding membrane, a "naked" replicator, or some combination of these? (2) was first life autotrophic (making all of its necessary components itself from simple, small molecules and a source of energy) or heterotrophic (taking in key nutrients from the environment)? (3) did life begin in a soup or at a solid surface; with a hot or cold start; in a strongly, weakly, or nonreducing atmosphere; with photons, hydrogen, heat, or something else as energy source? (4) did first life evolve over a long period of time or arise in an improbable flash of chemical emergence? (5) did first life resemble modern life "in outline" or was it fundamentally different and "taken over" by modern forms that evolved from it? (6) did life on Earth begin on Earth or in outer space? (7) was life an unlikely, wildly improbable, lucky accident or (nearly) inevitable, once the starting materials and conditions were present? (Griesemer 2008, p. 263; see also Bedau 2011, p. 459)

The variety and scope of these questions translate into a diversity of methods applied in the origin of life studies and a wide range of actual theories of the emergence of the first animate being(s). The former include (1) database analyses of classified organic molecular species, (2) reference to geophysical and fossil data, (3) chemical synthesis of components of living entities, (4) experiments on hypothetical early Earth conditions, (5) historical reconstructions of LUCA (the last universal common ancestor of modern life), (6) abstract cell modelling and deductive description of early life based on core functions of extant living beings, (7) geochemical and biological observations of deep-sea hydrothermal vents, and (8) the variety of methods applied in astrobiology. The latter comprise (i) replicator-first, (ii) protein-first, (iii) metabolism-first, (iv) dual-origin, (v) ribosome-first, (vi) thioester and iron–sulfur worlds, (vii) surface metabolism, (viii) "takeover," (ix) exobiological, and (x) neo-panspermia theories.[15]

Entering a meta-level reflection on the origin of life studies, Mariscal suggests that researchers working in this interdisciplinary enterprise usually embrace either the "bottom-up" or a "top-down" approach. The former departs from envisioned pre-biotic chemistry and—referring to physics, chemistry, and biology—strives to specify the way in which life evolved from it. It faces a number of difficult questions. Most notably, the laws of thermodynamics suggest that the most energetically efficient changes on the way that led to the emergence of life would most likely consume the proto-life forms involved. While the suggestion that the environment provided first boundaries (membranes) or even proto-genetic material in a viscous solvent or on a surface is not entirely implausible, the gap between the pre-biotic chemistry and simple life forms seems to be considerable and, as notes Mariscal, our current explanatory strategies "account for a tiny portion of the conceptual distance" (Mariscal 2021, sct. 4).

The second approach begins with current biological taxa and—referring to paleontology, comparative biochemistry, and phylogenetic inference—attempts to specify the nature and the timing of the origin of life and the way that led to the emergence of LUCA. Concerning the latter, opinions vary over its simplicity/complexity, whether it had a membrane resembling current membranes, whether its genome was made of DNA, and whether it was a heterotroph or autotroph.

Most importantly, despite considerable differences between the bottom-up and top-down approaches, they are both endorsed as complementary and indispensable for the further progress of the origin of life studies. Hence, their combination is usually favored to embracing either one of them alone.[16]

6. Meta-Analysis of the Origin of Life Studies

Following Mariscal's and Griesemer's meta-reflection on the origin of life studies, we can name other philosophical aspects of this field of research. Beginning with the question about its very aim (explaining how life could have originated or how it did originate), a number of further questions can be raised in reference to theoretical, practical, methodological, logical, epistemological, and metaphysical aspects of organizing such a complex interdisciplinary endeavor (see Griesemer 2008, pp. 266–70).

6.1. Origin of Life and Evolution

Probably the most important among these questions is the one concerning the relation between the origin of living systems and the theory of evolution. As Griesemer notes (2008, p. 264), "Evolutionary theory is a pretty good theory of transformations, but not such a good theory of origins . . . Indeed, scientific theories generally don't handle questions of origins, generation, innovation, or emergence very well."[17] He claims that many traditional and hotly debated problems in philosophy of biology—including units and levels of selection, the character of replicators, the concept of gene and genotype-phenotype relation, or functionality—become even more problematic in the context of the origin of life studies, which speak about a world of quasi-independent and near-decomposable proto-biological (chemical) systems—a world without genes, organisms, and genealogy as commonly understood (Griesemer 2008, p. 285).[18]

Because the earliest living systems were at the bacterial level of organization, at which level biological information is transferred horizontally rather than vertically (forming a net rather than a tree), it might be legitimate to suggest that life in its origins was not monophyletic and probably not even genealogical. If this is true, even if it is possible to build an evolutionary tree going back to the origin of genes, an analogical well-defined lineage-like pattern of relations going back to the first bearer of genes cannot be established (see Koonin 2011).

Some go as far as Carl Woese, who claims that the first exemplars of cellular life were so different from the known forms of life that they should be classified as a separate category. He coins the term "progenote" to describe living creatures with a primitive translation mechanism that made them unable to produce large proteins, which in turn affected the size of the genomes they were capable to maintain (due to high error rates in replication). He states that progenotes were "more or less bags of semi-autonomous genetic elements . . . that would come and go, especially on an evolutionary time scale" (Woese 1998, p. 6856).[19] This further complicates the assumption that life had an evolutionary origin.

6.2. Time Framework

The other important aspect of the origin of life studies, having a considerable impact on the proposed theories, is the attempt to specify the time framework of the emergence of the first living cell. Here, notes Griesemer, we can observe a considerable shift in the commonly accepted opinion. While prior to the 1960s, researchers traced life back to 540–550 million years ago, today we assume that it was already 3.5 billion years ago that life actually existed. This change is significant. The former estimation suggested that the advent of life was a highly improbable "all at once" chance event that required a vastly long period of preceding trials and errors, while the latter implies that it was a much more probable development effected by regularly operating causes.

Again, Griesemer claims that narrowing the window between the time when the Earth could not yet sustain life (due to its hot temperature and violent natural occurrences) and the time when life actually emerged, provides another argument in favor of the hypothesis

that it did not arise stochastically, after a long waiting time, and all at once, i.e., as a highly improbable chance event, but had a more probable, causal origin. He also thinks that this scenario limits the "space" and necessity of divine intervention in its origin. The idea of such intervention was much more plausible on the low probability scenario.[20]

7. Classical Aristotelian Notion of Life

Having presented the current debate on defining life, which continues to be rather provisional and unsettled, I would like to further contextualize it in reference to the classical Aristotelian understanding of animate beings. I claim that the ancient and modern discourses have much in common and may benefit from each other. More specifically, I want to argue that the former may bring some clarification and coherence to the latter.

7.1. Hylomorphic Essentialism

First of all, we should emphasize that despite the popularity of the operational (working) definitions of life among practicing scientists, and the attractiveness of the Wittgensteinian family resemblance approach to defining life among philosophers, many researchers remain persistent in their search for a "philosophical" or "real" definition of life, which is understood in essentialist terms.[21] Aristotle would certainly support their ambition. At the same time, I believe he would show more reserve toward their version of essentialism, which is defined in reference to the necessary and sufficient properties shared by living things. Naturally, such a phenomenological approach has a role to play in Aristotle's essentialism as well. He does specify powers characteristic of vegetative, animal, and human life, listing them, respectively, as: growth and reproduction, mobility and sensation, and thought and reflection (see *De an.*, books II and III). This corresponds with the properties of life listed in Section 2. Moreover, one might even say that Aristotle provides a definition of life based on such dispositions: "Now this word [to live] has more than one sense, and provided any one alone of these is found in a thing we say that thing is living. Living, that is, may mean thinking or perception or local movement and rest, or movement in the sense of nutrition, decay and growth" (*De an*. II, 2 [413a 22–25]).

At the same time, Aristotle would see all these powers present in animate beings as expressions, derivatives (functions) or indicators of life rather than its constitutive features (factors). Moreover, he would also specify the necessity of there being a unifying metaphysical grounding of these powers—a principle that actualizes potentiality, i.e., particular possible ways (forms) of being, that makes living things be what they are, that makes them be in a specific and unique way. He defines this active and dynamic principle as a substantial form actualizing primary matter (the correlative principle of pure potentiality)—a substantial form of a special kind, i.e., proper for living beings.

