Teleology and Biology: a defense of teleological thinking in biology

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Abstract: Teleological language refers to a forward-looking discourse, and various biologists are troubled with this issue. In this paper, I will discuss the misunderstandings that both philosophers of science and biologists have made against teleology. Among these misunderstandings, I can mention its relationship to anthropomorphism (i.e., a planning agent external to the world reference) and reference to a force immanent to the organisms ("vitalism") beyond the reach of empirical investigation. I will argue that they are misconceptions and that teleology has shifted its meaning and focus from its pre-evolutionary form. Now it is in the position that it can be used and maintained without violating the principles of modern science. Using an example of the adaptation and function debate, I will discuss how the teleological language is the best interpretation of these issues.
Key-words: adaptation; evolutionary biology; philosophy of science; teleology

Teleologia e Biologia: uma defesa do pensamento teleológico na biologia

Resumo: A linguagem teleológica pode ser definida como um discurso prospectivo, e isto tem preocupado biólogos em torno desse problema. Neste artigo, discutirei os mal-entendidos que filósofos da ciência e biólogos tiveram acerca da teleologia. Por exemplo, afirmam que a teleologia sofre de antropomorfismo (isto é, um agente de planejamento externo à referência mundial) e se refere a uma força imanente aos organismos (forças vitais ou "vitalismo") além do alcance da investigação empírica. Argumentarei que eles estão equivocados e que a teleologia mudou seu significado e foco de sua forma pré-evolutiva, e agora pode ser usada e mantida sem violar os princípios da ciência moderna. Usando

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como exemplo o debate sobre adaptação e função, discutirei como a linguagem teleológica é a melhor interpretação para essas questões.
Palavras-chave: adaptação; biologia evolutiva; filosofia da ciência; teleologia

1 TELEOLOGY AND BIOLOGY: A MISGUIDED BEGINNING

I will start with the following quotation "Perhaps no other ideology has influenced biology more profoundly than teleological thinking." (Mayr, 1992, p. 117). Indeed, mainly more recently, this influence was considered a negative one, a metaphysical reminiscent of the period before Darwin.

Michael Ghiselin wrote: "As a result of my work on Darwin, I realized that teleological thinking was still exercising a pernicious influence […]". (Guiselin, 1994, p. 489). Guiselin goes further in his attack against teleology by bringing this discussion to the mythological level: "The notion that Darwin somehow got teleological thinking back into biology is a myth." Ghiselin, 1994, p. 489). However, as we will argue, this is far from reality.

First, the "anthropomorphism" indicated earlier, is a chimaera of Greek thoughts: the Platonic and Aristotelian. The burden of the Platonic model is evident here, as, according to James J. Lennox (1992), this thinking explicitly treats the natural world as the production of a divine figure, and the physical universe as the result of a rational agent. However, matters are quite different when we consider Aristotle's approach to teleology.

The reading of Lennox (1992) shows that the Aristotelian thinking in teleology is close the modern biological explanations. So, for Aristotle, scientific understanding is achieved when somebody can correctly answer the question "Why?". Such an answer involves the identification of its causes. One knows that for the explanation of a fact, there may be several different answers, reflecting different causes. The following quote can explain it: "Except for the organism's form [...] none of the parts that contribute to the organism's life would come to be or exist" (Aristotle, *apud,* Short, 2002, p. 326)

Lennox concludes that for Aristotle the action of a rational agent is unnecessary, while this is not the case for Plato. Now we can see that this charge is misguided. Plato's teleology recurred to a supernatural or divine interpretation, while Aristotle's one was free from this constrain.

His thinking leads to a naturalistic approach without these drawbacks. Thus, his view is very approximate to the scientific teleology used today by a biologist.

According to Lennox (1992), natural theology is a form of the Platonic tradition of teleology. Some well-known authors, such as William Paley (1743-1805) or John Herschel (1792-1871) followed this idea and thinking after the Scientific Revolution and during the Enlightenment. This movement was according to the widespread belief in the development of ever-greater perfection in the world through the exercise of God's laws (Mayr, 1992, p. 372). However, the scientific endeavor broke with this tradition, discarding and any theological thinking *a priori*. The second charge teleology received from biologists and philosophers of science is that it is principled in a vitalist way.

