The influence of teleology in the comprehension of evolution and its consequences to education: an analysis from Aristotle to Mayr's teleological categories

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ABSTRACT

One of the most famous iconographies related to evolution is the "evolutionary march". It represents a linear progression from apes towards *Homo sapiens,* in a progressive view of evolution. The origins of this view can be found in Aristotle's *Scala Naturae,* in which human beings are at the highest hierarchical place. Aristotle's thinking was also based on three pillars: species' fixity, essentialism, and teleology, which is the assumption that everything in nature has a purpose. Even though Aristotle's framework has been overthrown by Darwin's Evolutionary Theory, its influence can still be seen in general thinking: when teleology is comprehended metaphysically, it generates the progressive view already mentioned and the idea that evolution has an intrinsic tendency to specific purposes. Another problem is that teleology can be currently understood in multiple ways. For instance, it can be used also to describe movements of inanimate objects in nature, to describe goal-directed behaviors, adaptations, or even the presence of a pre-determination aspect in some biological features, such as the genetic program. The concept of adaptation is commonly misunderstood and phrases with teleological meaning are often used in biological explanations. Students might create an erroneous idea that some characteristics could have been selected for a specific reason, or that there was something or someone behind the process. The term "Natural Selection" can itself also generate misconceptions, as it is an anthropomorphic name, analogous to the "Artificial Selection", with which farmers and cattle ranchers intentionally guide phenotypic changes. Furthermore, languages are finalistic and eliminating such problems is a hard task, so students must be aware of such difficulties to comprehend metaphors and not make conceptual confusions. Thus, it is important that students properly know the structure of evolutionary thinking from a philosophical perspective, regarding not only adaptation but also a view of evolution as a branched process in which contingency is essential. The present analysis aims at discussing the multiple meanings of the term teleology, based on the proposal established by Ernst Mayr (1904-2005), going backwards to its origins. Furthermore, it aims at analyzing the importance of this discussion to the teaching of evolution as a tool to dismiss some of the most common evolutionary misconceptions.

Keywords: Teleology; Teaching of Evolution; Evolutionary thinking

Introduction

One of the most famous figures related to evolution is the "evolutionary march", in which some primates are lined up as if marching from left to right, progressing towards humankind. According to Gould (1990), this is the only iconography immediately understood by everyone and it reinforces the comfortable idea of human superiority and inevitability. Although it is a very accepted image, it brings a misleading idea that evolution has a pre-established direction towards "perfection", in a progressive way. Nevertheless, evolution is not a linear process from basal species to superiors ones. It is a bush, a branching process of species, based on variation, natural selection, genetic drift, and common ancestors (Santos & Calor, 2008).

The idea of human superiority is not scientifically accurate, but it is widely spread in common sense. Authors such as Ruse (1996) sustain that a translocation of the cultural meaning of progress, such as technology, social and scientific progress, could influence understanding biological evolution. In addition, many misleading information are spread by media (internet, television, comic books, newspapers, publicities and others) affecting such concept formation (Santos & Calor, 2007b). The origin of human superiority idea can be found in Aristotle's *Scala Nature*, in which species are allocated linearly, as a ladder, and *Homo sapiens* is in the highest step. *Scala Nature* is not the only idea in Aristotle's framework. It comes together with three pillars: fixity, essentialism, and teleology (Solinas, 2012). Such framework has guided for centuries the natural history path, and it still exists in some ways inside religious theoretical core.

Thus, Aristotle's influence in human thinking is seen until currently, sometimes in an implicit way, even after Darwin's theory has overthrown such life conception. All the Aristotle's pillars have been opposed by Darwin. Fixity has been opposed by species modification through time. Essentialism, or the idea that species have an immutable essence, has been overthrown by the importance of individual variation. And, teleology has been opposed by natural selection.