In his understanding, the metaphysical notion of form goes beyond an organizing principle, arranging the geometrical structure and shape of the constituent parts of an entity (substance).[22] Rather—described by Aristotle as "the definition" or "the statement" of the essence of an entity (ὁ λόγος τοῦ τί ἦν εἶναι [*ho logos tou ti ēn einai*])—it is a principle that grounds all active and passive powers of a given thing.[23] Similar to primary matter, which—as the metaphysical principle of pure potentiality—is not accessible to empirical observation, a substantial form is not a thing either. It does not have the property of quantity or extension. For this reason, Michael Dodds says "we cannot make an imaginative picture of a substantial form. It is not imaginable, but it is intelligible" (Dodds 2010, p. 25).[24] A substantial form cannot increase or decrease. It is "educed" from the potentiality of primary matter and remains present in the entire substance and its parts as a fundamental principle of operation. It is expressed in the essential qualities of a given substance, which classifies Aristotelian ontology as essentialist.[25]

7.2. Goal-Directedness

The formal principle of a given living thing that grounds its active and passive powers (operations) remains closely related to yet another crucial Aristotelian principle, i.e., the

principle of finality or goal-directedness. Aristotle defines the final cause as "that for the sake of which" a thing is done, or a good that can be attained and that is proper for a being.[26] It takes its other name, "teleology," from the Greek τέλος (*telos*), which translates as "end" or "goal." Although he invokes necessity as an explanation of the availability of suitable matter, Aristotle acknowledges the need of an explanation in terms of purpose as a function of nature, to explain why given matter acquires the particular shape, structure, and intrinsic qualities it does.[27]

While he extends teleology (goal-directedness)—which is usually associated with conscious human decisions—not only to other living but also all nonliving entities, Aristotle would most likely agree that its actuality and "operation" are most apparent in living beings. This makes teleology—closely related to substantial form—a fundamental aspect of his definition of life. He also emphasizes that it should not be understood as a mysterious—quasi-efficient—cause, directing things according to a preestablished harmony. Quite the contrary, it should be seen as a natural tendency of things to realize what is proper to their nature (e.g., a tree blossoming and bearing fruit)—a tendency that does not have to be known or intended by a conscious agent. That is why Aristotle delineates in *Phys*. II, 8 (199b 26–27) that "it is absurd to suppose that purpose is not present because we do not observe the agent deliberating." (See also Bostock 2006, pp. 48–78; Gotthelf 1976, pp. 226–54; Guthrie 1981, pp. 114–18).

8. Aristotle's Contribution to Contemporary Attempts at Defining Life

The classical Aristotelian notion of life, defined in reference to appropriate substantial forms and goal-directedness, may serve as a valuable contribution to the current attempts to define life in at least three ways.

8.1. Grounding Properties of Life

Firstly, the category of a substantial form of a particular type (proper for animate things) provides a necessary grounding for all properties (characteristic phenomena) of life. Their phenomenological enumeration raises some fundamental ontological questions. Why do living entities continue as wholes? Why do they process energy in a way that maintains their inherent stability? What grounds their capability of flexible control of their own internal dynamism? What grounds the animate entities' powers to grow, reproduce, and evolve (with the use of their active information-processing systems)? Why do they cease to be in a seemingly programmed way (if their death is not premature)? If we do not want to treat these properties of living systems as brute facts, we face the challenge of specifying their foundation. The Aristotelian notion of substantial form (hylomorphism) may be seen as their fundamental (metaphysical) grounding.[28]

8.2. Life as an Emergent Phenomenon

Secondly, a more theoretical approach to defining life that goes beyond simple enumeration of its properties, often refers—in its non-reductionist strain—to the theory of emergence. It sees life as one of the many phenomena where an "unprecedented global regularity [is] generated within a composite system by virtue of the higher-order consequences of the interactions of composite parts" (Deacon 2006, p. 122). In its strong (ontological) version, the theory of emergence introduces the category of top-down (downward) causation. In the case of living systems, it may be defined as a global or wholistic determination of their lower-level constituent parts, remaining in synergy with the bottom-up causal activity of those structural components (see Campbell 1974, p. 180).

As commonly known among analytic metaphysicians, the category of downward causation triggers a detailed and nuanced philosophical analysis and debate. Its main opponents argue that downward causation-based emergence faces the difficulty of specifying both causal relata and the very nature of causation in question. Its supporters face a critical dilemma, namely, the struggle between supporting the rule of physical causal closure and acknowledging the novelty and irreducibility of downward causation (see Hulswit 2006;

Tabaczek 2019, pp. 71–78). This difficulty was probably best expressed by Jaegwon Kim's famous argument from causal exclusion, in which he shows—on the example of mental causation arising from neural patterns—that the argument in favor of downward causation involves causal overdetermination, i.e., the same mental state is caused by both lower-level neural patterns and downward causation. He claims the latter must be excluded, which consequently makes the whole project of emergence fall into physicalism (see Kim 1999, pp. 31–33).[29]

One of the important arguments defending the irreducibility of downward causation suggests it should be redefined in terms of Aristotle's plural typology of causes, especially in reference to his notion of formal and final causes (teleology) (see Emmeche et al. 2000; Moreno and Umerez 2000; Silberstein 2006). An attempt at realizing this postulate, in the context of both the classical and the contemporary neo-Aristotelian metaphysics—one that is also relevant with respect to the emergentist account of life—was offered in my first monograph that concentrates on the theory of emergence (see Tabaczek 2019, pp. 247–70).

8.3. The Retrieval of Teleology

Finally, the third important contribution of the Aristotelian natural philosophy to the current debate on the definition of life is his notion of teleology (goal-directedness). Indeed, in opposition to past centuries of anti-teleological sentiments and contemporary "teleonaturalists" who claim that references to teleology in biology are burdened with the error of anthropomorphism (and thus strive to explain goal-directedness away), a growing number of philosophers of biology recognize that the category of teleology is fundamental for understanding and defining life. To give an example, Terrence Deacon and Tyrone Cashman are convinced that inheritance, preservation, replication, and transmission of information are precisely what define goal-directedness, which distinguishes—together with persistent self-maintenance of a system in a far-from-equilibrium state—living from nonliving dynamics. Acknowledging this, Deacon and Cashman find the teleological factor crucial for explaining the property of life, which they define in terms of a primitive biological "self" and "self-directedness" (see Deacon and Cashman 2013, p. 290).[30]

Denis Walsh recognizes the immanent, naturalistic, and functional character of Aristotle's teleology (in opposition to its anthropocentric, transcendent, and creationist version found in Plato). He finds an irreducible example of this immanence in the adaptiveness and phenotypic plasticity of organisms, which is manifested in their self-organizing goal-directedness and capacity to make compensatory changes to form or physiology during their lifetime (e.g., acclimatization or immune response).[31] Mark Perlman presents a very clear and systematic description of the actual views on teleology in evolutionary biology, and philosophy of biology. He distinguishes between non-naturalistic, quasi-naturalistic, and naturalistic explanations of finality in nature. Although he suggests that Aristotelian teleology is quasi-naturalistic, our account of goal-directedness presented in Section 7.2 shows that it can be treated as a fully natural phenomenon. As such, it is important, if not to say inevitable, to ground the apparent teleological flavor of virtually all the properties of life enumerated in Section 2 (see Perlman 2010, pp. 149–63).

I claim that the reintroduction of teleology is indispensable in our efforts to understand and offer a meaningful scientific and philosophical account of living systems. In other words, without this category (this type of causation), the contemporary proposed comprehensive descriptions of life, such as the one brought by Noam Lahav (1999, p. 113), make little if any sense at all:

> Living entities are complex, far-from-equilibrium structures maintained by the flow of energy from sources to sinks. They are compartmentalized, organic, homochiral entities, closely associated and communicating with their environment (including other living forms) and at the same time separated from it by a boundary (in extant organisms, a lipid bilayer), and dependent in their activities on a continual flux of energy and matter through this membrane, from their environment. They can replicate, mutate, exchange matter and energy with their

> environment, and evolve, in processes that are catalyzed by a large arsenal of organic catalysts. The characteristics of most or all of these processes and molecules, as reflected by their chemical cycles, regulation, communication, complementarity, and rhythms, as well as potential life criteria of each organism, corroborate with the principle of continuity. Having evolved from inanimate matter, they constitute autocatalytic, evolvable, teleonomic organic systems that can transfer, store, and process information, based on template- and sequence-directed reactions, all of which characterize autopoietic entities.[32]

