A Case for Teleology in Modern Biology

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Although teleology, or explanations in terms of goals or ends, has historically been integrated in biology, within the past few hundred years, mechanistic explanations have dominated the field and teleology has largely fallen out of favor. A prominent advocate for the dismissal of teleology in biology is evolutionary biologist Ernst Mayr (1904-2005) who proposed teleonomy, or explanations of goals or ends as directed by a program, to be the proper way to understand biological processes and development of organisms. However, if we undertake Mayr's teleonomy instead of teleology, we are essentially left with biological reductionism and see living beings as complicated machines. If this is the case, we lose an understanding of what counts as a successful organism and therefore cannot speak of mutations or improper development in organisms. Thus, I suggest that we need to understand living beings for what they *are* and invoke Michael Thompson's notion of life form which suggests that living beings are distinguished from non-living artefacts insofar as they have a life form that encapsulates their capacities and activities beyond immediate response to being merely affected by their environment. I argue that this life form is the irreducible potential that Alan Gotthelf claims defines Aristotelian teleology and is what ultimately separates living beings from non-living artefacts, thus refuting Mayr's concept of teleonomy as a prominent understanding in biology, and bringing back Aristotelian teleology in individual organisms.

Introduction

When scientists want to understand a phenomenon, they try to understand the mechanisms by which the phenomenon occurs. Thus, they break it down into parts and processes. For example, in asking why the sunflower grows tall, a biologist will likely look for a corresponding gene that promotes the tall growth of the sunflower compared to shorter growth of a lily. Never would a biologist say that the sunflower is tall because that is what a mature sunflower should be like – to a scientist, this doesn't answer the question of *why*.

Science instead has come to focus on what we know as Aristotle's efficient cause, the instigator of change, rather than the final cause or telos, i.e. the purpose or end. The efficient cause speaks to the past, whereas the final cause speaks to the future. In trying to understand why the sunflower is tall, a scientist could take two directions: 1) He could look back at the evolution of the sunflower or 2) look at the current sunflower and see the mechanisms that enable the sunflower to grow tall. In either case, the scientist is referring to the past or the present and thus emphasizing the efficient cause. Never is he invoking the final cause, or the telos, and addressing the future of the sunflower.

Thus, it seems that teleology, or explanations in terms of goals and purpose, has no place in modern science, specifically in biology. Nevertheless, Aristotelian teleology was the dominant form of understanding the growth and development of organisms until the 1800s when the field was revolutionized by the works of Mendel and Darwin. With the rising emphasis on mechanisms in modern science, the role of teleology in biology had been challenged and is generally disregarded by current biologists. One such evolutionary biologist, and later philosopher, Ernst Mayr (1904-2005) claimed that teleology does not at all belong in biology and promoted the concept of teleonomy in its stead. In this paper I will argue that we need

Aristotelian teleology in our understandings of biology and furthermore that Ernst Mayr's teleonomy, explanations in terms of ends directed by a program, is not an adequate account to replace teleology.

First, I will review the notion of teleology and how its place in biology has altered with the emergence of new philosophies. The focus here will be on Aristotle, Descartes, Darwin, and then the vitalist and mechanist divide of the 1500s to 1700s. Second, I will give a deeper understanding of Aristotelian teleology and the manner in which we will understand teleology in this paper. Third, I will introduce Ernst Mayr, a prominent evolutionary biologist with works in the philosophy of science, and his contemporary Collin S. Pittendrigh and explore their notion of teleonomy. Lastly, I will argue against Mayr and offer an opposing view to Mayr's non-teleological one using a recent work by Michael Thompson on the notion of life.

A Brief History of Teleology

Teleology is often credited to be the invention of Aristotle, although the concept dates back to his predecessors and the exact term was not coined until the eighteenth century.[1] For Aristotle and his scientific inquiry, teleology played a central role in understanding the world. Furthermore, we should note that as with all ancient philosophers, philosophic and scientific inquiry were one and the same and thus the philosophical notion of telos or the end goal of an object, an animal, or a person was present in science and biology.

Central to Aristotle's work is his concept of the four causes within which all explanatory factors fall: The material, formal, efficient, and final cause. In his own work, Aristotle does not call these causes as such, but rather he calls them "the matter, the form, the mover, [and] the for

[1] Johnson, *Aristotle on Teleology*, 6

the sake of which."[2] Simply put, the four causes can respectively answer some version of each of the following four questions: What is it made of? What made it or instigated the creation/change of it? What is its form or structure? What is it for?