Before discussing vitalism, we should define it properly: "The vitalists position was that living organisms, unlike artefacts, are subject to the influence of vital force, which is independent of the body." (Morris *et al.*, 2000, p. 583). The vitalist movement added to an unknown and presumably unknowable, a factor that is usually untestable. Currently, from a biological and scientific point of view, vitalism became discredited and vanished from the discourse of biologists Thus, rather than postulating a mysterious, unknowable vital force, there is a recognition that life is inside the realm of the chemical-physical laws (Mayr, 1982, p. 52).

We can add Ghiselin's criticism on teleology: "Vast burden of worthless metaphysical baggage." (Ghiselin, 1997, p. 294). By eliminating the "burden of worthless metaphysical baggage" (anthropomorphism, theology, final causes and vitalism), it is possible to get a scientifically valid notion of teleology. It is possible to help biologists to understand and explain traits in organisms[1], including adaptation. Darwin forged the notion of adaptation in terms of the apparent design of the organism as if for a common purpose (Gardner, 2009). Thus, the explanatory framework of Darwin concerns functions as an explanation of adaptations.

[1] When we place teleology within the tenets of science, we are aligned with the three main bases of successful modern biology as considered by Williams (1992): mechanism, natural selection, and historicity. Thus, mechanism states that every vital function is performed from systems that possess a causal net that can be explained by physical and chemical factors (as opposed by vitalism); and the assumption that the Darwinian process of natural selection accounts for all explanatory framework for the existence of adaptation in an organism (as opposed to rational plan or to the ideas of Lamarck).

I intend to show how these vitalistic ideas were harmful for the teleological notion in biology as some philosophers of science, mainly the positivists, claim. The founding figures of the Vienna Circle, in the Manifesto, presented biology as a science with metaphysical problems (Mach [1929], 1996). The authors identified the presence of vitalistic thinking, and they rejected it as a metaphysical thesis. They insisted on the universal validity of the explanatory model in physics. They considered physics as a mature science and an example for all other sciences. As argued, the problem with vitalism sounded genuine, and for a long time, biology was considered an immature science by most of these philosophers, but I can mention other reasons, for instance, its inherently historical nature.

Salmon (1989) mentioned that the presence of the vitalist doctrine in biology motivated Carl G. Hempel and Ernest Nagel to study the teleological/functional explanation. Nagel (1961) argued that teleological explanations in biology could always be reformulated in non-teleological terms without the loss of content. Therefore, he was advocating the exclusion of this term from the sciences. Furthermore, Nagel (1961), alongside Hempel (1965), worked on what they have called the problem of functional equivalence in biology in terms of the deductive-nomological (DN) model of scientific explanation. We can understand functional equivalence as distinct traits that have the same function. These problems were aligned with the idea that functional explanations do not fit any pattern of scientific explanation, including the inductive or statistical ones (Salmon, 1989). This problem was exposed by Salmon:

> When we identify some item as fulfilling a function, we recognize that it is sufficient to produce some result in a certain situation. But usually we cannot claim that it is the only possible device that would fulfill that function. It is not necessary for the realization of the goal. (Salmon, 1989, p. 30)

Thus, in biology, mainly evolutionary biology, we have numerous examples that fulfil this line of reasoning. As a straightforward example, take the adaptations of Arctic and Antarctic mammals and birds to the challenges of polar life. The animals can regulate their body temperature by growing a winter plumage (birds – except penguins) and coat of fur (mammals), or by relying on a layer of blubber to prevent heat (penguins). Each of these strategies have the function to protect from the

cold, so they are functionally equivalent, and mainly, no law could follow it deductively.

Hempel concluded his discussion of functional analysis in the following terms:

> It remains true, therefore, even for a properly relativized version of functional analysis, that its explanatory force is rather limited; in particular, it does not provide an explanation of why a particular item i rather than some functional equivalent of it occurs in systems. (Hempel, 1965, p. 324)

Thus, for Hempel, functional analysis cannot qualify as a permissible type of explanation, but at best, it has heuristic value. So it is because the explanandum gives the necessary conditions for the explanans. In the deductive nomological model, the explanans must be logically sufficient for the explanandum (DiFrisco, 2017, p. 2). However, as we saw, this mode of thought fails to recognize the causal factors; as showed by famous counterexamples to Hempel's deductive-nomological account of explanation. Functional explanations are therefore, appropriate and necessary, as well as scientific; and any philosophical model of scientific basis which cannot accommodate functional analysis is inadequate (Salmon, 1992, p. 28-32). Henceforth functional analyses[2] and teleology can be considered a legitimate pursuit in philosophy and biology (see for instance: Brandon, 1990; Ayala, 2016; Neander, 1991; Cummins, 2002; Ruse, 1989; Gardner, 2009; Garson, 2019).