9. Origin of Life and the Classical Principle of Proportionate Causation[33]

Moving our analysis once again toward the origin of life studies—this time in reference to the classical Aristotelian notion of life—one may argue that this specific philosophical tradition is irrelevant here, as Aristotle simply assumed that life existed eternally (i.e., everlastingly—without a beginning or end in time). At the same time, however, the same tradition values a metaphysical principle called the principle of proportionate causation (PPC), which seemingly puts into question the contemporary commonly accepted and supported scientific notion of a spontaneous emergence of life from non-living systems.[34] The principle in question simply states that an effect cannot be more perfect than its cause:

> "[T]he begetter is of the same kind as the begotten." (*Meta*. VII, 8 [1033b 30])
>
> "[W]hatever perfection exists in an effect must be found in the effective cause." (*ST* I, 4, 2, co.)
>
> "[N]o effect exceeds its cause." (*ST* II-II, 32, 4, obj. 1) (See also *SCG* I, 67; *ST* II, 24, 6, s.c.; *De pot*. 3, 16, ad 8.)
>
> "[E]very agent produces its like." (*SCG* II, 21, no. 9)
>
> "[N]othing acts beyond its species." (*Super II Sent*. 18, 2, 3) (See also *De ver*. 24, 14; *Quodl*. 9, 5, 1; *SCG* III, 84; *De pot*. 3, 9; *ST* I–II, 112, 1.)
>
> "[T]he order of causes necessarily corresponds to the order of effects, since effects are commensurate with their causes." (*SCG* II, 15, no. 4)
>
> "[E]very agent acts according as it is in act." (*SCG* II, 6, no. 4)
>
> "No effect can be more powerful than its agent cause." (*Super II Sent*. 18, 2, 3, obj. 3) (See also *De pot*. 3, 8, obj. 13; *ST* I–II, 112, 1; *Comp. theo.* 1, 93.)

It is worth noting that Descartes forms a similar principle (often called the Causal Adequacy Principle) when he says in the "Third Meditation" that "there must be at least as much reality in the efficient and total cause as in the effect of that cause" (Descartes 1984, p. 28).[35] Stephen Boulter rightly notes that the core intuition of PPC is that every effect has an "adequate" (i.e., proportional, or commensurate) cause. However, what constitutes adequacy? A rough yet common interpretation of the PPC is that a cause cannot give what it does not have. However, such delineation of PPC is deficient, as it rules out the emergence of new active and passive powers (dispositions) from a causal base that does not possess them—basically, by virtue of their being, in a way, "new." This would render implausible a vast number, if not the majority of substantial changes observed in nature and analyzed in physics, chemistry, biology and other sciences (see Boulter 2021, p. 126). A number of solutions were more recently offered to this puzzle. I will enumerate four of them:

(1) The first strategy distinguishes Aristotelian and (Neo-)Platonic notions of what it means to be perfect. The former ties perfection with the completion of an entity within its own nature (in reference to its natural kind). The latter puts it on the hierarchy of perfection that flows from the One (God) all the way down to most imperfect beings. On the account of this distinction, it becomes clear that PPC becomes a problem only on the (Neo-)Platonic scheme, which sees perfection of contingent things in

reference to the absolute perfection of the One. Aristotelian metaphysics allows various beings to be considerably different in quantity, quality, and scope of their active and passive properties, and yet equally perfect within their own natural kinds. If true, this principle would certainly apply to the comparison of the entities standing at the transition from non-living to living systems (see Boulter 2021, pp. 131–34).

(2) The second strategy refers to the medieval concept of dispositions and properties present in things potentially (or virtually), and not actually (or formally). Applying this argument in the contemporary context, Edward Feser reformulates the classical version of the PPC, saying that what it means is that "whatever is in an effect must be in its *total* cause in *some* way or other, whether *formally*, *virtually*, or *eminently*" (Feser 2014, p. 155). The crucial point of Feser's proposal is the notion of a "*total* cause" of a given entity or phenomenon—in our case, the phenomenon of the origin of life. The category in question draws our attention to the fact that the proportionate cause of the emergence of a first living entity is not a single law or force, but a concurrence of many causal influences constitutive for a transition from non-living to living beings. Some of the perfections required for its occurrence might be present in the members of an evolutionary causal matrix formally, while others might be present in them virtually (through their powers). The causal contribution of such a multiplicity of causes, extended over time and space, provides for a new and higher level of perfection of the first living thing. The notion of an "eminent" presence of perfections in causes can be understood in two ways. First, a singular or a "total" cause may possess a given perfection in excess (eminently) due to its status of being a higher (more perfect) cause. Second, in reference to the medieval concept of a passive obediential capacity (*potentia obedientialis*), one might argue that the nature of a given cause can be "elevated" by a higher cause such that it is capable to give what by nature it does not have. The "elevation" of such agents is caused by the supernatural concursus of the First Cause, which enables them to bring about effects of an entirely higher order than those within the ambit of their natural powers.[36]

(3) The third strategy is based on the conviction that throughout the fundamental transitions in the history of life, the net "amount" of perfection of the universe remains stable. In his account of this approach, Boulter challenges our tendency to pay attention only to increases in operation or power, found in new kinds of entities. What is less immediately obvious, and for the most part neglected, is that new powers and dispositions are usually accompanied by new difficulties, problems, and defects. Hence, the balanced notion of changes reveals that each major transition in the history of the universe involves both increases and decreases in perfection. This allows us to postulate a principle of an overall conservation of perfection in an evolving universe. Again, applied to the origin of life, this strategy would successfully alleviate the difficulty posed by the PPC (see Boulter 2021, pp. 138–41).

(4) One last attempt at answering the challenge of the PPC, offered by Brian Carl, takes us back to Aquinas. He draws our attention to the complexity of the causal hierarchy in Aquinas, which is often ignored by many who concentrate merely on proximate causes in their analysis of causal dependencies. For Thomas, all causal relationships in the mundane reality happen within God's providence, where God is conceived as the first and principal cause, working in nature through secondary and instrumental causes. However, between God and mundane creatures, Aquinas sees the causality of angels and celestial spheres, especially the sun, which is the source of heat.[37] This approach relates to Feser's "*total* cause," reinterpreting it in reference to the variety of direct and indirect factors contributing to a given change. Applied to the origin of life, this strategy would enable an explanation of its emergence from "less perfect" ingredients and causes on the account of indirect causal contribution of higher contingent causes (see Carl 2020).

10. Theological Account of the Origin of Life

One more fundamental question concerning the origin of life refers to its dependency on a direct intervention of God. In other words, a question is being asked whether the emergence of first animate creature(s) required special divine action that transcends the causal efficacy of all contingent beings.

10.1. Life as Naturally Emergent Phenomenon

One of the currently predominant positions assumes that the emergence of living systems was fully natural. Griesemer presents this opinion, saying:

> Biologists generally take a naturalistic stance toward the big questions, considering evolutionary-biological and physical-chemical processes (including stochastic ones) as possible explanations while rejecting supernatural design as out of court. . . . Despite significant disagreement on many fronts in origins of life studies, there is emerging scientific consensus that life is indeed a natural property of certain types of organized matter . . . A fairly rapid, naturalistic origin of life is deemed much more plausible than was supposed even in the 1960s (Griesemer 2008, pp. 264, 268).

One of the respected authorities on the origin of life studies, Stuart Kauffman, echoes Griesemer's conclusion and states:

> Life has emerged in the universe without requiring special intervention from a Creator God . . . All, I claim arose without a creator God. . . . Is not this view, a view based on an expanded science, God enough? Is not nature itself creativity enough? What more do we really need of God . . . ? (Kauffman 2008, pp. 71, 229, 283)[38]

His view finds a more scientific elucidation in that of Abby Pross, who stipulates:

> [L]ife on the Earth appears to have emerged through the spontaneous emergence of a simple (unidentified) replicating system, initially fragile, which complexified and evolved towards complex replicating systems exhibiting greater DKS [dynamic kinetic stability]. In fact, we would claim that in the very broadest of terms, the physico-chemical basis of abiogenesis can be considered explained (Pross and Pascal 2013, p. 120190, sct. 6).

From the point of view of philosophy and theology, the naturalistic explanation of life's origin does not have to automatically exclude God or fall into deism. The classical Aristotelian-Thomistic tradition offers a coherent and reliable model of divine action in the created universe, based on the twofold distinction between the primary and principal causation of God and the secondary and instrumental causation of contingent creatures.

