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An Aristotelian Account of Evolution and the Contemporary Philosophy of Biology

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***Abstract*: The anti-reductionist character of the recent philosophy of biology and the dynamic development of the science of emergent properties prove that the time is ripe to reintroduce the thought of Aristotle, the first advocate of a "top-down" approach in life-sciences, back into the science/philosophy debate. His philosophy of nature provides profound insights particularly in the context of the contemporary science of evolution, which is still struggling with the questions of form (species), teleology, and the role of chance in evolutionary processes. However, although Aristotle is referenced in the evolutionary debate, a thorough analysis of his theory of hylomorphism and the classical principle of causality which he proposes is still needed in this exchange. Such is the main concern of the first part of the present article which shows Aristotle's metaphysics of substance as an open system, ready to incorporate new hypothesis of modern and contemporary science. The second part begins with the historical exploration of the trajectory from Darwin to Darwinism regarded as a metaphysical position. This exploration leads to an inquiry into the central topics of the present debate in the philosophy of evolutionary biology. It shows that Aristotle's understanding of species, teleology, and chance – in the context of his fourfold notion of causality – has a considerable explanatory power which may enhance our understanding of the nature of evolutionary processes. This fact may inspire, in turn, a retrieval of the classical theology of divine action, based on Aristotelian metaphysics, in the science/theology dialogue. The aim of the present article is to prepare a philosophical ground for such project.**

Keywords: Aristotle; Darwin; evolution; natural selection; hylomorphism; principle of causation; teleology; chance; essentialism

> Motto: Everything is mechanical in a machine, except the idea to construct it, which has dictated the plan of it. One hardly dares to touch the luminous, translucent page wherein Creative Evolution develops perfectly self-assured views, nourished by truths of every sort, and nevertheless dominated by a kind of metaphysical Manicheanism in which intelligence, dragging finality with it, is condemned to dwell in the house of geometry and evil. (Étienne Gilson, From Aristotle to Darwin and Back Again)

I. Introduction

Any attempt at a reliable dialogue between theology and science requires from us, at first, a careful analysis of the philosophical aspects concerning scientific theories, as well as the philosophical presuppositions and language grounding theological reflection. Thus, philosophy of science, philosophy of nature, and metaphysics become a bridge between science and theology, protecting both sides from misunderstanding and confusion. The aim of this article is to bring the contemporary philosophy of biological evolution and Aristotle's theory of hylomorphism, teleology and chance, into a conversation, which may further serve as a background for a theological reflection on divine action in evolution, rooted in Aristotelian/Thomistic tradition.

One of the major advances of the contemporary philosophy of biology is its criticism of the predominant reductionist dogma and the "bottom-up" approach in life-sciences. In the context of this methodological change, Aristotle – the first and one of the greatest philosophers of biology – reenters science/philosophy debate, presenting a position which cannot be neglected. While the predecessors of his philosophical reflection on nature found it necessary to specify the most basic and enduring entities, and define the principles of the compositional explanation of everything else, Aristotle opted for a "top-down" approach in life-sciences. As the first anti-reductionist, he argued that natural objects owe their characteristic modes of being and acting to their formal natures. Aristotle's way of doing biology reflected the basic principles of his substance metaphysics, founded on the concepts of hylomorphism (material and formal composition of entities), teleology, essence, chance and necessity, and thus remained in opposition to materialistic and reductionist explanations found among Pre-Socratics.

Although some of the affinities between Aristotle's biology and the contemporary anti-reductionism of the science

of emergent properties seem to be apparent and undeniable for certain participants of the science/philosophy debate,[1] other scientists and philosophers do not hesitate to notice and emphasize deep and far-reaching differences between these two traditions. Aristotle is accused of presenting too static an explanation of nature. His metaphysics of substances is opposed to the process understanding of the most basic levels of the fabric of the cosmos. His definition of species as fixed and enduring essences seems to remain in radical opposition to evolutionary theory, and his concept of teleology (final causation) appears to many as based on an unacceptable idea of backward causality of future goals on the present state of affairs.[2]

Nevertheless, I believe that many of these difficulties can be resolved as the basic assumptions of the Aristotle's philosophical system prove flexible enough to respond to current issues debated in science and philosophy of science. I claim that we find a particular example of this actuality of Aristotle's natural philosophy in the context of the contemporary science of evolution, which returns to the questions of understanding of forms (species), teleology, and the role of chance in evolutionary processes. Moreover, I think that the Aristotelian tradition successfully refutes the metaphysical claims of naïve mechanicism, and reductionism, presented in the past by some radical Neo-Darwinists.

In the first part of this article I will discuss metaphysical aspects of the theory of evolution in its encounter with hylomorphism and the classical principle of causation which says that higher effects cannot have lower causes. This consideration will serve as a necessary background for the second section. This second section will first begin with a historical inquiry exploring the transition from Darwin to Darwinism as a metaphysical position. Next, I will concentrate on philosophical aspects of species, natural selection, teleology, and chance in the theory of evolution. I will try to show that the Aristotelian philosophical tradition remains relevant with regard to some issues discussed recently among philosophers of biology.

Metaphysics of Evolution

If there exists a metaphysical foundation for the theory of evolution one would not expect to find it in the substance metaphysics of Aristotle and his followers. Juxtaposing Aristotle with Darwin seems like an oxymoron in the context of the general opinion that the latter ultimately proved the inadequacy of the biology of the former. A radical discrepancy between the evolution of species and a metaphysics of substances that excludes any notion of change or transformation of species seems evident and undeniable. However, although Aristotle seems to explicitly reject evolution, a careful study of his thought shows that he was concerned with the dynamics of change in nature, and that the basic categories of his metaphysics, such as hylomorphism, principles of causation, account of chance, and even the problem of species, do not rule out the concept of evolution. Quite the opposite, Aristotle's metaphysics proves to be an open system, ready to incorporate new hypothesis of modern and contemporary science. I will now discuss to a greater extent a possible response of Aristotle to the theory of evolution.

A. The Concept of Hylomorphism and Evolution

In order to understand better the process of generation, change, corruption, and decay, and give a proper description of both changing and persistent aspects of nature, Aristotle introduces the categories of mater and form. The first one refers not only to the stuff out of which things are made.[3] The idea of 'primary matter' (*prōtē hulē*) is the principle of potentiality, something that persists through all changes that a given substance can be exposed to, something that constitutes the very possibility of being a substance at all:

> The matter comes to be and ceases to be in one sense, while in another it does not. As that which contains the privation, it ceases to be in its own nature, for what ceases to be – the privation – is contained within it. But as potentiality it does not cease to be in its own nature, but is necessarily outside the sphere of becoming and ceasing to be. (…) For my definition of matter is just this – the primary substratum of each thing, from which it comes to be without qualification, and which persists in the result.[4]

Form, on the other hand, is not only an organizing principle arranging the geometrical structure and shape of the constituent parts of an entity (substance).[5] It is an

1 See for instance Philip Clayton, "Conceptual Foundations of Emergence Theory," in *The Re-Emergence of Emergence*, edited by Philip Clayton, and Paul Davies (Oxford, New York: Oxford University Press, 2006), 4-5; Terrence Deacon, *Incomplete Nature: How Mind Emerged from Matter* (New York: W. W. Norton & Company, 2011), 34-7, 230-4; Claus Emmeche, Simo Køppe, and Frederic Stjernfeld, "Levels, Emergence, and Three Versions of Downward Causation," in *Downward Causation. Mind, Bodies and Matter*, edited by Peter Bøgh Andersen, Claus Emmeche, Niels O. Finnemann, and Peder Voetmann Christiansen (Aarhus, Oxford: Aarhus University Press, 2000), 13-34; Alvaro Moreno, and Jon Umerez, "Downward Causation at the Core of Living Organization," in *Downward Causation. Mind, Bodies and Matter*, edited by Peter Bøgh Andersen, Claus Emmeche, Niels O. Finnemann, and Peder Voetmann Christiansen (Aarhus, Oxford: Aarhus University Press, 2000), 99-116.