2 DARWIN, TELEOLOGY AND ADAPTATION - A FRUITFUL UNION

As shown, the teleological thinking was in bad shape in the early 19th century. There were two options: (1) a theological approach which involved a supernatural explanation style; (2) a vitalist explanation, as an untestable metaphysical discipline. However, all of this had changed when Charles Darwin published his book, *Origin of Species* (1859), in it, he laid down the fundamentals of the evolutionary thought by natural selection, as being a goal-directed, teleological force.

[2] Functional analysis is the operational way that we can study teleology scientifically; biological functions, thus, can generate genuine teleological explanations.

Lennox (2013, p. 136) cited a passage of Darwin presenting a teleological form. Darwin, as showed by Lennox, was explicitly accounting for adaptations as consequence of chance variation and natural selection. In that way, we can see the use of selection-based (teleological) explanation, that it is unlike any of the forms of teleology available to him at that time as discussed. Ayala wrote:

> Darwin accepted the facts of adaptation, and then provided a natural explanation for the facts. One of his greatest accomplishments was to bring the teleological aspects of nature into the realm of science. [He substituted a theological view by a scientific teleological one]. The teleology of nature could now be explained, at least in principle, as the result of natural laws manifested in natural processes, without recourse to an external Creator or to spiritual or nonmaterial forces. At that point biology came to maturity as a science. (Ayala, 2016, p. 121)

When Darwin "re-invented" teleology (Lennox, 1993), he opened a new road for the scientific problem related to functions in biology. Because Darwin considered an explanation of adaptation as the chief requirement of evolutionary theory (Gould, 2002), adaptation became an important matter from that day after (mainly for the architects of the Neo-Darwinian program).

Before going further, we need to answer what, precisely, is an adaptation? The term "adaptation" derives from *ad* + *Optus*, that is, the process by which populations of organisms evolve in such a way as to become better suited to their environments as advantageous traits become predominant driven by natural selection. In other words, the study of adaptation aims to understand the fit between organismal form and function across the living world (Brandon, 1990). So, as Kim Sterenly (1996) argues, the reasoning to detect an adaptation is the same as a functional rationale.

According to Stephen Jay Gould, the problem of adaptation is "transforming environmental (external) information into internal changes of form, physiology and behavior." (Gould, 2002, p. 157). Thus, adaptation is for Darwin the primary subject for practical study of evolutionary mechanisms. In Darwin's words:

> Over all these causes of Change I am convinced that the accumulative action of Selection, whether applied methodically and more quickly, or

> unconsciously and more slowly, but more efficiently, is by far the predominant Power. (Darwin, 1859, p. 43)

Although natural selection was the most important evolutionary mechanism for Darwin, this was not the only process, as the following quote shows us: "I am convinced that Natural Selection has been the main but not exclusive means of modification." (Darwin, 1859, p. 6).

As Darwin wrote, we need to be aware that there are other processes that can generate diversity and modification, which are unrelated do natural selection[3]. Closely related to Darwin's quotation, there is a widely famous case of methodological uniformity, that became known as the "adaptationist programme" by Stephen Jay Gould and Richard Lewontin (1979). They argued that the only hypothesis being considered by some authors in their studies of the evolution of traits is an adaptational one, by that, excluding any other hypothesis (e.g., developmental constraint). However, before exposing in details the points of this oft-cited and influential paper, I will show that, as argued by Dennett (1995), the paper of Gould & Lewontin is a "massively misread classic". Many scientists thought of the paper written by Gould & Lewontin (1979) as a refutation of adaptationism; or even as a criticism of teleology. But this is in error. For example, Michael Heads (2009) and Philippe Grandcolas (2015) regarded the argumentation of Gould & Lewontin (1979) as a criticism of teleology; however, a close read can show us that it is not the case. Instead, if Heads (2009) and Grandcolas (2015) criticized the erratic notion of "preadaptation", that would be correct. For instance, feathers can be "preadaptations" for flight; however, this suggested terminology is very misleading as it treats evolution in a forward-looking process, anticipating the future needs of the organism (which is clearly a misguided approach and reasoning). This was the reason why Gould and Elisabeth Vrba (1982) proposed the concept of exaptation – characters that evolved for other usages (or for no function at all) and posteriorly merged with other characters in order to reach their current function.