Aquinas distinguishes first between God as the "primary cause" and creatures as "secondary causes," emphasizing that "God's immediate provision over everything does not exclude the action of secondary causes; which are the executors of His order" (*ST* I, 22, 3, ad 2; see also *ST* I, 19, 6, ad 3; I, 19, 8, co.; I, 23, 5, co.; I, 105, 5, ad 2; I–II, 10, 4, ad 2.). Since God as the Creator has gifted every creature with its proper causality, according to its nature, his influence cannot interfere with this causality, but must rather be its source. Consequently, although we can say that a particular natural effect comes to be both through the agency of God and through the agency of a created entity, we must remember "that the same effect is not attributed to a natural cause and to divine power in such a way that it is partly done by God, and partly by the natural agent; rather, it is wholly done by both, according to a different way, just as the same effect is wholly attributed to the instrument and also wholly to the principal agent" (*SCG* III, 70, no. 8).[39]

The second important distinction introduced by Aquinas is between principal and instrumental causes. Whereas some secondary causes act according to their natural dispositions, others produce effects beyond their capacities. Thomas classifies the latter as instrumental causes and emphasizes their dependence on principal causes for their opera-

tion. He notes that the nature of an instrument is to move something while being moved itself by a principal agent. A saw working upon a bench has two operations, one belonging to its own form (to divide), and another "which belongs to it in so far as it is moved by the principal agent and which rises above the ability of its own form" (to make a straight cut agreeing with the pattern) (*De ver*. 27, 4, co.; 27, 4, ad 8).[40]

This model of divine action makes plausible a suggestion that life emerged spontaneously, as an outcome of natural causes, which nonetheless operated as secondary and instrumental factors moved by God who is the primary and principal cause of all changes in the created universe. In other words, the origin of life would be an outcome of a concurrence of divine (transcendent) and created (immanent) action—in accordance to Aquinas's further explication of how exactly God acts in the world through contingent causes:

> God is the cause of everything's action inasmuch as he gives everything the power to act, and preserves it in being and applies it to action, and inasmuch as by his power every other power acts. And if we add to this that God is his own power, and that he is in all things not as part of their essence but as upholding them in their being, we shall conclude that he acts in every agent immediately, without prejudice to the action of the will and of nature (*De pot*. 3, 7, co.).[41]

10.2. Life as an Outcome of Direct Divine Intervention

The opposite theological opinion concerning the origin of life is inclined to assume that some kind of direct divine intervention was necessary to bridge the gap between the non-living and the living. The argument of those who support it proceeds from the classical distinction between immanent (intrinsic) and transient (transeunt) causation:

> There are . . . two sorts of operation, as Aristotle teaches in Metaphysics IX [1050a 25]: one that remains in the agent and is a perfection of it, as the act of sensing, understanding, and willing; another that passes over into an external thing, and is a perfection of the thing made as a result of that operation, the acts of heating, cutting and building, for example (*SCG* II, 1, no. 2; see also *Super I Sent.* 1, 40, 1, ad 1; *De ver.*, 14, 3).

David Oderberg builds on this distinction and stipulates:

> [The] essence [of life], I claim, is what Aristotelians and Thomists sometimes call *immanent causation*.[42] This is causation that originates with an agent and terminates in that agent for the sake of its self-perfection. It is a kind of teleology, but metaphysically distinctive in what it involves. Immanent causation is not just action for a purpose, but for the agent's own purpose, where "own purpose" means not merely that the agent acts for a purpose it possesses, but that it acts for a purpose it possesses such that fulfillment of the purpose contributes to the agent's self-perfection. Hence, in immanent causation, the agent is both the cause and the effect of the action, and the cause itself is directed at the effect as perfective of the agent (Oderberg 2013, p. 213).[43]

Oderberg further develops his argument and emphasizes that transient and immanent types of causation are not only "fundamentally different", but also "mutually exclusive," even if a number of transient causal reactions may subserve an immanent action (e.g., the consumption and processing of food) (see Oderberg 2013, p. 218). In reference to a more literal interpretation of PPC, the next step of the same argumentation may arrive at the conclusion that only the agent that shows immanent causation—i.e., is alive—could give origin to life in general, and more specifically to life on the Earth. It seems that one of the important contributors to the science–theology dialogue, William Carroll, became recently inclined to embrace this position. At the 2022 conference entitled *The Origin of Life and Nature before Sin: Scientific and Theological Perspectives*—organized by the Project for Science and Religion of the Angelicum Thomistic Institute in Rome—Carroll delivered a lecture titled *Causes and the Origin of Life: Philosophy of Nature, Metaphysics, and Theology*. In reference to Oderberg and Edward Feser, he argued that non-living substances, unless

they possess in some way immanent causality, cannot by themselves be the causes of living substances:

> If there is, or so it seems—we could say—no immanent causality what so ever, either formally or virtually, in non-living substances, or in some combination of them, then it is not possible for them to be the cause or causes of living substances. The origin of life then would have to be the effect of something completely other than an inanimate natural cause (Carroll 2022, pp. 44:48–45:25).[44]

Carroll concluded his entire presentation with the following pronouncement:

> If inanimate things were in themselves to possess the power to cause living things to come into existence, in some way, then it seems that they, these inanimate things, would not be inanimate but rather living things themselves. God's causality is at work in all changes and God obviously has the power to cause living things to come into existence. But God creates causes to be the kind of causes that they are. If inanimate things by nature could cause living things to emerge, God would be creating that which was and that which was not what it is . . . So, it seems to me that the initial emergence of life requires something more than natural causes functioning in the ordinary way according to which nature and God are the complete causes of what happens in the world (Carroll 2022, pp. 49:13–50:53).[45]

11. *Status Questionis* on Divine Action in the Origin of Life

The theological reflection concerning the natural versus supernatural origin of life continues. One can find compelling arguments on both sides of the debate. I would like to refer shortly to three such lines of reasoning.

11.1. The Limits of Natural Science

Those in favor of the latter view emphasize that despite an enormous progress in natural sciences in the twentieth century, we have not developed a conclusive theory of life's origin. This fact makes them argue that in this regard we have reached the limits of the scientific knowledge, which becomes an invitation to look for a supernatural (transcendent) cause of the emergence of life.[46] Their opponents respond by saying that true science never gives up in its search for explanation and that the introduction of the transcendent cause at the current stage of the research on the origin of life is ad hoc and reminiscent of the "God of the gaps" type of argumentation.

11.2. Aquinas on the Emergence of Life

Another line of reasoning on the side of those who support the idea of the supernatural origin of life criticizes their adversaries' conviction that all natural things and phenomena in the universe may be caused by God acting through secondary and instrumental causation of his creatures. They argue that this conclusion, based on Aquinas's philosophical theology, remains in conflict with his exegetical reflection on the account of creation in Genesis. An answer to this charge requires some more explanation.

Interpreting the work of six days in Genesis 1, Aquinas follows Augustine's conviction that "God made everything together without any moments of time intervening" (*De Gen. ad litt*. 5.11). Naturally, Augustine did not think that all things, including the sun, Earth, seas, plants, animals, etc., came to be fully formed in that first moment. Comparing and contrasting the two creation accounts opening the book of Genesis, he suggests that what were present in the first instant of the existence of the universe were only the "seed-principles" (*rationes seminales*; *logoi spermatikoi* [λόγοι σπερματικοὶ]) of all natural kinds, and that over the history of the universe, God "unfolds the generations which He laid up in creation when He first founded it" (*De Gen. ad litt*. 5.20). In other words, "[God] created all [creatures] together . . . whose visible forms He produces through the ages, working even until now" (*De Gen. ad litt.* 5.23).[47] Following this interpretation of Genesis 1–2, Aquinas

distinguishes—in his analysis of the work of the six days in the first part of the *Summa theologiae*—among (1) the work of creation (*opus creationis*) and those of (2) distinction (*opus distinctionis*) and (3) adornment (*opus ornatus*) (see Aquinas's introduction to *ST* I, q. 65). Positing the origin of all living creatures under (2) and (3), he states that plants and trees might have been produced "in their origin or causes," that is, the Earth "received . . . the power to produce them." They were subsequently brought into existence in "the work of propagation."[48] Similar with fishes and birds, which Augustine saw as produced by "the nature of waters on that [fifth] day potentially" (*ST* I, 71, 1, co.), and animals, whose "production was potential" as well (*ST* I, 72,1, co.).[49]

The crucial question in the context of the theological reflection on the origin of life is whether the actualization of *rationes seminales* of living creatures (including the first animate entities) required/requires a direct divine intervention. On the one hand, Augustine seems to claim that when the proper conditions are met, gradual and spontaneous unfolding of *rationes seminales* occurs naturally: "All things were created by God in the beginning in a kind of blending of the elements, but they cannot develop and appear until the circumstances are favorable" (Augustine, *De Trinitate* 3.9, quoted in Portalié 1960, p. 138). This might suggest that God actualizes them through contingent (secondary and instrumental) causes. On the other hand, however, he sometimes tends to interpret Genesis more literally as implying that each new kind originates in its adult form, which seems to require a direct divine intervention. At the end of the day, he thinks we should acknowledge that natural kinds came (come) into being in both ways:

> We must conclude, then, that these reasons [*rationes seminales*] were created to exercise their causality in either one way or the other: by providing for the ordinary development of new creatures in appropriate periods of time, or by providing for the rare occurrence of a miraculous production of a creature, in accordance with what God wills as proper for the occasion (*De Gen. ad litt*. 6.14).