2 See for instance Mark H. Bickhard and Donald T. Campbell, *Emergence*, http://www.lehigh.edu/~mhb0/emergence.html (accessed 26 September, 2014); Menno Hulswit, "How Causal is Downward Causation?," *Journal for General Philosophy of Science* vol. 36, no. 2, p. 276, 2005.

3 "[T]hat out of which a thing comes to be and which persists, is called 'cause', e.g. the bronze of the statue, the silver of the bowl, and the genera of which the bronze and the silver are species" (Aristotle, *Physics* in *The Basic Works of Aristotle*, edited by Richard McKeon [New York: The Modern Library, 2001], II, 3 [194b 24-25], from now on *Phys.*). See also Aristotle, *Metaphysics*, in *The Basic Works of Aristotle*, edited by Richard McKeon (New York: The Modern Library, 2001), V, 2 (1013a 24-25), from now on *Meta.*

4 Aristotle, *Phys.* I, 9 (192a 25-33). See also *Phys.* I, 7 (191a 8-12); II, 7 (198a 21-22); *Meta.* VII, 3 (1029a 20-21); VIII, 4 (1044a 15-23); IX, 7 (1049a 19-22, 24).

5 "'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" (Aristotle, *Meta.* V, 2 [1013a 27-28]). See also *Phys.* II, 3 (194b 26-27). In both definitions of formal causation Aristotle uses the term "ὁ λόγος τοῦ τί ἦν εἶναι," which Gaye translates as "the statement of the essence," and Ross as "the definition of the essence." However, Aristotle uses also two other terms: μορφή and εἶδος which translate as "shape" or "appearance." These may bring a confusion and a reduction of form to a geometrical shape, which flattens out Aristotle's original

informing principle of actuality, that, by which a thing is what it is; an intrinsic, determining principle that actualizes primary matter and thus constitutes an individual being. The meaning of form is easier to grasp in the context of Aristotle's account of accidental and substantial change:

> [T]here is 'alteration' when the substratum is perceptible and persists, but changes in its own properties, the properties in question being opposed to one another either as contraries or as intermediates. The body, e.g. although persisting as the same body, is now healthy and now ill; and the bronze is now spherical and at another time angular, and yet remains the same bronze. But when nothing perceptible persists in its identity as a substratum, and the thing changes as a whole (when e.g. the seed as a whole is converted into blood, or water into air, or air as a whole into water), such an occurrence is no longer 'alteration'. It is a coming-to-be of one substance and a passing-away of the other-especially if the change proceeds from an imperceptible something to something perceptible (either to touch or to all the senses).[6]

The form of an entity body is therefore more than just a shape. As an intrinsic and constitutive principle of the essence of its being, substantial form persists through accidental changes. However, Aristotle notes that a thing can change as a whole in a way which brings not only an alteration of an existent being, but the coming-to-be of a new substance.

Matter and form are intrinsically related for Aristotle. They cannot exist separately. In other words, we know form only as realized in primary matter, and we know primary matter only as in-formed; there is no place for Platonic dualism here. Aristotle observes a substantial unity of being at first, and introduces a distinction between primary matter and substantial form to explain this unity and the fact that things can change. In the book VIII of the *Metaphysics* we read:

> What then, is it that makes man one; why is he one and not many? (...) [I]f, as we say, one element is matter and another is form, and one is potentially and the other actually, the question will no longer be thought a difficulty. (...) The difficulty disappears, because the one is matter, the other form. (...) [T]he proximate matter and the form are one and the same thing, the one potentially, and the other actually. (...) Therefore there is no other cause here unless there is something which caused the movement from potency into actuality.[7]

This hylomorphic doctrine of Aristotle's metaphysics proves to be of special importance for the theory of evolution. Both matter and form, refer to the principles of persistence and change. Aristotle claims, "The matter comes to be and ceases to be in one sense, while in another it does not." By saying this, he emphasizes that, when in-formed, primary matter as the subject of the privation of form, somehow "ceases to be." But on the other hand, its potentiality is never lost. Because of this, primary matter is "outside the sphere of becoming and ceasing to be", and "persists in the result."[8] When speaking about form, Aristotle argues that although the substantial forms of living and non-living beings are fixed, nevertheless, substances may be altered with respect to their accidental forms (e.g. green apple changing its color from green to red when ripe). What is more, when the primary matter of an already existing being is properly disposed, it may receive a new substantial form in a process of the coming-to-be of a new substance, that is 'generation' or 'corruption.'[9]

The idea of the disposition of matter is related to a natural tendency of matter to be in-formed by more perfect forms. Aristotle recognizes an ascent of perfection of the beings in nature. On his *scala naturae* we can observe a gradual crescendo from non-living, through plant and animal, to human forms:

> Nature proceeds little by little from things lifeless to animal life in such a way that it is impossible to determine the exact line of demarcation, nor on which side thereof an intermediate form should lie.[10]

idea. Aristotle uses one more term: ἐντελέχεια, which relates formal to final causation and denotes form as actualized in the final state of a being.

6 Aristotle, *On the Generation of Animals*, in *The Basic Works of Aristotle*, vol. 5, edited by J. A. Smith and W. D. Ross (Oxford: Clarendon Press, 1912), I, 4 (319b 10-18), from now on *On Gen.* See also Aristotle *On Generation and Corruption*, in *The Basic Works of Aristotle*, edited by Richard McKeon (New York: The Modern Library, 2001), I, 4 (319b 10-18).

7 Aristotle, *Meta.* VIII, 4 (1045a 14, 21-25, 29-30; 1045b 18-19, 21-2). We find a similar argumentation in *On the Soul*: "That is why we can wholly dismiss as unnecessary the question whether the soul and the body are one: it is as meaningless as to ask whether the wax and the shape given to it by the stamp are one, or generally the matter of a thing and that of which it is the matter. Unity has many senses (as many as 'is' has), but the most proper and fundamental sense of both is the relation of an actuality to that of which it is the actuality" (Aristotle, *On the Soul*, in *The Basic Works of Aristotle*, edited by Richard McKeon [New York: The Modern Library, 2001], II, 1 [412a 6-9]). See also Aristotle, *On the Parts of Animals*, in *The Basic Works of Aristotle*, vol. 5, edited by J. A. Smith and W. D. Ross (Oxford: Clarendon Press, 1912), I, 1 (640b 22-29), from now on *Part. An.*

8 Aristotle, *Phys.* I, 9 (192a 25-33).

9 The need for proportion between form and matter (act and potency) is emphasized by Aristotle in *Meta.* VIII, 4 (1044a 15-23), and even more explicitly by Aquinas in his *Commentary on Metaphysics*: "From the things which are said here then it is evident that there is one first matter for all generable and corruptible things, but different proper matters for different things" (Thomas Aquinas, *Commentary on The Metaphysics of Aristotle*. 2 Vols. Translated by John Rowan [Chicago: Regnery Press, 1961], VIII, lect. 4 [§1730], from now on *In meta.*). In *Summa contra gentiles* he adds: "Thus, form and matter must always be mutually proportioned and, as it were, naturally adapted, because the proper act is produced in its proper matter. That is why matter and form must always agree with one another in respect to multiplicity and unity" (Thomas Aquinas, *On the Truth of the Catholic Faith: Summa Contra Gentiles*. 4 Vols., translated by Anton C. Pegis *et al.* [Garden City, New York: Image Books, 1955-1957], II, 81, no. 7, from now on *SCG*).