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[3] However, we should be very careful in stating this "pluralism". Mayr (1983), in a response to Gould & Lewontin, said that nobody nowadays use the same "plurarism" as Darwin, because he accepted alternatives to natural selection, as the effects of use and disuse and the direct action of external conditions on organisms, that were completely discarded as options by the architects of the modern synthesis.

However, before exposing the points of this oft-cited and influential paper, I will show that, as stated by Dennett (1995), the article by Gould & Lewontin (1979) is a "massively misread classic". It is considered a refutation of adaptationism or even as a criticism of teleology. But this is in error. Michael Heads (2009) and Grandcolas (2015) regarded the argumentation of Gould & Lewontin (1979) as a criticism of teleology; however, a close read can show us that it is not the case. Instead, if Heads (2009) and Grandcolas (2015) criticized the erratic notion of "preadaptation", that would be correct. For instance, feathers can be "preadaptations" for flight; however, this suggested terminology is very misleading as it treats evolution in a forward-looking process, anticipating the future needs of the organism (which is a misguided approach and reasoning). Thus, Gould & Vrba (1982) proposed the concept of exaptation – characters that evolved for other usages (or for no function at all) and posteriorly merged with other characters to reach their current function.

3 TELEOLOGY AND ADAPTATION: THE "HARDENED" MODERN SYNTHESIS AND THE CENTRALITY OF ADAPTATION

The Modern Synthesis of the 1930s and 1940s is a well know theoretical and epistemological union in evolutionary biology, is considered a canonical example of a paradigm shift – a unification of research groups – in biology (Futuyma, 2005; Gould, 2002; Pigliucci & Müller, 2010). For the sake of brevity, I will simply provide the highlights of these ideas (for a detailed historical analysis, see Mayr & Provine, 1980).

Julian Huxley (1887-1975) proposed the name of this movement 1942. He settled the conceptual structure underlying evolutionary biology and tried to capture and synthesize the knowledge on this subject. As Futuyma (2005) summarized, their program hold:

> (a) that genetic variation in phenotypic characters arises by random mutation and recombination; (b) that changes in the proportions of alleles and genotypes within a population may result in replacement of genotypes over generations; (c) that such changes in the proportions of genotypes may occur either by random fluctuations (genetic drift) or by nonrandom, consistent differences among genotypes in survival or reproduction rates (natural selection); and (d) that due to different histories of genetic drift and natural selection, populations of a species may

> diverge and become reproductively isolated species. (Futuyma, 2005, p. 14)

These are the principal claims of the evolutionary synthesis, and even though these principles, clarified, or modified or extended since then, constituting the foundations of modern evolutionary biology. But these extensions and modifications became so substantial that, recently, some authors set out a new evolutionary biology plan, known as the Extended Synthesis. Their agenda accounts for particular fields of inquiry, such as Evo-Devo and phenotypic plasticity (West-Eberhard, 2003). This movement had their synthetic book as well, the Pigliucci & Müller's (2010) *Evolution - the extended synthesis*. This program presents five main goals (Pigliucci & Müller 2010): (1) to emphasize the importance of the developmental biology; (2) to provide a "holistic" view of species (as a criticism of molecular biology); (3) to incorporate and give more explanatory importance of phenotypic plasticity, genetic accommodation, epigenetic inheritance as contributing factors to phenotypic diversity; (4) to include elements from computational biology and (5) to incorporate insights from evolvability, modularity and robustness. So they propose the addition of some features, the redefinition of others from the old principles of the Modern Synthesis, taking into account the results of the most recent research conducted in the various fields in biology.

Gould (2002) argued that the process of synthesizing had two main phases. The first one was the integration of Mendel and Darwin to the discipline of population genetics. This integration explains all life forms on Earth. Besides that, dismisses essentialism, the inheritance of acquired characters, orthogenetic trends, and saltationism (Mayr, 1982, p. 131). The second is the phase of "hardening" that reached to orthodoxy by maintaining that adaptation is an option to be ascertained to an *a priori* "assumption of near-ubiquity". After the establishment of the adaptationist program, prevailed the idea that the power of natural selection, as an optimizing agent, is executed through the conceptual breakdown of organisms into unitary characters, proposing an evolutionary explanation for each of them.