Aquinas is somewhat more specific at this point. Commenting on the second book of Sentences of Peter Lombard, he claims that the origin of plants requires merely causal principles proper for the work of distinction (*opus distinctionis*) and adds that the role of fathering in this process belongs to the powers of celestial bodies, while the role of the mother is fulfilled by the primordial matter (i.e., elements) (see *Super II Sent*., 14, 1, 5, ad 6). Similar is his opinion presented in *De potentia*, where we find him saying:

> Now the production of plants from the earth into actual existence belongs to the work of propagation, since the powers of the heavenly body as father, and of the earth as mother suffice for their production. Hence the plants were not actually produced on the third day but only in their causes: and after the six days they were brought into actual existence in their respective species and natures by the work of government (*De pot*. 4, 2, ad 28).[50]

The case of animal species is different. Thomas seems to be saying that the origin of the first member of each new animal kind requires, in fact, a direct divine intervention:

> [Some things come into being neither through motion nor through generation] because of the necessity that generation always generates what is similar in species. For this reason the first members of the species were immediately created by God, such as the first man, the first lion, and so forth (*Super II Sent*., 1, 1, 4, co.).

However, this might not be true for at least some species of insects, of which Aquinas says here (and on other occasions) that they originated from putrefaction:

> Man, for instance, can only be generated from man. It is, however, otherwise with those things which are not generated by an agent that is similar to them in species. For these, rather, the power of celestial bodies along with appropriate matter is sufficient, as, for example, those things which are generated by putrefaction (*Super II Sent*., 1, 1, 4, co.).

Taking into account the Genesis account of the work of six days and the fact that—metaphysically speaking—Aquinas saw plant life as more primitive than animal life; he must have considered plants as the first living things that preceded the emergence of animals on earth. If this is true, then one might argue that the origin of life was for him an outcome of the work of propagation, instantiated by secondary and instrumental causes working under the primary and principal transcendent agency of God.

11.3. Transient and Immanent Causation

Finally, I would like to refer to Oderberg's and Carroll's argument, which many might find to be a metaphysically most compelling line of reasoning in support of the necessity of a supernatural divine intervention in life's origin. I believe there are at least two important aspects of this argument one should take into account in order to provide its critical evaluation.

Firstly, Carroll seems to assume that a natural non-living entity or a combination of such entities—possessing their specific transient causal powers—can give origin to animate creature(s) only if they themselves possess immanent causality "either formally or virtually." Note that the latter (possessing immanent causality virtually) is not equivalent with being alive. However, in the next step of his reasoning, Carroll indirectly dismisses such a possibility, saying: "If inanimate things were in themselves to possess the power to cause living things to come into existence, in some way, then it seems that they, these inanimate things, would not be inanimate but rather living things themselves."[51] Assuming that the qualification "in some way" refers to both the formal and virtual possession of a given property (immanent causation), this statement contradicts the former, since it assumes that things that have immanent causation virtually are in fact alive.

However, this reasoning does not stand. While it might be valid with respect to formal (actual) possession of immanent causation by inanimate things, it can be easily refuted on the account of the virtual possession of such causation by non-living beings. The very notion of the virtual presence of a property assumes that a thing in question does not have it in actuality. Unfortunately, Carroll does not discuss the meaning of virtual presence. Nor does he clarify what he means by the notion of possessing life "in some way."

Hence, following Feser's definition of virtual presence as the presence of a given perfection or its "parts" ("aspects") in a "*total* cause" of a given entity, one might argue that the origin of life was an outcome of a causal process that was extremely complex, multifaceted and extended in time. We might speak here about a causal matrix where the relevant contributors to the actual emergence of life were incredibly numerous. Their number might be, in fact, virtually impossible to estimate. Hence, the amount of information the first animate entity contained in an integrated form was no greater than the amount of information present in the historical process of its emergence. The immanent causation proper for animate things would be formally and/or virtually present in all causes entering the causal matrix (Feser's "*total* cause") that contributes to their first instantiation. In other words, the numerous causes constituting such a causal matrix would be jointly capable of educing (over time) from the properly disposed primary matter a substantial form that grounds the power of immanent causation. The process of its eduction might be treated as the outcome of the primary and principal causation of God, working through the secondary and instrumental causation of contingent causes.

The second important aspect of Oderberg's and Carroll's argument goes back to Oderberg's radical distinction between transient (transeunt) and immanent causation and the claim that they are not only "fundamentally different", but also "*mutually exclusive*"—based on his conviction that immanent causation is "a kind of teleology." Oderberg's language is rather imprecise at this point. Immanent causation is not so much "a kind of" final cause, but a particular type of efficient causation, grounded in a substantial form and intrinsic teleology proper for a given entity. As such, it may be referred to both living and non-living entities. Naturally, the immanent powers of living beings would be much more sophisticated than those of the non-living beings—differing qualitatively

and not just quantitatively. However, this does not mean the latter show no immanent efficient causation, as Oderberg, Feser, and Carroll seem to implicitly assume.[52] In fact, Aquinas does not seem to explicitly limit immanent causation to living things. Moreover, contemporary science referring to molecular, atomic, and subatomic levels of organization and complexity of matter reveals a whole variety of efficient causal activities that might be thought as terminating in the good of a given (inanimate) whole. Assuming either an emergentist or a hylomorphic ontology, it is plausible to suggest that these intrinsic efficient activities are organized and controlled at the level of a substance they "belong to" or "constitute." This higher level of organizing and controlling activity (attributed either to a downward causation or a substantial form) may be described in terms of an immanent causation of an inanimate substance in question.[53]

This clarification can be further specified in the context of both Aristotle's and Aquinas's convictions concerning the interrelatedness of causes, which goes beyond the hylomorphic union of material and formal causes. At one point, Aquinas speaks about the relation between formal and final causes, saying: "The form and the end coincide in the same thing," and "it must belong to the natural philosophy to consider the form not only insofar as it is form but also insofar as it is the end" (*In Phys*. V, lect. 11 [§ 246]). This becomes even more apparent in reference to one of the terms Aristotle uses to describe the formal principle of a given being, which makes it to be what it is. Apart from terms such as παράδειγμα (*paradeigma*) = "paradigm" ("archetype," "pattern," "model," "characteristics of the type"), μορφή (*morphē*) = "shape," εἶδος, (*eidos*) = "form," and ὁ λόγος τοῦ τί ἦν εἶναι (*ho logos tou ti ēn einai*) = "statement (definition) of the essence"—he describes form, on several occasions, in terms of ἐντελέχεια (*entelecheia*), which relates formal to final causation and denotes form as actualized in the final state of a being: "For the action is the end, and the actuality is the action. And so even the word 'actuality' [ενέργεια, *energeia*] is derived from 'action' [ἔργον, *ergon*], and points to the complete reality [ἐντελέχεια, *entelecheia*]" (*Meta*. IX, 8 [1050a 21–23]).[54]

Now, as grounding all dispositions of a given entity, a substantial form is foundational for all types of its efficient agency, including all instantiations of transient and immanent efficient causation. Moreover, all types of efficient causation exercised by living and nonliving beings are not random but goal-directed due to the intrinsic teleology proper for each natural kind. Hence, Aquinas states, after Aristotle, that "three causes can coincide in one thing, namely, the form, the end, and the efficient cause" (*De prin. nat*. 34).[55]

Naturally, the interrelatedness of transient and immanent types of efficient causation does not mean that the accumulation of the former can be considered as identical with the latter. Oderberg is right when saying that "no transient causal relation can be identified with an immanent one . . . [nor] can a network or system of such relations" (Oderberg 2013, p. 220).[56] At the same time, the analysis of living beings suggests that the actualization of their immanent efficient causation assumes a complex network of causal (transient) interactions with the environment, while their external transient causal exchange is being subsumed under the immanent efficient causation that aims at sustaining their energetic equilibrium. Hence, rather than mutual exclusion, life assumes a synergy of transient and immanent efficient causation.