10 Aristotle, *The History of Animals*, in *The Basic Works of Aristotle*, vol. 4, edited by J. A. Smith and W. D. Ross (Oxford: Clarendon Press, 1910), VIII, 1 (588b 4-6), from now on *Hist. An.* Aristotle gives at this point an example of the ascent of nature from plants to animals: "[T]here is observed in plants a continuous scale of ascent towards the animal. So, in the sea, there are certain objects concerning which one would be at a loss to determine whether they be animal or vegetable"

> [N]ature passes from lifeless objects to animals in such unbroken sequence, interposing between them beings which live and yet are not animals, that scarcely any difference seems to exist between two neighbouring groups owing to their close proximity.[11]

> There is a good deal of overlapping between the various classes.[12]

Similar is the position of Aquinas, one of the most prominent commentators of Aristotle, who also notices a tendency of nature towards superior forms in the process of generation and corruption. In his *Summa contra gentiles* we find an important reflection on the hierarchy of degrees in substantial transformation, which I should quote extensively:

> [T]he more posterior and more perfect an act is, the more fundamentally is the inclination of matter directed toward it. Hence in regard to the last and most perfect act that matter can attain, the inclination of matter whereby it desires form must be inclined as toward the ultimate end of generation. Now, among the acts pertaining to forms, certain gradations are found. Thus, primary matter is in potency, first of all, to the form of an element. When it is existing under the form of an element it is in potency to the form of a mixed body; that is why the elements are matter for the mixed body. Considered under the form of a mixed body, it is in potency to a vegetative soul, for this sort of soul is the act of a body. In turn, the vegetative soul is in potency to a sensitive soul, and a sensitive one to an intellectual one. (...) So, elements exist for the sake of mixed bodies; these latter exist for the sake of living bodies, among which plants exist for animals, and animals for men. Therefore, man is the end of the whole order of generation.[13]

Our reflection on hylomorphism, substantial and accidental change, the disposition of matter and its tendency to be in-formed by more perfect forms, helps us to think about metaphysical aspects of the mechanism of evolution. Evolution can be understood, according to Moreno and O'Rourke, as a series of accidental changes in the structure of genetic material (DNA), effecting the disposition of primary matter, and leading to a precise instant at which the primary matter of the egg and sperm, when joined, is not disposed to the old substantial form (F_1) of the parents, but to a new substantial form (F_2), constituting a new species. It takes many mutations (outcomes of which are regulated by natural selection) to produce such an effect, and its actual occurrence may be extremely difficult to capture. But this does not exclude the possibility of its occurring, especially in a situation where members of a species migrate to a new environment and can be modified gradually in subsequent generations, to the point where they cannot mate with the descendants of their ancestors any more. Thus it becomes clear that, even if Aristotle's biological research was far from discovering the possibility of the transformation of species, his metaphysics left much room for such a possibility.[14]

B. Causation Principle and Evolution

An Aristotelian response to the theory of evolution faces another important metaphysical problem. It seems to violate the basic philosophical principle of causation, which says that the higher cannot come from the lower.[15] To deal with this difficulty we should first notice a fundamental difference between the metaphysical order of various degrees of perfection of different 'essences,' and the biological order of different forms of life which is based on a historical and phenomenological analysis. Metaphysical categories of 'higher' and 'lower' should not be equated with biological concepts describing organisms as 'more complex' and 'better adapted.' In other words, 'more complex' and 'better adapted' do not presuppose a higher perfection of 'essence.' Insects, for instance, are certainly not the highest organisms in terms of the metaphysical perfection of their 'essence,' but they can be regarded as a culmination of an evolutionary line in terms of adaptation to their environmental niche. That is why, when biology speaks of different species, it does not mean to speak of different 'essences,' as it is not interested in levels of ontological perfection.

Moreover, the mechanism of biological evolution does not coincide with the philosophical notion of efficient causality. To 'descend from,' or to 'be produced out of' differs in meaning from the philosophical notion of being 'caused' or 'produced by.' In addition, the emphasis on the historical aspect of the development of various species helps us to see it as a complex result of many causal influences. The mechanism of evolution would then seem to involve

(*Hist. An.* 588b 11-13). With the advance of modern science we find it easier to define taxon-specific characteristics.

11 Aristotle, *On the Parts of Animals*, in *The Basic Works of Aristotle*, vol. 5, edited by J. A. Smith and W. D. Ross (Oxford: Clarendon Press, 1912), IV, 5 (681a 12-15), from now on *Par. An.* Aristotle gives an example of the sponge which here he classifies as a plant: "A sponge, then, as already said, in these respects completely resembles a plant, that throughout its life it is attached to a rock, and that when separated from this it dies" (*Par. An.* 681a 15-17), whereas in *History of Animals* he compares it to animals, due to its sensation: "Stationary animals are found in water, but no such creature is found on dry land. In the water are many creatures that live in close adhesion to an external object, as is the case with several kinds of oyster. And, by the way, the sponge appears to be endowed with a certain sensibility" (*Hist. An.* I, 1 [487b 9-10]).

12 Aristotle, *Gen. An.* II, 1 (732b 15). See also Fran O'Rourke, "Aristotle and the Metaphysics of Evolution," *The Review of Metaphysics* no. 58, pp. 39-40, Sept., 2004. He claims that "Without exaggerating its importance, Aristotle recognizes man's link to the primates: the ape, the monkey, and the baboon, he states, *dualize in their nature with man and the quadrupeds*" (*Hist. An.* II, 8 [502a 16-18], transl. A. L. Peck). In *Par. An.* IV, 10 (689b 31-33) Aristotle adds that: "The ape is, in form, intermediate between man and quadruped, and belongs to neither, or to both."

13 *SCG*, III, 22, 7. See also Antonio Moreno, "Some Philosophical Considerations on Biological Evolution," *The Thomist* no. 37, pp. 440-41, July, 1973.

14 Moreno, "Some Philosophical Considerations," 429-31; O'Rourke, "Aristotle," 26-7: "If Aristotle's metaphysical analysis of growth and change is correct, the principles of form and the affirmation of potency will hold *a fortiori* for the evolutionary process" (O'Rourke, "Aristotle," 27).

15 "[T]he begetter is of the same kind as the begotten" (*Meta.* VII, 8 [1033b 30]). "[N]o effect exceeds its cause" (Thomas Aquinas, *Summa Theologica*. 5 Vols., translated by the Fathers of the English Dominican Province [Scotts Valley, CA: NovAntiqua, 2008], II-II, 32, 4, obj. 1, from now on *ST*). "[E]very agent produces its like" (*SCG* II, 21, no. 9). "[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).

a matrix of various causes. But can this matrix of causes or any one of them individually be considered the efficient cause of the eventual product of evolution? As Aristotle conceives, an efficient cause always acts for a particular end. But none of the factors involved in evolution is understood as intending its eventual product. That is why we may conclude by emphasizing one more time that the proportionate cause of the emergence of the new species is not a single law or force, but a concurrence of many causal influences constitutive for an evolutionary event, or rather a history of evolutionary changes.[16]

II. Philosophical Problems of Darwin and Darwinism

The fact that the Aristotelian tradition is ready to accommodate the principles of evolution does not mean that it will do so uncritically. This tradition's careful analysis allows us to distinguish between evolutionary science and the philosophical conclusions drawn from it. It also proves to be an important voice in the discussion of species, natural selection, teleology, and the role of chance in nature. I will refer to all of these problems in what follows.