Aristotle's teleology assumes that everything in nature has a specific purpose. It is the science of final causes and, therefore, there is nothing vain in nature. In this perspective, there is a static balance that guarantees all species conservation. Obviously, universe is not static and immutable. Environment changes and so do populations over time. Species diversify and get extinct. Stochastic events happen and there is not a final cause for everything in nature.

Currently, the concept of teleology has been used in many different cases with heterogeneous phenomena. For this reason, Mayr (2004) has created categories to differentiate and classify these various term meanings.

This paper aims to discuss the teleological polysemy according to Mayr's proposal, going back to Aristotle's teleology and, then, to think about its influence in evolutionary comprehension. To comprehend difficulties and the historical origins of our thoughts, thus emphasizing philosophical aspects of evolutionary thinking, could be a pedagogical strategy to dismiss misleading ideas as progress in evolution.

Aristotle's teleology

Tradition based on Aristotle had been the main life conception until the Scientific Revolution of the 16th century, when there was a mathematization of space and a change in reasoning. The most important question in science has changed from "how" to "why". Although it happened on the scientific field in general, it has had a more important influence in Physics. In Biology, Aristotle's view remained for a longer period, until Darwin's theory had come to light (Solinas, 2012).

Biology, or the life science, was born with Aristotle (although with no specific name as a singular area of knowledge). It was based on his experiences and direct observations, from which his pillars came: fixity, essentialism and teleology, showing a belief on universe eternity, without a beginning or an end point. In this universe, species were thought to be immutable and perfectly adapted. According to Aristotle, organisms were made by a wise nature and nothing would have been made in vain. Everything would have a final cause, a purpose to be, so to say. Nature's wisdom would ensure perfect adaptations. Every organ would have a specific function to ensure a vital function and to preserve the survival of species. Aristotle's teleology has a guiding principle, which says that nature adapts organs to functions, and not functions to organs. The perfect correspondence does not happen only between organ and function, but also between species and environment. Hence, it ensures a static balance and there is no space for species extinction. The final cause of all living being is self-preservation. There cannot be extinction also because there is a perfect distribution among species defense and attack traits.

Another important aspect in Aristotle is the so-called human superiority. He believed in an organization of living beings according to an increasing scale of progress and complexity, also called *Scala Nature*, in which humans have the highest place because we are the only species with the NOUS soul, which makes our ability to think something possible.

In short words, the life conception that we inherited from Aristotle is characterized by a stable and static world, in which there are inferior and superior organisms, all of them well adapted with a specific pre-established role in nature. It is important to have in mind that, for Aristotle, environment does not come before adaptations. Everything occurs at the same time because there is neither a beginning nor an end in the history of the Universe.

Even though Aristotle had found some problems to explain, as useless organs (mole's eyes, for instance), his tradition survived for more than a thousand years. In the 13th century, Creationism reconciled with Aristotle's teleological core, bringing the concept of admirable adaptations, which was defended intensely by Paley and his natural theology. Aristotle's and creationist views are very similar is some aspects. Aristotle's wise nature had been changed for a wise God that has created all living creatures.

As mentioned before, the Scientific Revolution transposed the Aristotelian epistemology, except in the living world. In Natural History, Aristotle had great influence until the middle of the 18th century. It is seen, for instance, on Linnaeus' *oeconomia naturae.* Aristotelian crises began only with the transformational theories, as Lamarck's in the 19th century. Lamarck counterpoised Aristotelian fixism, but his evolutionary

mechanism was teleological and it resulted in an endless process increasing complexity and perfection (Ferreira, 2003). Only Darwin's evolutionistic revolution represented a gradual epistemological overthrow of Aristotelian matrix in Biology.

Current discussion and Mayr's solution

It is very common to use a teleological language when talking about evolutional process, especially subjects related to adaptations. Teleological terms are used to describe organic functions, physiological processes and individual's behavior, usually characterized by the words purpose or goal (Mayr, 1998). Thus, phrases such as "the heart evolved to pump blood" are commonly used and can be discussed if they offer a finalistic meaning or just an explanatory metaphor. According to Mayr (2004), the problem is that the word "function" refers to two different phenomenal groups: it can be related to an immediate causality or an evolutionary one (the "why" question in Biological Sciences). In other words, it can refer to some goal-orientated activity or to adaptive systems, in which a metaphysic and teleological meaning cannot be found.