Once again, the new type of immanent causation proper for living beings is not an effect of accumulation of transient or even lower-level immanent efficient causes. Rather, it might be the case that a matrix of nonliving agents—characterized by their proper transient and immanent powers—can give origin to the first animate entity, which shows a new type of immanent (and transient) agency. It is indeed a unique self-referential immanent causation in relation to the environment, directed toward maintaining a delicate homeostatic energetic balance of a living system. However, its novelty does not mean it cannot be instantiated in a new type of entity, brought into existence by a matrix of causes acting for a purpose due to the lower-level or less robust kind-specific immanent powers. On this scenario, a direct divine intervention is not necessary. The secondary and

instrumental causality of creatures depending on the providential primary and principal agency of God would suffice.

12. Conclusions

Defining life and explaining its origin remain among the most inscrutable endeavors of contemporary scientific and philosophical research. Mariscal speculates that "This is unlikely to change given the disciplinary backgrounds, explanatory values, and theoretical commitments of the stakeholders involved." He finds more plausible the scenario in which

> life will be accepted as a polysemous concept with each definitional cluster applying to a subset of the whole: biochemical life, evolutionary life, metabolic life, etc. Researchers may rely on context, accept some miscommunication, or simply stipulate the kind of life they mean (Mariscal 2021, sct. 8).

Griesemer joins Mariscal saying that the field of the origin of life studies "is a giant jigsaw puzzle that tempts, but resists, simple historical narrative and clean conceptual reconstruction." For this reason, he thinks many are prompted to suppose that the "origins of life studies are doomed to idle speculation, unfit for serious scientific investigation, or worse: fit only for an unresolvable confrontation of science with religious beliefs" (Griesemer 2008, pp. 267, 269). This invokes the theological debate on the necessity of direct divine action in the emergence of the first living creature(s), which is also unlikely to be settled as new arguments on both sides of the conversation will most likely be developed in the future.

All this points to the fact that we will most likely remain mystified by what life is and that "the 3000-year 'what is life' riddle remains [and will remain] that—a riddle" (Pross 2012, p. 4). However, this should not undermine the considerable progress in our understanding of the nature and properties of life that came with the development of astronomy, thermodynamics, geology, paleontology, many branches of organic and inorganic chemistry, molecular biology, systematics, evolutionary biology, ecology, and many other branches of natural science. Inspiring further and more profound philosophical and theological reflection on animate entities, they should make us ever more enthusiastic about what we may understand and learn about this intriguing phenomenon in the future.

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Notes

1 Carlos Mariscal notes that "Scientists grow more concerned about philosophical questions when scientific limitations or conceptual choices are made apparent to them. Those scientists who study deep time, deep space, abstract issues, or questions of ethics are often keenly aware of the philosophical choices that influence their research from identification of research question to interpretation of the data" (Mariscal 2021, sct. 6).

2 To have a grasp of the complexity of the more recent state of the debate on the definition of life, see (Bedau 2011; Bedau and Cleland 2010, 2019; Gánti et al. 2003; Mariscal 2021; Mix 2018; Popa 2004).

3 Bedau notes that there are many similar lists and that the items listed in them—even if they are heterogenous—mostly overlap. He refers to (Smith 1986) and (Mayr 1997).

4 On mortality, see (Musi and Hornsby 2021).

5 See (Mariscal 2021, sct. 1.2). I will say more on the origin of life below. Astrobiology strives to specify biosignatures (markers of life) in the universe. Its separate division searches for extraterrestrial intelligence (SETI). Studies on artificial life (A-life) take either a functionalist (strong) or a more wholistic (weak) approach. Strong A-Life states that robots or computer programs might qualify as animate. Weak A-Life strives to better understand life as we know it by placing it in a broader context of possible biology. The former receives pushback based on ontology (the assumption that life requires biochemical embodiment). Synthetic biology strives to produce self-replicating minimal genomes (simple living organisms). They all need a definition of life to proceed. See (Mariscal 2021, scts. 3, 5, and 7).

6 See (Mariscal 2021, table 1 in sct. 1.2; Bedau 2011, pp. 462–66). Mariscal grounds his exposition in (Popa 2004; Trifonov 2011; Malaterre and Chartier 2021).

[7] Bedau thinks that biochemical definitions of life may be charged with presupposing a prior account of life. He also thinks they are often myopic (presuming that all possible life forms are quite similar to the ones we know). Concerning the functional approach, Bedau claims it can be challenged on being too general, as it seems to treat life substratum's material nature as irrelevant to life-defining functions. Moreover, it might be the case that processes defining life are not amenable for formal and computational description. It is also possible that, at the end of the day, functionalism does not answer to the question about which processes play what role in the functional account of life. With respect to the metabolism- and catalysis-related definition, on many accounts of the energetic cycle of living entities, it is closely related to autopoiesis. See (Bedau 2011, pp. 462–65). The emergentist approach defines life in reference to new and irreducible regularity and order instantiated on higher levels of complexity of matter. See (Tabaczek 2020).

[8] The hierarchical approach is mimicked in synthetic biology, where "an artificial cell is viewed as any chemical system that chemically integrates three processes: The first is the process of assembling some kind of container, such as a lipid vesicle, and living inside it. The second is the metabolic processes that repair and regenerate the container and its contents, and enable the whole system to reproduce. Those chemical processes are shaped and directed by a third chemical process involving encoded information about the system stored in the system ('genes'). Errors ('mutations') can occur when this information is reproduced, so the systems can evolve by natural selection. The integrated-triad view of life requires that the chemical processes of containment, metabolism, and evolution support and enable each other, so that there is functional feedback among all three" (Bedau 2011, p. 463).

[9] It becomes apparent, on further reflection, that these positions need not be competitive. To give an example, metabolism- and function-related definitions of life may go hand in hand with the hierarchical integrated-triad account of minimal life proposed in synthetic biology.

[10] Note that Bedau refers here to the contemporary analytic notion of hylomorphism, where essences of natural kinds are defined in reference to underlying passive and active causal powers of things/processes, which are amenable for a scientific description and verification. See (Kripke 1980).

[11] As Griesemer notes, "An alternative to the definitional approach is to develop metaheuristics that delimit the evaluation of criteria, models, and evidence rather than attempting to delimit what constitutes life" (Griesemer 2008, p. 274).

[12] See (Mariscal 2021, sct. 1; Bedau 2011, p. 458). In Section 6 of his article, Mariscal adds that ecology is another division of biology where we can observe "a twilight zone": "Organisms form populations, species, lineages, clades, and ecosystems. The status of each of these is an open question, but they have many of the same features associated with life . . . Perhaps the strongest case can be made for eusocial insects, such as some ants, bees, wasps, and termites" (Mariscal 2021, sct. 6). Even more controversial is the notion of Gaia, which personifies the entire planet Earth and sees the Earth-wide set of ecosystems as a single entity (see Lovelock and Lovelock 1979).

[13] Having listed various types of definitions, Mariscal notes that more recently we can observe a movement away from definitions towards (1) "prototypes" (concepts listing abstract features shared by most but not all members of one category; (2) "exemplars" (concepts built around similarities to particular known cases); or (3) "theory concepts" (concepts modeled on scientific theories). See (Mariscal 2021, sct. 1) with references to main proponents of all three strategies. One more strategy is simply to give a taxonomy of living things. This may be challenged on its assumption that the life we know exhausts what life is or could be. Bedau classifies it as a form of skepticism about defining life (see Bedau 2011, p. 462).

[14] This debate has a long history, going back to ancient Greek philosophy. See (Griesemer 2008, pp. 267–68; Mariscal 2021, scts. 1.1 and 4). For the more recent account of this conversation, see (Deamer 2020; Deamer and Fleischaker 1994; Dyson 1999; Eigen and Winkler-Oswatitsch 1992; Fry 2000; Hazen 2005; Kauffman 1993; Luisi 2006; Morowitz 2002).