A. Darwin Was Not an Evolutionist

As Étienne Gilson shows in his excellent study *From Aristotle to Darwin and Back Again*, in Charles Darwin's *On the Origin of Species* the word "evolution" appears only once, in the last of the six editions of the book published during his lifetime. We can name at least two reasons for which Darwin wanted to avoid using this term in his synthesis. First of all, it was already in use by a tradition which had assigned to it a meaning radically opposite to what he himself discovered. St. Augustine, St. Bonaventure, and Malebranche, wanting to emphasize that after creation nothing has been added to the world, claimed that everything originally contained in nature in the form of seminal notions (*rationes seminales*) gradually 'e-volves,' 'un-folds,' or 'en-velops' in time. The most representative advocate of this position in the 18th century was Charles Bonnet of Geneva, who would place his own ideas of preformation and evolution in opposition to the doctrine of epigenesis (growth by the successive acquisition and formation of new parts). It is clear that this definition of evolution remained in radical opposition to what Darwin was suggesting in his *On the Origin of Species*.[17]

Darwin was also familiar with the work of Herbert Spencer, a philosopher who regarded himself as a father of the doctrine of evolution, which he defined as "an integration of matter and dissipation of motion". For a biologist such as Darwin, assertions of this kind were simply pointless. But he must have been familiar with Spencer's biological views supporting Lamarckism, which he radically rejected, after he had developed his idea of natural selection. Spencer would agree with Lamarck saying that variations in the surrounding environment force organisms to modify themselves. For Darwin the principle of change was natural selection. For this reason he did not want to be associated with the position of Spencer.[18]

The capital truth of Darwin's position was trifold: 1) That species are groups of individuals that vary slightly from one another, and have a tendency to increase their number over generations in a process which is constrained by a struggle for existence, due to limited resources, diseases, and predators.[19] 2) That favorable variations in species are preferred in virtue of a general phenomenon which Darwin called 'natural selection.' 3) That over time this process brings changes in descendant populations of an ancestor species that differentiate them enough so that they can be classified as different species.[20] Darwin wanted to stay away from the philosophical baggage of the term 'evolution' used by Spencer. He referred rather to the idea of 'transmutation of species' or 'change of species by descent,' which better described his position. Knowing that his theory was in opposition to the literal reading of the Bible, he argued against a naïve creationism and the notion of miraculous divine intervention in the coming-to-be of new species, which he thought was incompatible with the scientific spirit.[21] But other than this, Darwin did not want to engage himself in philosophical or theological debates. He was and wanted to remain a scientist. However, that history wrote its own scenario which made Darwin a herald of the new science and philosophy of evolution, is now undeniable. Reflecting on this fact Gilson says:

> It is popularly asked who, Lamarck or Darwin, is the first inventor of the doctrine of evolution, although neither of them may have claimed the paternity of the discovery,

16 Benedict Ashley, "Causality and Evolution," *The Thomist* no. 36, p. 215, Apr., 1972; Norbert Luyten, "Philosophical Implications of Evolution," *New Scholasticism* vol. 25, pp. 300-302, July, 1951; Leo J. Elders, "The Philosophical and Religious Background of Charles Darwin's Theory of Evolution," *Doctor Communis* vol. 37, p. 56, 1984.

17 Étienne Gilson, *From Aristotle to Darwin and Back Again. A Journey in Final Causality, Species, and Evolution* (San Francisco: Ignatius Press, 2009), 59-61.

18 In his *Autobiography* Darwin says: "I am not conscious of having profited in my work by Spencer's writings. His deductive manner of treating every subject is wholly opposed to my frame of mind. (…) His fundamental generalizations (…) which I daresay may be very valuable under a philosophical point of view, are of such a nature that they do not seem to me to be of any strictly scientific use" (*The Autobiography of Charles Darwin, 1809-1882*, ed. Nora Barlow [London: Collins, 1958], 108-9). Spencer, on the other hand, defending his position says that "[J]ust as the theory of the Solar System, held up to the time of Newton, would have continued outstanding had Newton's generalization been disproved, so, were the theory of natural selection disproved, the theory of organic evolution would remain. (…) The theory of natural selection is wrongly supposed to be identical with the theory of organic evolution; and the theory of organic evolution is wrongly supposed to be identical with the theory of evolution et large" (Herbert Spencer, "Lord Salisbury on Evolution, Inaugural Address to the British Association, 1894," in *The Nineteenth Century* [November 1895], 740-1, 757).

19 Darwin adopted the idea of struggle for existence from Rev. T. Malthus, who was concerned with social and political issues. Coming from a naturalist point of view he claimed that nature necessarily eliminates most of what she produces, due to the limited resources sustaining populations. He applied this rule to human population as well suggesting that the Poor Law should be abolished because it perpetuates and multiplies the ill-adapted. Darwin used political and economic views of Malthus in his biological explanation of nature. See Gilson, *From Aristotle*, 88-95.

20 James G. Lennox, "Darwinism and Neo-Darwinism," in *A Companion to the Philosophy of Biology*, ed. Sahotra Sarkar and Anya Plutynski (Oxford: Blackwell, 2011), 80.

21 Darwin's view of philosophical theology and his image of God were rather superficial, which triggered criticism of his work in theological circles.

while no one would dream of attributing it to Spencer, who claims it with good reason. This new unicorn, *evolutionismus darwinianus*, gives proof of a remarkable vitality. It owes this, no doubt, to its peculiar nature as a hybrid of a philosophic doctrine and a scientific law. Having the generality of the one and the demonstrative certitude of the other, it is virtually indestructible.[22]

Despite Spencer's protests, the doctrine of evolution was attributed to Darwin, who had changed his mind noticeably with the publication of the *Descent of Man*, in which he spoke of evolution as a 'great principle.' This must have been a surprise for those who knew that thirteen years before he had written the *Origin* without even mentioning such a term. Nevertheless, Darwin was already regarded as an apostle of evolution. Moreover, the term itself, which had had philosophical roots and connotations in Spencer, remained a philosophical doctrine in Darwin as well. The popular understanding of the Neo-Darwinian synthesis, which has been developed on the basis of Darwinism, laboratory genetics, and the mathematical theory of population genetics, is praised by many as a purely scientific theory:

[T]here is a profound truth in the claim that 'the Evolutionary Synthesis' is, at its core, a brilliant integration. Experimental and mathematical genetics are wedded to those subjects that dominate *On the Origin of Species*: natural selection acting on chance variation as the principal mechanism of evolutionary change; the fossil record as the principal historical evidence of the evolutionary process; and biogeographic distribution providing overwhelming evidence that current populations are the products of an evolutionary process.[23]

However, this optimism seems to be somewhat exaggerated if not unjustified. Experimental and mathematical genetics do not answer all the questions concerning concrete examples of species and their evolutionary traits. The fossil record, although much more advanced and complete than in the times of Darwin, still has many substantial gaps.[24] But most importantly, the theory of evolution is by no means purely scientific, which is sometimes neglected in scientific circles. In its Neo-Darwinian version it introduces significant philosophical claims and raises many philosophical questions concerning species, the nature of selection, the problem of teleology, and the nature and role of chance as a factor in evolutionary changes. Some of these problems are a subject of an intriguing discussion among philosophers of biology. I shall now try to introduce the Aristotelian tradition into this debate

22 Gilson, *From Aristotle*, 83.

23 Lennox, *Darwinism*, 84.

24 It seems that what Darwin says in the *Origin* is still relevant: "Geology assuredly does not reveal any such finely graduated organic chain; and this, perhaps, is the most obvious and gravest objection which can be urged against my theory. The explanation lies, as I believe, in the extreme imperfection of the geological record" (Charles Darwin, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* [London: John Murray, 1859], http://en.wikisource.org/wiki/On_the_Origin_of_Species_(1859) [accessed 26 September, 2014], 280).