Some biologists, called reductionists, have the intention to eliminate the teleological vocabulary of the field. Even though it is used consciously as metaphors or linguistic strategies, it can cause confusions, especially among non-scientists. The elimination is mainly focused in two kinds of explanations: those refereeing to present events causing future ones, and those suggesting intentionality-guiding processes and phenomena (Ferreira, 2003). Even if there is no consensus, this possibility indicates the importance of discussing the influence of teleological language. Ferreira (2003) also emphasizes that this discussion does not include exactly Aristotle's teleology, neither the medieval theologians, but a transformed teleology in which diverse concepts have been put together over time. Even though there is a "new" teleology, Aristotle's influence on human general thinking is undeniable.

In this context, Mayr (2004) discussed that, actually, the word teleology is being used to describe different kinds of phenomena and, therefore, he has created five categories to think about these phenomena in a broader sense. In these categories, he included both biological and non-biological phenomena, as those referring to natural processes, especially those related to the laws of Physics. For instance, gravity makes objects fall downwards to the center of the Earth, and thermodynamics make hot objects cold until they arrive to the same temperature as the surrounding environment. These examples have a finalistic and pre-determined meaning, but they cannot be applied to Biology. That is why Mayr created new terms to differentiate those patterns. He divided the word "teleology" in six processes: **teleonomic process, teleomatic process, intentional behavior, adaptive features, and cosmic teleology**.

Teleomatic processes are those natural processes already mentioned that are guided by physical laws, such as gravity, and they are usually related to the inorganic world. **Teleonomic processes**, on the other hand, are related to Biology. They are characterized by the presence of a purpose, caused by genetic program, in cellular development (processes) or animal behavior. Even though there is a genetic program established in the past that guides some processes, there is not intentionality in it. There are

two kinds of teleonomies: the first one is the closed program, in which all information is found in the DNA, and the second one is the opened program, in which new information (or behavior) can be achieved through learning and conditioning. **Intentional behaviors** are those behaviors oriented by specific purposes, which require planning. They had been thought initially only for humans, but then expanded for other animals (e.g. chimps).

Adaptive features are characteristics that contribute to the organism's fitness. They are often understood as teleological or functional systems, but from Darwin's theory, all adaptations are evolutionary results, in which variation is very important and permits the differential statistic survival of the fittest that has more offspring. Therefore, adaptation is *a posteriori* result that cannot be established at first. Finally, **cosmic teleology** is the idea that there is an intrinsic tendency to progress in nature, and that such progress can be transferred to evolution. Darwin understood that evolution is not linear. It is a branched process without a pre-determined direction.

Before Darwin's revolution, the most important conception of life was based on Aristotle's view, already mentioned, and it was characterized by an eternal world with an intrinsic tendency to improvement and perfection. This life interpretation was Mayr's cosmic teleology and can be currently understood as a progressive evolution from underdeveloped organisms to more developed ones.

Solinas and Mayr agree with each other about teleology in Darwin's work. At the beginning, Darwin used to believe in final causes and used this idea to build his theory. Then, he put it aside. According to Solinas (2012), teleology was like a scaffold to Darwin's theory. At first, it was a structural thought that helped him to build it, but then he realized that natural selection is not a teleological process, and he further abandoned this idea completely. There is no need to use teleology to explain the natural world.