[15] I follow the list presented by Griesemer (2008, p. 265) with the examples of researchers applying particular methods and offering particular theories. A separate topic of discussion is the origin of the DNA–protein system. In response to the fact that DNA is replicated and transcribed only in the presence of protein enzymes, the structure of which is, in turn, specified by DNA (genes)—a classical example of the chicken–egg problem—the RNA world hypothesis was offered. It assumes that RNA once served both functions: the replicative-information carrying function of nucleic acid and the catalytic metabolic function of protein. The division of labor was kept because it provided an evolutionary advantage. While plausible, this hypothesis raises a number of critical questions, including: (1) the exact mechanism of the division of labor, (2) the source of the energy and nucleotides for RNA to function as a naked ribozymic replicator, (3) the origin of the genetic code, and (4) the way in which replication worked in a mixed world of RNA and DNA, before the advent of protein enzymes (assuming that DNA came first, which might not have been the case). These and other aspects of the RNA hypothesis are summarized in (Griesemer 2008, pp. 279–82).

[16] See (Mariscal 2021, sct. 4; Griesemer 2008, p. 276). Concerning the top-down approach, Griesemer claims that "The LUCA was too similar to modern life to be much of a guide to how life of that sort could have originated from mere chemicals" (Griesemer 2008, p. 273).

[17] In a related yet more general reflection, he adds: "His [Darwin's] vision no longer seems grand enough, however, in the face of our vastly greater knowledge of chemistry, biochemistry, molecular developmental biology, phylogenetic systematics, evo-devo, epigenetics, genomics, proteomics, and metabolomics, in addition to paleobiology, geophysics, geochemistry, mineralogy, climatology, and astrobiology" (Griesemer 2008, p. 266).

[18] Griesemer concludes that "*All* of our biological assumptions must be reassessed or risk begging questions, e.g., that genes are made of nucleic acids, that life must be cellular, and even that evolution is the driving process" (Griesemer 2008, p. 267).

[19] Woese thinks that life is currently still at the bacterial level of organization (once we take into account the proportion between the biomass of micro- and macro-organisms), and that the common conviction that cellular life is divided into procaryotes and eucaryotes is likely false.

[20] See (Griesemer 2008, pp. 270–73). He notes that while some researchers date life to be 3.8 or 3.9 billion years old and estimate the time window of its origin to fall between 0.2–0.4 billion years, David Penny narrows it even more, to 100 million years (Penny 2005, p. 660). Others go still further and speak about a mere 10 or even 5 million years. However, if life had its origin somewhere else (not on the earth), our estimated time framework of its emergence is most likely wrong.

[21] This means they also remain doubtful about nominal, demonstrative, and stipulative definitions of life (see Section 4 above) or following definitional skepticism in reference to the phenomenon of life.

[22] "'Cause' means (. . .) (2) The form or pattern, i.e., the definition of the essence, and the classes which include this (e.g., the ratio 2:1 and number in general are causes of the octave), and the parts included in the definition" [*Meta*. V, 2 (1013a 27–28)]. See also *Phys*. II, 3 (194b 26–27).

[23] Trying to avoid the error of reducing the metaphysically robust notion of substantial form to geometrical shape or outward appearance, Terrence Irwin rightly notes that "if the form of the statue is essential to it, then other features besides shape must constitute the form, and the reference to shape can at most give us a very rough first conception of form. If we turn from artifacts to organisms, it is even clearer that form cannot be just the same as shape" (Irwin 1988, p. 100).

[24] Michael Storck notes that "not only do we not sense substantial forms, but we do not measure them with scientific instruments either. We sense the size, shape, color, and so forth, of things, and we measure their frequency, mass, temperature, electrical charge, and so on. It is only through our intellect that we are able to grasp something, often not very clearly, of the substantial forms of natural things" (Storck 2008, p. 55).

[25] Dismissing ontological uncertainty and the tendency to treat substantial unity as mereological structures, Aquinas distinguishes among notions of form as the (1) arrangement of parts, (2) union by contact and bond, and (3) union effecting an alteration of the component parts. Only the last refers to the substantial form and substantial change of parts at their entering wholes, which makes certain composite things (most notably living beings) be not mere aggregates of building blocks, but unified entities. See, *In Meta*. V, lect. 3 (§ 779). See also (Tabaczek 2019, pp. 217–18).

[26] "Again (4) in the sense of end or 'that for the sake of which' a thing is done, e.g., health is the cause of walking about. ('Why is he walking about?' we say. 'To be healthy,' and, having said that, we think we have assigned the cause.) The same is true also of all the intermediate steps which are brought about through the action of something else as means towards the end, e.g., reduction of flesh, purging, drugs, or surgical instruments are means towards health. All these things are 'for the sake of' the end, though they differ from one another in that some are activities, others instruments" (*Phys*. II, 3 [194b 29–195a 2]). A similar definition can be found in *Meta*. V, 2 (1013a 29–1013b 2). See also *Phys*. II, 7 (198a 18–20); *Meta*. I, 2 (983a 30–32).

[27] See, for instance, *De part. an*. III, 2 (663b 12–14); IV, 5 (679a 25–30); *De gen. an*. II, 4 (739b 27–31); III, 4 (755a 17–30). Bostock lists a number of scholars claiming that "Aristotle would concede (at least for the sake of argument) that a complete materialist explanation might perhaps be available, and yet still insist that a teleological account was also needed" (Bostock 2006, p. 58). He suggests this "seems to be roughly the position that we ourselves are in nowadays" (ibid., p. 60).

[28] The approach to the phenomenon of life that sees its properties as ontologically constitutive for animate beings remains close to the bundle theory of substance. Similar to this theory, it faces the question concerning the "metaphysical glue" that unifies and holds together a set of more or less rigidly specified properties of life. Once again, Aristotle's hylomorphism offers a valuable and intriguing response to this query. At the same time, the phenomenologically grounded reference to empirically traceable (structural and dispositional) properties of organisms makes their grounding principle of substantial form accessible beyond a purely speculative analysis.

[29] For an account of the debate triggered by Kim's argument, see (Paolini Paoletti and Orilia 2017; Tabaczek 2019, pp. 78–91).

[30] See also (Deacon and Koutroufinis 2014, pp. 407–8; Deacon 2012, chp. 12). Deacon and Cashman notice that the teleological character of the physical work required in the construction of an organism "is ignored in theories of evolution that are limited to natural selection logic alone" (Deacon and Cashman 2013, p. 291).

[31] Walsh offers an answer to the three standard objections concerning teleological explanations: (1) To the argument of the backward causation of nonfactual future states of affairs, he answers that it is goal-directedness, as an intrinsic property of a system, and not unactualized goals, that explains the presence of traits in an organism; (2) to the argument that all teleological explanations require intentionality, he answers that, for Aristotle, teleology is present in both non-rational and rational nature. Intentionality is not necessary to apply a teleological explanation; (3) to the argument that all teleological explanations appear to have a normative import, he answers that "Teleology does not require a category of value-bearing goal states; it only requires goal-directedness" (Walsh 2008, pp. 116–21). See also (Wallace 1996, pp. 15–18).

[32] For more on the debate concerning teleology and function in the contemporary philosophy of biology, see (Robert Cummins 1975; Craver 2013; Wright 1973, 1976; Allen and Neal 2020; Allen et al. 1998; Walsh 2008; Grene and Depew 2004, pp. 313–21; Rosenberg and McShea 2008, pp. 87–93; Sober 1993, pp. 83–88; Godfrey-Smith 2010, pp. 175–88).

[33] The treatment of this problem presented here is based on my upcoming monograph, entitled *Theistic Evolution: A Contemporary Aristotelian-Thomistic Perspective* (Cambridge University Press, forthcoming).

[34] See, for example, the views of William Carroll described in Section 10.2; (Chaberek 2019).

[35] Boulter (2021, p. 142n2) notes that "The scholastic principle of proportionality has close affinities with the contemporary principle of causal commensuration in that it codifies a set of intuitions regarding what we take to be a possible cause of a given effect. The contemporary formulation of the shared core idea is that a cause is commensurate with an effect if it has 'all that is required to produce the effect, and as little as possible that is not' (Yablo 1992). This is thought to be equivalent to the claim that a commensurate cause is sufficient but also necessary for a given effect."

[36] Although one could argue that the divine "elevation" of contingent causes is not so much a miracle but an expression of God's agency in the universe through the instrumental causation of creatures, the argument based on *potentia obedientialis* might be less favored by the naturalistically oriented mind of a contemporary scientist.