B. The Problem of Species

The fact that the very term 'evolution' is not found in the book heralded as the foundation of the theory named after it, is itself a striking paradox; yet this paradox is followed by another. The title of Darwin's work is, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life.* However, as Gilson notices, similar to Buffon and Lamarck, Darwin actually criticizes the very idea of species, taking a nominalist position in the dispute over universals. In the oft-cited passage from the *Origin* Darwin states:

I look at the term species as one arbitrarily given, for the sake of convenience, to a set of individuals closely resembling each other, (…) [I]t does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms. The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, for convenience's sake.[25]

Of course, the question remains of whether Darwin is truly denying the objective reality of species. Some say that he is merely pointing towards the problem that goes back to Aristotle, who, as we have seen, also had difficulties distinguishing between non-living and living beings, plants and animals, and neighbouring groups of animals, and saw "a good deal of overlapping between the various classes."[26] But I think that it is undeniable that Darwin, even if he does not reject the concept of species as such, dissolves it into an endless variety of individuals. Even if he cannot help using the term 'species' from time to time, his transformism happens rather on the level of individuals.

And here comes the problem. If species are only constructs of our mind, then evolution also exists merely on the level of the abstraction of human reason. But this then questions the very credibility of evolution as an empirical scientific theory. That is why in the Neo-Darwinian synthesis species are making their comeback. Ernst Mayer, one of the leading evolutionary biologists of the 20th century, says that:

[W]hoever, like Darwin, denies that species are non-arbitrarily defined units of nature not only evades the issue but fails to find and solve the most interesting problems of biology."[27]

Without speciation there would be no diversification of the organic world, no adaptive radiation, and very little evolutionary progress. The species, then, is the keystone of evolution.[28]

But the debate and search for a precise definition of a species based on objective scientific facts has not brought a satisfactory solution to the problem yet. At the foundation of the Neo-Darwinist approach, both Mayer and Dobzhansky were looking for a middle way between essentialism and nominalism. Mayer proposed the Biological Species Concept (BSC), which was based on the observation of the reproductive processes operating at the base of generation

25 Darwin, *On the Origin*, 52.

26 See above, point I *A*.

27 Ernst Mayer, *Animal Species and Evolution* (Cambridge, MA: Harvard University Press, 1963), 29.

28 Mayr, *Animal*, 621.

and maintenance of species. He defines species in a following way:

> Species are groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups. (...) Isolating mechanisms are biological properties of individuals which prevent the interbreeding of populations that are actually or potentially sympatric.[29]

This definition emphasizes the relational aspect of members of a species which are related to one another by causal and historical situations, rather than a shared relation to a common type. However, although it seems to describe properly epistemological aspect of the differentiation of species, I think that Mayer's definition is not quite successful in answering ontological questions. Applying the criterion of interbreeding we may conclude epistemologically that two populations are different species. But the question remains of what makes them to be various kinds ontologically? Others criticize Mayer's proposition and the whole variety of other definitions which have it as their base, such as recognition, genetic, agamo, and ecological species concepts,[30] pointing to the difficulty in determining the potential for interbreeding in the case of groups of organisms that do not overlap or interact due to geographic separation?

The critique of this commonly accepted Neo-Darwinist theory of species brought a shift towards more operational concepts based on morphological and genetic similarity. We classify in this group morphological, phenetic, polythetic, genotypic cluster, and genealogical concordance species concepts.[31] Although they refer mainly to some observable traits, regardless of their phylogeny or evolutionary relation, their proponents distance themselves from the essentialist language of intrinsic properties and substantial form. These theories were criticized for various reasons. It is difficult to find a common similarity algorithm and clustering approach. Some similarities seem to be more important than others. Moreover, similarity based concepts do not distinguish between polymorphisms in populations and differences across genera, between similarities due to common ancestry and homologies, and those due to parallel evolution.

Another attempt in defining species emphasized the historical dimension of an ancestral-descendent sequence of populations evolving separately from the others, and having its own tendencies. This historical turn finds its expression in the evolutionary species concept (ESC), successional, paleospecies, and chronospecies concepts.[32] Because of the problem of drawing borders on the way of the transformation of lineages, some evolutionists concentrate on phylogenetic branching as a way to demarcate the beginnings and endings of species (cladistics, composite, intermodal, and phylogenetic species concepts).[33] Others opt for the idea of species-as-individuals. Still others want to save essentialism by either conceiving species not in terms of intrinsic but rather extrinsic, relational properties (Grene and Depew), or by defining them as homeostatic property cluster kinds with an ability of some of their properties to change, which will still save the idea that they have essences in a weaker sense (Boy, Griffiths, Wilson).[34]

Because this debate seems to multiply definitions of species, some thinkers suggest that instead of looking for a consensus we should rather accept the plurality of species concepts. In its pragmatic version, pluralism simply approves the idea of choosing different species concepts regarding the interests guiding the classification. Ontological pluralism goes further and claims that there is no essence to the species concept and that the species category is heterogeneous. The consilience position accepts pluralism but at the same time remains optimistic about the possibility of finding a single, monistic species concept in the future. The fourth, hierarchical pluralism distinguishes between theoretical and operational species concepts and brings the idea of a division-of-labor solution (e.g. the ESC serves as a primary, unifying theoretical concept, while other concepts have an operational function in the identification and individuation of species).[35]The whole debate regarding the problem of species leaves no doubt that contemporary evolutionary biology recognizes and acknowledges the need for a definition of species. Various attempts to formulate a single, objective definition of species based on the data of empirical science, such as reproductive processes or morphological and genetic similarities, prove that science is tending towards a realist position in the dispute over universals. Strict scientific nominalism would question evolution, which is in fact observable at the level of populations. However, our analysis shows that while science tends to provide an adequate account of individual organisms, it seems less capable of specifying universal traits, traits that are essential to a definition of species. Given this difficulty it may be helpful to refer to the philosophy of nature.

Here we find the classical Aristotelian concept of species as essences that is presented in his metaphysical and biological works. Essentialism is generally associated with Plato, Aristotle, and Christian creationism. It is oftentimes misunderstood and dismissed for presenting the idea of species defined as eternal, immutable, determined by God, and discrete.[36] Essentialism is also rejected due to the fact that its definition of species is based on the idea of internal and intrinsic properties of organisms.[37] However, what needs to

29 Ernst Mayer, *The Growth of Biological Thought* (Cambridge, MA: Belknap, 1976), 273-4.

30 For definitions of all these species concepts see Appendix. See also Richard A. Richards, "Species and Taxonomy," in *The Oxford Handbook of Philosophy of Biology*, ed. Michael Ruse (Oxford, New York: Oxford University Press, 2008), 177-8.

31 See Appendix; Richards, "Species," 178-9.

32 See Appendix. ESC identifies species as a "single lineage of ancestor-descendent populations which maintains its identity from other such lineages and which has its own evolutionary tendencies and historical fate" (Richard L. Mayden, "A Hierarchy of Species Concepts: The Denouement in the Saga of the Species Problem," in *Species: The Units of Biodiversity*, ed. M. F. Claridge, H. A. Dawah, and M. R. Wilson [London: Chapman and Hall, 1997], 419).

33 See Appendix.

34 See Richards, "Species," 179-81.

35 See Richards, "Species," 181-5. Richards himself believes in the possibility of finding "a single, primary concept that colligates facts via a set of correspondence rules (not concepts) that serve to bridge the theoretical concept to the observable data" (*ibid.*, 185). He finds the ESC concept proposed by Mayden as promising as any other. The debate is thus still open. On the problem of species see also Marc Ereshefsky, "Systematics and Taxonomy," in *A Companion to the Philosophy of Biology*, ed. Sahotra Sarkar and Anya Plutynski (Oxford: Blackwell, 2011), 100-4; Marc Ereshefsky, "Species, Taxonomy, and Systematics," in *Philosophy of Biology. An Anthology*, ed. Alex Rosenberg, and Robert Arp (Oxford, Blackwell, 2010), 255-61.