Even though the natural selection concept is not teleological, there are a lot of misleading interpretations. One of the possible reasons for this is the analogy with Artificial Selection. Darwin's explanation in his book "On the origins of species" (Darwin, 1859) began with the artificial selection concept, in which farmers and cattle ranchers drive the selection and choose desired features according to their own interests. It was an argumentative strategy to help people visualize the possibility of species changing and common ancestors (Pievani, 2013). It is important to realize that in artificial selection, there is someone behind the process. Although this analogy between artificial selection and natural selection was a very useful strategy, people can easily transfer the idea that there is also someone (a type of God or a supernatural force) behind natural selection as well. With this misleading conception, adaptations can be seen as pre-determined with some specific purpose or function. This idea is very similar to Aristotle's thought, with the difference that for him the Universe is static and stable, and species do not chance through time. It is important to say that for Aristotle, the wise nature is responsible for the perfections found. Later, such thought changed, especially by the teleological deists for a God who is also wise and who was responsible for creating purpose. In this idea, as in Creationism, there is a beginning point and the Universe is not eternal anymore (with no beginning nor ending), as it was for Aristotle.

Mayr concluded that the first four kinds of teleology are material, non metaphysic, and Cosmic teleology does not exist. According to him, even though there are natural

processes with some kind of purpose, there is no need to use supernatural phenomena to explain them, i.e. there is never a retroactive cause.

Thinking about teaching evolution

As we could see in brief, there are many alternative conceptions regarding evolution. Thus, teaching evolution is not an easy task and it represents a challenge in every scholar age. Among the difficulties are: 1) temporal assimilation of evolutionary changes; 2) populational thinking (it is very common to think of individual changes over time, as in Lamarck' theory, and not of populations); 3) difficulties in finding ancestors groups; 4) recognizing kinship among humans and other living beings; and, 5) the idea of progress in evolution (Santos & Calor, 2007a).

Gregory (2009) analyzed essential concepts and common misconceptions regarding specifically Natural Selection pointing out that it is poorly understood not only by members of the public in general, but also by people who have had specific instruction and teachers. One of those misconceptions is a functional understanding of natural selection in which there is a tendency toward teleological explanations, or in other words, explanations based upon purpose. This could be a result of human psychology, including a functional bias, because "much of the human experience involves overcoming obstacles, achieving goals, and fulfilling needs" (Gregory, 2009, p. 167). Need-based explanations for natural selection, as the classic giraffe's neck example, are also very common and they are related to the misconception that individuals can change purposes depending on the challenges that environmental pressures put upon them. This makes the difficulty number two (populational thinking) also a problem of understanding natural selection and adaptations.

In addition, children from late preschool tend to show a promiscuous teleological bias, which seems to strengthen during elementary school (Kelemen, 2012). When trying to elucidate its origins, studies described by Kelemen have discarded parents' influences, the cultural religiosity factor, and media exposure, thus showing that external social forces have a weak potential to explain the teleological explanations. This suggests a natural cognitive teleological intuition that can even influence older students to elaborate need-based explanations.

Thinking about teaching evolution, there is no need to distinguish all Mayr's teleological categories. Despite the philosophical importance of understanding the current polysemy of the word 'teleology', including a non-biological discussion, teaching evolution can create further problems. Nonetheless, it could be very useful to introduce and distinguish two of the five categories proposed by Mayr: adaptive features and cosmic teleology.

Regarding the first category related to adaptive features, a very common problem is the way language is used to explain them and to describe organs' functions, maybe because of the cognitive bias already mentioned. Students might comprehend that an organ has evolved for a specific reason, related to the function it currently has. It is necessary to make students understand that the fact that an organ has a function today does not mean that it has always had this function, neither that its functions have been pre-determined (function first, organ after, as in the Aristotelian view). It is common in evolution patterns

as exaptation, in which the function related to an organ changes completely. Adaptations are the result of natural selection: the differential survival (or reproduction) of classes of entities that are different between one another from one or more characteristics (Futuyma, 2005). Even though natural selection is a non-random process, mutation (the evolutionary force that creates new variability) is and cannot have a pre-established purpose or function.