[37] It is important to remember, in this context, that the ancient and medieval idea of causation of celestial bodies is not just a relic of an outdated cosmology. It is not entirely implausible to see the energy emitted by the sun, forces of gravitation, and other universal cosmological causal principles as contributing to the educing particular forms from primary matter in processes of substantial changes occurring in nature. At the same time, this general supposition must be distinguished from the outdated science. The ancient and medieval scientists thought that it was through heat that matter was qualitatively disposed to enter a substantial change in which its underlying primary matter was informed by a soul of a given type. They thought semen was a thoroughly concocted blood endowed with powers similar to blood (to produce flesh and organs) yet directed to do so in the conception of a new organism, from the matter provided by the female (see *De gen. an.* II, 4 [740b 24]).

[38] "(Life) is a natural, emergent expression of the routine creativity of the universe . . . To the devout who require that a Creator God have brought it forth, science says, wait—we are coming to understand how it all arose naturally with no Creator's hand" (Kauffman 2008, pp. 59, 89).

[39] "Just as it is not unfitting for one action to be produced by an agent and its power, so it is not inappropriate for the same effect to be produced by a lower agent and God: by both immediately, though in different ways" (*SCG* III, 70, no. 5). On this account, a natural agent is a cause of the coming-to-be (*causa fiendi*) of a thing, whereas they cannot be the ultimate cause of its being (*causa essendi*). See *Super I Sent*. 7, 1, 1, ad 3; *De ver*. 5, 8, ad 8; *De pot*. 5, 1; *ST* I, 104, 1.

[40] See also *ST* III, 62, 1, co.; III, 62, 1, ad 2; *Super III Sent*. 18, 1, 1, ad 4; *SCG* III, 147, no. 6; *ST* I, 45, 5, co.; III, 19, 1, co.; 62, 4, co.; 66, 5, ad 1. One of the anonymous reviewers of the article refers to Aquinas spelling out God's primary causation through creaturely secondary causation in a fourfold way in *De Pot*. 3, 7, saying that God (1) creates and (2) conserves the powers of creatures, as well as (3) applies them to act, and (4) does so instrumentally. Hence, in a way, instrumental causation is built into the distinction between primary and secondary causation. He also mentions John Wippel's argument that if only God can be the cause of *esse* and yet secondary causes can be considered as producing *esse*, then each and every secondary cause must be an instrumental cause. Therefore, even the secondary causes that act according to their natural dispositions could be regarded as instrumental causes in some sense. See (Wippel 2000).

[41] On another occasion, commenting on Aristotle's *Physics* (II, lect. 14 [§ 268]), Aquinas states: "Nature is nothing but a certain kind of art, i.e., the divine art, impressed upon things, by which these things are moved to a determinate end. It is as if the shipbuilder were able to give to timbers that by which they would move themselves to take the form of a ship." The view presented here finds support in (Vicuña 2015, pp. 9–10).

[42] Oderberg notes: "Aquinas speaks of self-movement rather than immanent causation, but he means the same thing: organisms change themselves (*motus* meaning "change" for Aquinas); see *Summa theologiae* I.q18.aa1 and 2" (Oderberg 2020, p. 111, note 4). He develops similar argumentation in (Oderberg 2007, pp. 177–83; Oderberg 2018, pp. 211–33).

[43] In a similar vein, Juan Eduardo Carreño claims "[T]he living being possesses *esse* in a more radical fashion than non-living beings, and because of this it is a more perfect sort of substance. This intensified substantiality, in turn is manifested at the entitative level by a more radical fulfillment of transcendental perfections and, at the operative level, in immanent and spontaneous activity, the two notes that are *prima facie* evident to us" (Carreño 2015, p. 375).

[44] Carroll claims "This is exactly the philosophical conclusion of Oderberg and Feser. For them immanent causation can never arise in any way from transient causation. That is, no amount of transient causation can ever, over time, give rise to immanent causation. Immanent causation is not simply a matter of greater complexity in the agent that exercises such causality. It is not, so to speak, transient causation plus something extra" (Carroll 2022, pp. 46:00–46:40).

[45] This view differs significantly from the one Carroll expressed in (Carroll and Vicuña 2017).

[46] A similar argument is proposed by the followers of the Intelligent Design project. See, e.g., (Behe et al. 2002).

[47] Later on, in book 7, Augustine adds: "The things [that God] had potentially created . . . [came] forth in the course of time on different days according to their different kinds . . . [and] the rest of the earth [was] filled with its various kinds of creatures, [which] produc[ed] their appropriate forms in due time" (*De Gen. ad litt.* 7.22).

[48] *ST* I, 69, 2, co.: "In these first days God created all things in their origin or causes, and from this work He subsequently rested. Yet, afterwards, by governing His creatures, in the work of propagation, 'He worketh until now.' Now the production of plants from out the earth is a work of propagation, and therefore they were not produced in act on the third day, but in their causes only."

[49] See also *De pot.* 4, 2, ad 28: "Before the plants were produced causally, nothing was produced, but they were produced together with the heaven and the earth. In like manner the fishes, birds and animals were produced in those six days causally and not actually." Aquinas alludes to the concept of *rationes seminales* on several other occasions. See, e.g.,: *Super IV Sent*., 48, 2, 1, ad 3; *ST* I, 62, 3, co.; *ST* I, 74, 2, co. and ad 1–2.

[50] It should be remembered that the second part of the corpus and all responses to arguments in this article were most likely written by Vincentius Castronovo and not by Aquinas himself, who probably left the article in question unfinished.

[51] The reference for this quotation was provided above, in Section 10.2. Concerning the causality of celestial spheres, it would not be justified to claim that in Aquinas's hierarchy of causes, the sun—as a higher cause—is a source of life as such, i.e., sharing a perfection it itself possesses. Rather, it should be seen as an instrumental cause through which God brings into existence something that goes beyond its natural dispositions (educing vegetative substantial form from the potentiality of primary matter).

[52] In other words, to claim with Oderberg that the essence of life is defined by immanent causation (which he identifies with teleology) is rather imprecise. The essence of life for Aristotle and his followers is specified by a unique type of substantial form which he calls soul.

[53] Another important aspect of this conversation requires an introduction of a distinction between the two types of immanent causation. It may be either (1) a purely intrinsic action of a substance or (2) an extrinsic action of a substance that terminates in an effect that is beneficial for the cause. (1) can be defined as an action of an entity that influences one of its parts either (a) spontaneously or (b) in response to an external stimulus. An example of (1a) may be a replication of DNA in a living cell or the persistent "sustenance" and "control" of a dynamic configuration of elementary particles and the atomic structure of an inanimate complex molecule. An example of (1b) may be a change of an ionic gradient in a living cell in response to the external environment or a reconfiguration of atoms in an inanimate chemical compound within an electromagnetic field. In the case of (2), one might think about a living cell secreting substances to fight an external pathogen or a resistance of a molecule or a compound in response to an external force that effects the change of its configuration (in terms of an action—re-action type of interaction). Note that (2) brings together transeunt and immanent causation, which reveals the complexity of causal dependencies in nature. It is also important to remember that (1) (both 1a and 1b) does not violate the Aristotelian principle that everything that is moved must be moved by someone else, since it refers to the situations in which a whole substance "moves," i.e., exercises efficient causation on one of its parts.

[54] As Joe Sachs notes, "Aristotle invents the word by combining *enteles* [ἐντελής] (complete, full-grown) with *echein* (= *hexis*, to be a certain way by the continuing effort of holding on in that condition), while at the same time punning on *endelecheia* [ἐνδελέχεια] (persistence) by inserting *telos* [τέλος] (completion). This is a three-ring circus of a word, at the heart of everything in Aristotle's thinking, including the definition of motion" (Sachs 1995, p. 245). Commenting on this term, O'Rourke says, "It is form (μορφή), therefore, which is nature (φύσις [*physis*]). It is form as ἐντελέχεια which is the τέλος [*telos*] of γένεσις [*genesis*], that is, of the coming-to-be of φύσις. In its state of completion, φύσις is synonymous with ἐντελέχεια, the fulfillment of εἶδος" (O'Rourke 2004, p. 17).

[55] See also *In Phys.* II, lect. 11 (§ 242).

[56] One of the main difficulties of Deacon's retrieval of teleology is his conviction that it is necessary to explain the way in which teleological properties emerge from nonteleological, i.e., explain the way in which the causal dynamics of teleological processes emerges from simpler, blind, mechanistic systems. See (Deacon 2012, p. 275).

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