36 See for instance Richards, "Species," 174-6.

37 I have mentioned above about the attempt to save essentialism at the cost of defining it in terms of external and relational, rather than intrinsic properties. It shows that the central idea of essentialism is still

be emphasized is that the static Platonic concept of species conceived as immutable forms, separated from matter and existing in the realm of eternal ideas, has little to do with the dynamic Aristotelian understanding of species which forges a middle path between the absolute realism of Plato and pure nominalism. For Aristotle, species are real, immutable and eternal in the sense that each one of them involves a form which causes a species to be what it is and to exhibit fixed and permanent traits. But at the same time, every species exists only as realized in concrete, temporal, individual, and contingent organisms. Thus the essential intrinsic traits of the species are immutable, but not their existential realization in nature. Aristotle argues that all representatives of a species have a 'common nature' (substantial form), which finds its expression in the variety of inter-actions and inter-relations between unique individuals. In other words, species are forms which cannot exist apart from realization in concrete substances. In the first part of this article I showed that the concept of evolution can be explained as a series of existential realizations of forms in nature, carried out through the process in which primary matter becomes properly disposed to be informed by new substantial forms. Species can thus be said to gradually change (evolve) in time, but not without a qualification. What needs to be clarified is the fact that what actually changes is accidental traits and properties of concrete organisms, which brings in turn an alteration of the disposition of primary matter, preparing it to receive the form of a new species. Therefore, strictly speaking, what the complex nexus of evolutionary processes brings about, from the Aristotelian point of view, is an existential realization of species as forms, educed from the potency of primary matter.

Such an understanding of species puts an emphasis on its historical dimension and thus resonates with the ESC. Its main advantage is that it brings together both the individual and universal traits of an organism. Its philosophical character can be easily distinguished from its theological implications which renders the concept available to be used in the context of contemporary science.[38] This is why I am of the opinion that Aristotle's concept of species understood as an intrinsic substantial form individually possessed by the whole group of organisms (whether the group is defined in terms of genotype, phenotype, morphogenetic field) should be brought back into discussion as an important philosophical principle, complementary rather than competitive with scientific views. This opinion is all the more reasonable given the growing interest among natural scientists in philosophy of nature and philosophical aspects of various scientific disciplines, including biology.[39]

C. *Natural Selection, Teleology, and Chance*

Among the philosophical aspects of evolution, there are other important issues concerning natural selection (NS), teleology, and chance. Yet, an attempt to analyze them brings about another paradox. In his article on Darwin published in 1874, Asa Gray said: "We recognize the great service rendered by Darwin to natural science by restoring teleology to it, so that instead of having morphology against teleology, we shall have henceforth morphology married to teleology." To this Darwin replied saying: "What you say about teleology pleases me especially, and I do not think anyone else has ever noticed the point." Similar was the opinion of his son Francis, the editor of Darwin's *Autobiography*: "One of the greatest services rendered by my father to the study of Natural History is the revival of Teleology. The evolutionist studies the purpose or meaning of organs with the zeal of the older Teleologist, but with far wider and more coherent purpose."[40] But as I have mentioned above, Darwin was first and foremost a scientist, not a philosopher. In his correspondence with William Graham, the author of *The Creed of Science*, Darwin acknowledged that he had no practice in abstract reasoning. We find a proof for that in the same letter to Graham in which he first denies that the existence of natural laws implies purpose, but then assures him that Graham's belief that the universe is not the result of chance is his inward conviction.[41]

This ambiguity makes it difficult to specify the exact position of Darwin in the philosophical dispute between Descartes, Bacon, and Spinoza, who rejected final causes calling them "barren virgins dedicated to God" (Bacon),[42] and Leibniz and Kant, who tried to defend the concept of final causality arguing that we must acknowledge that organisms are 'natural purposes.'[43] The course taken by

received with skepticism.

38 See Ashley, "Causality," 221-6; Elders, "Philosophical," 50-3; Moreno, "Some Philosophical Considerations," 425-7.

39 I side here with Travis Dumsday, who, accepting the pluralism of species concepts, in the conclusion to his article about the scholastic ontology of species says: "What I hope to have shown however is that an essentialist mode of classification is just as legitimate as any other. Of course, from a Scholastic perspective there *is* a privileged goal in taxonomy, namely, definition in accordance with real essence as opposed to accidental division by relational or other criteria. If one's chief concern is fundamental ontology, this is clearly the way to go; but biologists are not necessarily concerned with fundamental ontology, and we should hardly be surprised that alternative modes of classification are employed by them." See Travis Dumsday, "Is There Still Hope For a Scholastic Ontology of Biological Species?," *The Thomist* vol. 76, p. 394, July, 2012. On a retrieval of essentialism in species concept see also Michael Devitt, "Resurrecting Biological Essentialism," *Philosophy of Science* vol. 75, pp. 344-82, 2008.

40 Asa Gray, "Charles Darwin," *Nature*, June 4, 1874; Darwin, *Autobiography*, 308, 316. Huxley's opinion, which Francis Darwin used to support his thesis, was the same: "Perhaps the most remarkable service to the philosophy of biology rendered by Mr. Darwin is the reconciliation of Teleology and Morphology, and the explanation of the facts of both, which his views offer" (Thomas Huxley, "Genealogy of Animals," *The Academy* [1869]).

41 Darwin, *Autobiography*, 68.

42 Francis Bacon, *The Dignity and Advancement of Learning* (London/New York: The Colonial Press, 1900), 99. In his *Letter to Mersenne* Descartes writes: "The number and the orderly arrangements of the nerves, veins, bones, and other parts of an animal do not show that nature is insufficient to form them, provided you suppose that in everything nature acts in accordance with the laws of mechanics (quoted in Denis Walsh, "Teleology," in *The Oxford Handbook of Philosophy of Biology*, ed. Michael Ruse [Oxford, New York: Oxford University Press, 2008], 114). Spinoza in Appendix 1 to his *Ethics* says this about teleology: "That which is really a cause it considers as an effect, and *vice versa*: it makes that which is by nature to be the last, and that which is highest and most perfect to be most imperfect" (Benedict Spinoza, "Ethics," in *The Chief Works of Benedict de Spinoza. Vol. 2*, tr. R. H. M. Elwes [New York: Dover Publications, 1951], 77).

43 Leibniz defends the idea of final and formal cause. The internal forces of his monads can be identified with substantial form (according to the principle of the identity of indiscernibles). When conceived as appetites, they also have a teleological character. However, although in his system efficient and final causality are complementary, Leibniz does not escape entirely the problem of determinism, which in his philosophy

Neo-Darwinism, however, is clear and transparent. The line of reasoning that had its foundation in 1869 in Von Helmholtz's praise for Darwin for bringing the study of biological form under the ambit mechanism (1869), found its culmination a hundred years later in 1969, in the position of David Hull who declared: "From the point of view of contemporary biology, both vitalism and teleology are stone-cold dead."[44] Despite Quine's philosophical objections to this reductionist dogma,[45] teleology retained its bad reputation in the second half the 20th century, among many philosophers and scientists, who are willing to replace with chance. Driven to the extreme, this position led Richard Dawkins to formulate his famous metaphysical manifesto in which he declares: "The universe we observe has precisely the properties we should expect if there is, at bottom, no design, no purpose, no evil and no good, nothing but blind pitiless indifference."[46]

That this position is highly problematic, however, has become evident for many. The first signs of the rehabilitation of teleology in biology came with the work of three important evolutionary biologists: Dobzhansky, Mayr, and Ayala. The first one simply notices that "mutation alone, uncontrolled by natural selection, would result in the breakdown and eventual extinction of life, not in the adaptive or progressive evolution."[47] Similar is the position of Francisco Ayala, who strives in addition to explain in more detail the nature of NS. Defined as differential reproduction, dependent on differential survival, mating success, fecundity, and survival of offspring, NS is determined by the environment. However, Ayala emphasizes that NS is not only a purely negative mechanistic end-directed process that promotes the useful and gets rid of harmful mutants increasing thus reproductive efficiency, but also:

> is able to generate novelty by increasing the probability of otherwise extremely improbable genetic combinations. Natural selection is creative in a way. It does not 'create' the genetic entities upon which it operates, but it produces adaptive genetic combinations which would not have existed otherwise. (…) Natural selection is teleological in the sense that it produces and maintains end-directed organs and processes, when the function or end-state served by the organ or process contributes to the reproductive fitness of the organisms.[48]

This attempt to legitimize teleology was criticized by Mayr, for whom teleology is equivalent to goal-directedness and implies a causal activity of a future goal on the present situation, which he thinks is not acceptable in Neo-Darwinism. For this reason he suggests replacing 'teleological' with 'teleonomic' and 'teleomatic.' He defines the first term as a process or behavior "that owes its goal directedness to the operation of a program." The other one refers in his view to "processes that reach an end-state caused by natural laws."[49] But this explanation is problematic and reveals Mayr's misunderstanding of Aristotle and his definition of teleology. For who is the author of a 'program' operating towards goal-directedness? As Terrence Deacon notices "The major problem with the term *teleonomy* is its implicit agnosticism with respect to the nature of the mechanism that exhibits this property."[50] The question of the source of teleology is simply replaced by the one concerning the source of a 'program.' Moreover, Mayr's objection about the alleged causal activity of future goals with reference to the present is simply an outcome of a flattened-out understanding of causality, that he accepts after Pittendrigh, who coined the term 'teleonomy.' In his letter to Mayr, Pittendrigh says: "Teleology in its Aristotelian form has, of course, the end as immediate, 'efficient,' cause. And this is precisely what the biologist (…) cannot accept."[51] What we find here is an example of a reduction of multiple kinds of causality to the efficient cause alone. If an end-state operated simply as an efficient cause, we would have no reason to speak about final causality at all. It seems that even Ayala succumbs to this type of reductionism at one point, when following Nagel he says that "Teleological explanations can be reformulated, without loss of explicit content, to take the form of nonteleological ones."[52]

Nonetheless, among some philosophers of biology, there is a growing awareness of the limits of this kind of reductionism. The budding interest in the classical plural account of causality, offered by Aristotle, brings about a new understanding of teleology. We find an example of this turn in the article by Denis Walsh answering to the three

takes the form of a pre-established harmony.

44 David Hull, "What Philosophy of Biology Is Not," *Journal of the History of Biology* vol. 2, p. 249, 1969.

45 Willard van Orman Quine, "Two Dogmas of Empiricism," in *From a Logical Point of View* (Cambridge, MA: Harvard University Press, 1953), 20-46.

46 Richard Dawkins, *River Out of Eden: A Darwinian View of Life* (New York: Basic books/Harper Collins, 1995), 132-3.

47 Theodosius Dobzhansky, *Genetics of the Evolutionary Process* (New York: Columbia University Press, 1970), 65.

48 Francisco J. Ayala, "Teleological Explanations in Evolutionary Biology," in *Nature's Purposes. Analyses of Function and Design in Biology*, ed. Colin Allen, Marc Bekoff, and George Lauder (Cambridge, MA/London: A Bradford Book/The MIT Press, 1998), 35, 41. Ayala distinguishes between 'internal' (natural end-directedness) and 'external' (product of purposeful activity) teleology. He also talks about 'determinate' (end-state reached in spite of environmental fluctuations, e.g. physiological or developmental homeostasis), and 'indeterminate' (end-state as a result of a selection of one from among several alternatives) teleology. See Ayala, "Theological," 43; Francisco J. Ayala, "Teleological Explanations," in *Philosophy of Biology*, ed. Michael Ruse (New York, MacMillan Publishing Company, 1989), 190.

49 Ernst Mayr, "Teleological and Teleonomic: A New Analysis," in *Evolution and the Diversity of Life. Selected Essays* (Cambridge, MA/London: The Belknap Press of Harvard University Press, 1976), 387-90, 403. Mayr also compares his idea of operational program in nature with a computer program: "The purposive action of an individual, insofar as it is based on the properties of its genetic code, therefore is no more nor less purposive than the actions of a computer that has been programmed to respond appropriately to various inputs. It is, if I may say so, a purely mechanistic purposiveness." Again, Mayr seems to forget about the fact that the computer program has its conscious designer. His analogy begs a question of the source of the properties of the genetic code. Ernst Mayr, *Toward a New Philosophy of Biology. Observations of an Evolutionist* (Cambridge, MA/London: Harvard University Press, 1988), 31.

50 Deacon, *Incomplete*, 121.

51 Mayr, "Teleological," 392n1.

52 Ayala, "Teleological," 43. He follows Nagel who claims that "teleological explanations are fully compatible with causal accounts. (…) Indeed, a teleological explanation can always be transformed into a causal one." By "causal explanation" he means an explanation in terms of efficient causes. Ernst Nagel, "Types of Causal Explanation in Science," in *Cause and Effect*, ed. D. Lerner (New York: Free Press, 1965), 24-5. See the criticism of Ayala in Walsh, "Teleology," 123.

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 explanation 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: "It is absurd to suppose that purpose is not present because we do not observe the agent deliberating."[53]
3. To the argument that all teleological explanation appears to have normative import, he answers that "Teleology does not require a category of value-bearing goal states; it only requires goal-directedness."[54]

Walsh recognizes the immanent character of Aristotle's teleology (in opposition to its transcendent Platonic version). 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). On the level of evolutionary changes, lineages undergo selection to thus become ever more suited to the conditions of their environment. Walsh shows that the Darwinian process of iterated mutations and selection does not provide a satisfactory explanation for adaptive evolution. A careful observer notices that the explanatory role of phenotypic plasticity brings back a genuine Aristotelian teleology.[55] It gives a reason why organisms of the one species resemble one another, despite genetic variations and environmental influences. It also illuminates Aristotle's idea of hypothetical necessity, by showing that alterations to development are hypothetically necessary for the continued existence of an organism in its environment.[56]

Regarding this approach to teleology, Walsh is by no means an isolated thinker. Mark Perlman in his article entitled "The Modern Philosophical Resurrection of Teleology," presents a very clear and systematic description of the actual views on teleology in evolutionary biology, and the philosophy of biology. He distinguishes between non-naturalistic, quasi-naturalistic, and naturalistic explanations of finality in nature. He categorizes both Aristotle's teleological explanation and teleological explanations proposed by the science of emergent properties as quasi-naturalistic. In opposition to these quasi-naturalistic theories, he classifies naturalistic theories as those that strive to reduce teleology to a present, past, or future functional analysis.[57] Thus we can see that both authors acknowledge the significance of the rehabilitation of the classical notion of teleology in science. As Walsh explains:

> The 'Aristotelian purge' was seen as a pivotal achievement of early modern science. As a consequence of the scientific revolution, the natural sciences learned to live without teleology. Current evolutionary biology, I contend, demonstrates that quite the opposite lesson needs now to be learned. The understanding of how evolution can be *adaptive* requires us to incorporate teleology – issuing from the goal-directed, adaptive plasticity of organisms – as a legitimate scientific form of explanation. The natural sciences must, once again, learn to live with teleology.[58]