The direct production of adaptation through its operation becomes the primary cause of almost organic traits. Pleiotropy and phenotypic plasticity occur scarcely. (Gould & Lewontin, 1979). The influence of

other processes such as genetic drift, genetic constraints is low. Consequently, they should be dropped from the discussion. To make one example, consider the persistence of basic structural similarities across different taxa, as the neck skeletons of giraffe, man, and mouse. Even having very different ways of life, they all present seven cervical vertebrae (Williams, 1992, p. 7). This striking persistence can be explained historically (descent from a common ancestor) not by natural selection (that explains adaptation and diversity) but by this constraint. Thus, stabilizing selection should be called to make this explanation coherent (Sterenly & Griffths, 1999, p. 227).

Arguing for the circularity in the adaptationist program, adaptive stories would be very to confirm, but very hard to falsify (Gould & Lewontin, 1979), and this is a hallmark of poor scientific hypotheses. The epistemological role is very plain: adaptationists regard the simple presence of a trait as a confirmation that it is an adaptation shaped by natural selection. The under-appreciation of other factors as being relevant for the modifications on an organism was one of the results of the simplistic idea of selection acting more or less directly on genes (Pigliucci & Kaplan, 2000) – different genes for each aspect of the organism which can be separately molded by natural selection (*one-gene one-trait* approach) – was a serious issue at that time. In their same work, Gould & Lewontin (1979) describe some "common styles of argument" by the adaptationists:

> The failure of one adaptive explanation should always simply inspire a search for another of the same general form, rather than a consideration of alternatives to the proposition that each part is 'for' some specific purpose. (Gould & Lewontin 1979, p. 589)

Therefore, after this work, considered the "final proclamation of death" (Rose & Lauder, 1996) of the adaptationist program, or orthodox Darwinism (Dennett, 1995), as known and endorsed by the architects of the Modern Synthesis, come to an end. In Gould's words:

> Lewontin and I… would later call 'just-so stories' or plausible claims without tested evidence, whereas other prominent trends could not even generate a plausible story in adaptationist terms at all. (Gould, 2002, p. 39)

Thus, this would be an adaptationist scenario to confirm the proposed narrative of the adaptation of a particular trait. However, this way of thought sometimes was so ample to include the origins of any kind of trait (Smith, 2016).

For one side, the "Panglossian Paradigm" was right in its criticism. It forced the evolutionary biologists to be more cautious with their evidence and their form of confirmation; it constituted a *bona fide* example of confirmation bias. Those criticisms contributed to provide more coherency to evolution and biology. Any theory which intends to deliver a fully-fledged narrative history (teleological or adaptationist) must be consistent with the tenets of modern science. Therefore, if the hypotheses of adaptation are unfalsifiable and do not possess an (explicitly) non-circular criterion of acceptability, this approach is not a strong scientific endeavor. By incorporating those relevant data, it is possible, then, to support or disconfirm a hypothesis of adaptation

We should see the efforts made by Gould and Lewontin to approximate one main branch of evolutionary research within a scientific rigor necessary for any serious field. They introduced some ontological problems to be dealt with by those scientists. They are the existence of pleiotropy, epistasis and developmental constraints, which connect up the expression of genetic variation among loci in nonlinear ways (Pigliucci & Kaplan, 2000). And finally, they gave some alternative hypotheses to be considered when discussing the explanation of a trait, like an explanation considering no adaptation and no selection or selection without adaptation.

Pigliucci and Kaplan wrote: "It is this synthesis of constraints (spandrelism) and selection (panglossianism) that is the key to a more sober and realistic understanding of phenotypic evolution." (Pigliucci & Kaplan, 2000, p. 67). Afterwards, even committed adaptationists began to recognize these criticisms, as their discussion and claims of adaptation were much more cautioned (Amundson, 1996). Consequently, the problem that we are trying to explain, the apparent design of organisms as a result of adaptation (Gardner, 2009), could be adequately answered.

So far, so good. However, one of the side effects of being one of the most influential and cited articles in evolutionary biology is that various authors have caricatured, misunderstood and even failed to appreciate

their views properly. What happened next can be exemplified by the following quotation:

> This paper [Gould & Lewontin, (1979)] had such a substantial impact on the fashions of evolutionary biology that the very term 'adaptationism' and sometimes even 'adaptation' itself, became pejorative. To a significant extent, the term adaptation was banished from the lexicon of evolutionary biology, for fear of being associated with the dread adaptationism. (Rose & Lauder, 1996, p. 2)

It is plain to see that the criticism by Gould and Lewontin even though is correct, lead some authors to abandon the pursuit of adaptations. Accordingly, Dennett argues that some hypotheses of adaptation were, indeed, handled by excess by some authors and deserves criticism, but we need caution because while:

> Adaptationist reasoning is not optional; it is the heart and soul of evolutionary biology. Although it may be supplemented, and its flaws repaired, to think of displacing it from central position in biology is to imagine not just the downfall of Darwinism but the collapse of modern biochemistry and all the life sciences and medicine. (Dennett, 1995, p. 238)

Gans (1988), argued for the lack of rigor of some authors in adaptive explanations, such as why the "buffalo eat grass". He considered that the responses "buffalo are adapted to eat grass" or "buffalo evolved to eat grass", do not explain. There is no answer to "why-question". To present this case is to give a narrative explanation. The methodological error that the adaptationists make can be pointed by the following quote made by Mayr (1983) when he asks: "What is the function of a given structure or organ?" in this way, he already assumes adaptation; we just have to make discovery it. However, when we ask, "Does this trait have a function?" there is no assumption, *a priori*, that the trait is an adaptation (Lloyd, 2015). Thus, we should start our determination of the evolution of any trait by asking whether it is causally related to a particular function, only afterwards we can give any proposition of its adaptiveness.

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In the next twenty years, after the fall of the naive adaptationism, we met the "post-spandrel adaptationism" or "the new adaptationism" (Rose & Lauder, 1996). It inaugurated a new schedule for adaptations, selection and historicity (narrative explanations). This movement is also known as the "Adaptive-historical thinking" (Griffiths 1996), because he identified, alongside Rose & Lauder (1996), a historical turn, with its new tools and more robust methodologies, incorporated in the studies of adaptation.

Within this scenario, Rose & Lauder (1996) proposed new assumptions that for being considered in the analysis that evolutionary biologists must make pursuit in the study of selection and adaptation: (1) the use of phylogenies in the comparative method. It provides the critical evaluation and questions about the nature of homology and looks rigorously at morphological data of all sorts. (2) the use of population biology through the development of methodologies based on quantitative genetics theory that involves selective manipulation that can replicate extant differences among populations; and (3) the rigor of functional morphology and biomechanics (as disciplines whose goal is the analysis of biological design and teleology). Adaptational studies by correcting some methodological mistakes ("just-so stories" and the adaptationist program) and introducing new ones (the new adaptationism) got a refreshment. They can, finally, present unbiased and well-confirmed hypothesis.

The difficulty in proposing a strong hypothesis of adaptation will always be present. Historical hypotheses are tough to grasp because morphology, environment, can change as time goes by. Despite these difficulties, the pursuit of adaptation, the core of evolutionary biology, is very legitime. The fact that evolutionary processes are not easily testable is not an epistemological excuse to give up the research it all together. Making science is not an easy task.

Using these criteria, scientists can formulate scientifically testable and non-speculative argumentation in favor of adaptation. In the next section, we will try to show that teleological thinking is legitime.

4 FINAL REMARKS

Stoddard *et al.* (2017) proposed an "adaptative explanation" for the size of the eggs. They considered the asymmetry and ellipticity in various avian clades. They have found that these forms, when correlated with biometric, life history, and environmental parameters, show that egg size is regulated and causally linked by life history characteristics and spatial constraints in the nest. Hence, the form is functionally related to adaptations for flight (as a key driver). They further proposed that the "general adaptations for strong flight select for a constrained, muscular, streamlined body plan in both males and females, giving rise in the latter, directly or indirectly, to asymmetric and or elliptical eggs." (Stoddard *et al.* 2017, p. 1253) So, it is plain to see that when they gave a functional explanation, they achieved the evolutionary (adaptationist) explanation.

In this example, we can see that they are explaining a trait, the egg shape, by the ends, or function – in this case, selection for a strong flight – thus, we are describing something that is forward in time relative to the thing explained. This is what a teleological explanation means. Therefore, in biology, especially evolutionary biology, this language is commonplace and correct. It is obvious how teleology (with its forward-looking approach) is essential for evolutionary biology; being one of the main reasons it distinguishes itself from the physical sciences (Ruse, 1989).

As a canonical example, the motion of the Earth around the Sun results from the laws of gravity, and this is the result of laws of nature; it does not exist to satisfy certain ends or goals. Teleological explanations, unlike nonteleological ones, make a distinctive talk of a means-to-an-end relationship of the process. This characteristic is one of the primary distinction of biology as a natural science (Ayala, 2016).

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