Thus, it is important to comprehend evolution as a plural process, in the same way Darwin had understood it, in which some external events might influence (as environmental changes, for instance) and natural selection is only one of the forces that drives the changes in population over time. Many features seen today are the result of other evolutionary forces, such as genetic drift and migration, or can just be the result of ancestry, not having any function at all.

Therefore, it is important that students properly know the structure of evolutionary thinking. For example, it is important that they can distinguish adaptations from other features. Adaptations are features that were favored by natural selection because they had a positive effect in the struggle of life. It is also important that they understand that the most interesting evidence to comprehend evolution include imperfections, apparently accidental peculiarities, not the perfect adaptation. Imperfections come, sometimes, out of inherited structural constraints that guarantee an effective rejection if creationists' favor the argument about an intelligent designer. Useless organs have been the weakest point in Aristotle's theory and, at the same time, the strongest to support Darwin's theory.

On the other hand, cosmic teleology has probably been the biggest misunderstanding disseminated in human thought. Gould (1990) has defined the history of life as a history of elimination and mass extinction followed by differentiation inside a few survived groups. It is neither a tale of continuing progress towards improvement, nor a predictive scale of progress. Life branches continuously, and extinction represents a very important pattern is this ramification. That is why the image of the tree of life or phylogenetic tree is so useful to teach evolution. According to Santos & Calor (2008), cladograms decrease misinterpretations about human progress because they are branched diagrams, in which both common ancestry and relatedness across species are represented. It is essentially different from a linear representation.

Solving such misconceptions is not an easy task and needs a clear comprehension of evolution. Sinatra and collaborators (2008) emphasized that the most important thinking when teaching about evolution is to help students revise their own previous knowledge to create a new and more scientific way of seeing the world. Focusing not only upon the biological aspects of evolution, but also on discussing the philosophy of evolution and the history of evolutionary thinking, can be an important pedagogical tool to dismiss some of the misleading ideas related to evolution. This can also include the explicit discussion of teleology, specifically the categories of adaptive features and cosmic teleology. Evolution runs counter to intuition and common sense, and teaching and learning it need an active effort to identify and confront misconceptions to supplant them.

Final considerations

First of all, it is important to emphasize that current teleological discussions are ontologically diverse from Aristotle's classic teleology. Aristotelian teleology is one of

Aristotle's pillars and it comes with an immutable world, in which species do not change. Nowadays, instead, evolution is a fact and there is space neither for fixism, essentialism, nor cosmic teleology. In Mayr's ideas, every possible application of the term "teleology" is related to an idea of movement. Therefore, Mayr's categories are not Aristotelian, even if, surely, they have influenced a lot of teleological thoughts in general.

Mayr's teleological categories appear in philosophical discussions, especially in the biological field. When thinking about teaching biology, though, such division is not practical, as it includes non-biological terms. It does not necessarily help non-scientists, including students, to better understand nature and evolutionary process. Thinking in biology and science teaching, it would be very useful to introduce two of the five categories proposed by him: adaptive features and cosmic teleology. These categories may help students to better understand evolution and dismiss some misleading ideas as adaptations that evolved "for" a reason.

Summarizing, Aristotle's influence remained across centuries mainly because it was based in what could be directly observed. It was intuitive in ways evolution will never be. To think that the "perfect" adaptations we see in many organisms are not pre-determined is not intuitive and to think that humans are not inevitable, is not comfortable. Although, it is very important to comprehend evolution in a non teleological way, both regarding to adaptations and the non-linearity of the process. This comprehension would make us have a different and healthier relationship with the environment and other living beings. Not only the origins of the human way of thinking would be important but also the dissemination of scientific thinking, thus the philosophy of science and specifically the philosophy of evolution are very important when teaching this subject. When teaching evolution, it is possible to decrease the teleology presence without using all Mayr's categories (epistemological discussion) once they are complex and include non-biological conceptions. Making students aware of such contradictions and actively understand the reasons why evolution is not progressive could be a way to improve students' understanding and acceptance of evolution.

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