The question of teleology and the character of NS is usually accompanied by the further question concerning the role and nature of chance in evolutionary processes. In the light of what I have already said about teleology and NS, it becomes clear that evolution cannot be attributed to blind chance, which is actually a pure absence of explanation. What chance tells us is that a referred-to event does not have a *per se* efficient cause. It does not occur for a purpose and is inherently unpredictable. But Aristotle reminds us that chance, as an *accidental* cause, occurs always in reference to a *per se*, or proper cause. It does not happen in a void. Quite the contrary: it takes place in the world of regularity and predictability. Thus although mutations, which are regarded as the necessary condition for the possibility of natural selection, are truly unpredictable and occur by chance, they have an *accidental* character in reference to the *per se* cause of living beings that strive to survive and produce offspring. The acceptance of the plural notion of causality helps us understand that the absence of a direct efficient cause of mutations does not exclude other kinds of causality from being active. Aristotle's philosophy of nature reminds us to take formal and final causality into account in our attempt to explain the nature of an evolutionary change.[59]

From what I have said in this section we can see that the contemporary philosophy of biology finds its way back to the Aristotelian philosophy of nature. Scientists have begun to slowly acknowledge that the well-established and highly effective method of empirical science does not provide answers to all relevant questions. Moreover, they have begun to understand that an openness towards philosophy of nature and metaphysics does not require that they abandon their science. Quite the contrary. Philosophical questions

53 Aristotle, *Phys.* II, 8 (199b 27). In his *Modeling of Nature*, William Wallace distinguishes three meanings of teleology: *terminus* of an action, perfection of nature of a thing or being, and intention of cognitive agents. See, William A. Wallace, *The Modeling of Nature. Philosophy of Science and Philosophy of Nature in Synthesis*. Washington D.C.: The Catholic University of America Press, 1996, 17.

54 Wash, *Teleology*, 116-21.

55 To find more about Aristotle's final cause in the context of other types of causality see Allan Gotthelf, "Aristotle's Concept of Final Causality," *The Review of Metaphysics* vol. 30, pp. 226-54, 1976.

56 Walsh, "Teleology," 128-32. For Aristotle on hypothetical necessity see *Part. An.*, I, 1 (639b 23-6); IV, 2, (677a 15-19); *Gen. An.*, IV, 8 (776b 31-3).

57 Perlman ascribes to Aristotle's teleology a quasi-naturalistic character due to some commentators (e.g. Aquinas, *ST*, I, 6, 1, ad 2) who would say that acting for an end means achieving the 'good.' For someone who does not acknowledge the existence of natural values, this statement may seem to have a normative character. See Mark Perlman, "The Modern Philosophical Resurrection of Teleology," in *Philosophy of Biology. An Anthology*, ed. Alex Rosenberg and Robert Arp (Oxford: Blackwell, 2010), 149-63.

58 Walsh, "Teleology," 133. See also an interesting defense of teleology which takes on account major skeptical arguments coming from science in Robert M. Augros, "Nature Acts for an End," *The Thomist* vol. 66, pp. 535-75, 2002.

59 See Aristotle, *Phys.* II, 4-6 (195b 31-198a 13); John Dudley, *Aristotle's Concept of Chance. Accidents, Cause, Necessity, and Determinism* (New York: Sunny Press, 2012), 334-54.

not only arise out of empirical observation of the universe, but also remain thoroughly grounded in this observation. A plain fact of history that serves as a great testament to this truth is that so many prominent philosophers throughout the ages were also engaged in rigorous observation of the natural world. Without doubt, Aristotle and his followers are among them. For these reasons, the recent revival of Aristotle's thought, in both the philosophical and scientific circles, bears potential to thrust both disciplines unto a new horizon of cooperation.

III. Conclusion

I hope to have proved, through the course of this article, that, despite a still present skepticism towards classical philosophy, the longstanding legacy of the Aristotelian tradition is all the more ready to enter into a fruitful conversation with contemporary science and philosophy of science. What we find in Aristotle's natural philosophy and metaphysics is a system of thought that is not only coherent and consistent, but also flexible and open to the new data and current ways of understanding of the universe, its structures and processes.

When introduced to the evolution debate in particular, the Aristotelian tradition presents itself, not as an aged doctrine that is limited to humble listening and adjusting of its principles to the new scientific theories, but, quite to the contrary, as an interlocutor that has much to offer. In the debate on the concepts of species, natural selection, teleology, and the role of chance in evolutionary processes, the Aristotelian tradition brings an essential contribution to the results achieved by science; a contribution that is highly influential, and has a considerable explanatory power which must not be neglected.

I believe that this conversation sets up a stage for a fruitful dialogue between science and theological account of evolution rooted in Aristotelian/Thomistic tradition.

IV. Appendix: Definitions of Species Concepts[60]

Agamospecies Concept – A variation of the Genetic Species Concept applied for all taxa that are uniparental and asexual, represented typically as a collection of clones. Examples include many bacteria and some plants and fungi. The boundaries of agamospecies are often hard to define.

Biological Species Concept – Species are groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups. (...) Isolating mechanisms are biological properties of individuals which prevent the interbreeding of populations that are actually or potentially sympatric.

Cladistic Species Concept – Species are lineages of populations between two phylogenetic branch points (or speciation events). The cladistic concept recognizes species by branch points, despite of how much change occurs between them.

Composite Species Concept – A variation of the Cladistic Species Concept. A species is defined, in reference to the fossil record, as a segment of a lineage in which a new character state becomes fixed. It continues from the point where it arises (by cladogenesis) to the point where a new lineage (in which another character state becomes fixed) emerges by cladogenesis.

Ecological Species Concept – Species is a lineage (or closely related lineages) which occupies an adaptive zone minimally different from that of any other lineages in its range.

Evolutionary Species Concept – Species is a single lineage of ancestor-descendent populations which maintains its identity from other such lineages and which has its own evolutionary tendencies and historical fate.

Genealogical Concordance Concept – Population subdivisions concordantly identified by multiple independent genetic traits constitute the population units worthy of recognition as phylogenetic taxa.

Genetic Species Concept – Species is the largest and most inclusive reproductive community of sexual and cross-fertilizing individuals which share a common gene pool.

Genotypic Cluster Concept – Species are clusters of monotypic or polytypic biological entities, identified using morphology or genetics, forming groups of individuals that have few or no intermediates when in contact.

Internodal Species Concept – Related to Cladistic Species Concept, the notion that a species exists between two branching points in a fossil lineage. It is based on a fictional presupposition, that a species ceases to exist as soon as it branches into two daughter species.

Morphological Species Concept – Organisms are classified in the same species if they appear identical by morphological (anatomical) criteria.

Paleospecies Concept – The term refers to temporally successive species in a single lineage. It is also identified as **Chronospecies**, **Successional Species,** or **Allochronic Species Concept**.

Phenetic Species Concept – Also known as taximetrics, is an attempt to classify organisms based on overall similarity, usually in morphology or other observable traits, regardless of their phylogeny or evolutionary relation. It is closely related to numerical taxonomy which is concerned with the use of numerical methods for taxonomic classification.

Phylogenetic Species Concept – The concept of a species as an irreducible group whose members are descended from a common ancestor and who all possess a combination of certain defining, or derived, traits. Hence, this concept defines a species as a group having a shared and unique evolutionary history. It is less restrictive than the biological species concept, in that breeding between members of different species does not pose a problem. Also, it permits successive species to be defined even if they have evolved in an unbroken line of descent, with continuity of sexual fertility. However, because slight differences can be found among virtually any group of organisms, the concept tends to encourage extreme division of species into ever-smaller groups.

Polythetic Species Concept – A cluster concept that defines species in terms of significant statistical covariance of characters.

Recognition Species Concept – The recognition species concept is a concept of species, according to which a species is a set of organisms that recognize one another as potential mates.

60 For a more detailed analysis of the definition of species see Mayden, "A Hierarchy;" Richards, "Species;" George G. Simpson, *Principles of Animal Taxonomy* (New York: Columbia University Press, 1961).

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