The efficient cause was previously mentioned in regards to the sunflower example and will be important to a later discussion as it is the primary explanatory factor in the scientific domain. However, our current focus is on the final cause, or the 'for the sake of which' as it is of the same idea as teleology, i.e. it explains something with regard to its end or purpose. The final cause, or telos, was central to satisfying Aristotle's curiosity about the nature of plants and animals and how they worked. For example, he was able to observe the development of a chicken from embryo to adult. In his observations, he developed a constitutive understanding of what a chicken, or plant, person, etc., is and thus an understanding of telos, or doing something for the sake of something, in natural beings.

Considering all living beings, Aristotle states in *De anima* that "It is manifest that the soul is also the final cause [of the living being]. For Nature, like thought, always does whatever it does for the sake of something, which something is its end."[3] This explains why, for example, chicken eggs give rise to chickens and not to frogs or horses. In other words, living beings have a natural, end-directed change that is seen explicitly in the development of the organism from embryo to adult.

We should note, however, that teleology was not just viewed in developing organisms but teleological explanations can be used to explain behaviors and other such actions. For example, we can ask the teleological question of what the purpose of a bird spreading its wings is, and

[2] Johnson, *Aristotle on Teleology,* 42
[3] Aristotle, *On the Soul* in *The Complete Works of Aristotle,* 661.

give the answer that the bird is trying to attract a mate. Thus we have an acceptable "for the sake of which" for the action of spreading wings for that particular bird.

The Aristotelian view of teleology in biology was the predominant framework in western scholarship offering a teleological perspective of organismal development, among other things, for the next millennia. Yet, a turning point in the status of teleology occurred with Descartes' mind-body dualism which altered our way of thinking. Descartes himself converts from holding the common teleological view on the world to a completely non-teleological view on the world. He uses an example on gravity in his *Sixth Replies* to explain this change of thinking. Descartes says that initially he "thought that gravity carried bodies towards the centre of the earth as if it had some knowledge of the centre within itself. For it could not act as it did without knowledge…"[4] In other words, a stone would fall to the ground because its telos was for it to go downward by gravity. However, with Descartes new understanding of a separate mind and body, it is impossible for the stone to have knowledge or a telos that directs it downwards. He says, "…and even all of the forms of inanimate bodies can be explained without having to assume anything else for this in their matter but motion, size, shape, and the arrangement of their parts."[5] Here Descartes is suggesting what has developed into the mechanistic way of viewing things, i.e. it is merely the size, shape, etc. and how they are affected by other forces that dictate the functioning of things.

With Descartes, scientific inquiry changed such that matter became the sole subject of biology and thus material things could be understood in simple, physical ways.[6] Descartes argued that the nature of the mind as a thinking thing was completely different from that of the

[4] Descartes, as quoted in Skirry, "Rene Descartes: The Mind-Body Distinction."
[5] Descartes, as quoted in Slowik, "Descartes' Physics."
[6] Bynum, *A Little History of Science*, 77

body as a non-thinking, extended object, and thus it is possible for them to exist separately.[7] Whereas with Aristotle, the inanimate was modeled on the animate, with Descartes, the reverse was followed insofar as the animate was modeled on the inanimate. Thus, living beings were reduced to complicated machines and the idea of a telos in all living beings was largely discarded.

This mechanistic view of life was further endorsed in the field of biology with Darwin's theory of natural selection. His theory of natural selection explained how, in a system S with the function X, X could exist to benefit S simply due to forces of nature. X would get passed down through generations precisely because X was useful to S. In this way, X was said to exist in S due to evolution, not at all because it was part of the end goal or telos of S.

For example, with Darwin's famous finches, a finch with a blunt, stout beak is biologically successful and thus passes down these beaks to its offspring. Thus, in future generations, an entire cohort of finches acquire this beak because it is very useful in cracking open seeds.[8] These future generations of finches do not develop a blunt beak because that is the goal of the finches, i.e. the finches see it best to obtain nourishment in that way, but rather the blunt beak is a result of successful evolution. Darwin's contribution to biology suggests a more mechanistic way of evolution, such that the parts of living beings are not *for* anything in a way that is essential to explanation, but rather the parts are just the result of physical, blind interactions.[9]

[7] Skirry, "Rene Descartes: The Mind-Body Distinction."
[8] Cornwall, "DNA Reveals How Darwin's Finches Evolved."
[9] Godfrey-Smith, *Philosophy of Biology*, 60

While Darwin's work influenced biology insofar as teleology was pushed outside the entire field, I will later discuss the relationship between teleology and evolution and how this is distinct from teleology in other aspects in the biological field.

Thus, we have seen how Aristotle's original teleological notions, in which he claimed that living beings had final causes that directed them towards their mature development, had largely fallen out of favor after having been the favored view point in western society for over a millennia. Descartes' dualism, together with Darwin's theory of natural selection, has given rise to a more mechanistic view of biology in which the interaction of molecules and parts yields results that are simply a direct consequence of their causal relationship. Put nicely, Ernst Mayr states that with the theory of natural selection, the proposed view was that "Evolution is purposeless, organisms and their parts are not *for* anything, and teleology is an illusion except in cases where an intelligent agent is making choices for reasons."[10]

Lastly, to further understand the history of teleology with respect to biology, we should look at the vitalist and mechanist debate that persisted throughout the time of both Descartes and Darwin. These opposing schools of thought argued over what separated living beings from non-living artifacts, a prominent point that we will return to later in this paper. Vitalists believed that there was a non-physical element, often described as a vital spark or spirit that gave life to organisms and made them fundamentally different from non-living things.[11] Mechanists, on the other hand, did not think there was any one thing that gave life to an organism, but rather an organism was considered alive because it had certain activities, such as reproduction, that

[10] ibid
[11] Bechtel and Richardson, "Vitalism."

occurred in its structure.[12] In the eyes of a mechanist, the difference between a living being and a non-living thing was simply a matter of complexity.[13]

For example, mechanist James D. Watson of the famous double-helix discovery of DNA claimed that the consequences of molecular interactions can fully explain *all* aspects of a living organism, just as they would a non-living organism. Included in this explanation is the concept of life, as certain molecules simply interact in certain ways to produce living beings.[14] On the other hand, vitalist Edmund Sinnot stated that too much focus on molecular and chemical mechanisms in organisms will "distract attention from the fact that there are fundamental problems in biology that have stubbornly resisted solution by chemical means alone. Conspicuous among these is the problem of the form [of life]."[15] In other words, Sinnot says that we cannot understand life with just an understanding of chemical interactions in living beings.

Eventually, vitalism declined in popularity and the mechanist view point emerged on top. The end of vitalism came about as thousands of experiments failed to find anything resembling the hypothesized vital spark. Furthermore, with the rise of modern science, genetics and molecular biology were able to explain problems that were originally solved with a vitalist approach.[16] For example, many vitalists argued that if living beings were actually mechanistic in nature, i.e. like a machine, they wouldn't be able to reproduce or regenerate lost parts, and thus living beings must have a vital force. The field of genetics and molecular biology provided insight as to how this could be possible without such a vital force.[17]

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[12] Fancher, "Vitalism and Mechanism."
[13] Bechtel and Richardson, "Vitalism."
[14] Hein, "The Endurance of the Mechanism-Vitalism Controversy," 174
[15] Ibid, 175.
[16] Mayr, "The Autonomy of Biology."
[17] Ibid.

For now, the key take aways from this vitalism-mechanism divide is that it highlighted the growing mechanistic view of biology that was eventually captured by Ernst Mayr in the late 1900s. Later, I will draw the connection between vitalism and teleology, as it parallels the connection between mechanism and Mayr's teleonomy. For Descartes and Darwin, it is notable that there is a suggestion insofar as both see teleology as involving knowledge. That is, implicitly in separating the mind and body, Descartes separates teleology from physical events. Similarly, in the finch example, the idea is that evolution *just happens* with no knowledge of what is better or worse for the species. As we will see with Aristotle, next, this relationship between teleology and knowledge is absent as there is a focus on the inherent nature of the thing, regardless of the rational, knowledge-involving perspective.

A Closer Look at Aristotelian Teleology

We will now return to Aristotle and his teleology to become clearer on how this will play an important role in the argument I will later make. Although teleology is widely believed to play an important role in Aristotle's philosophy, as Monte Ransome Johnson states in the introduction to his book *Aristotle on Teleology*, there is rather "widespread disagreement, both about the general character of Aristotle's teleology, and about many specific issues."[18] Nevertheless, what *is* clear is that Aristotle's notion of teleology differed largely from his predecessors because his teleological explanations came from within nature itself, whereas previously teleological explanations were credited back to God or some higher being.[19]

This connection between teleology and nature is important insofar as it is distinctive of the previous relationship described with Descartes and Darwin in which teleology was

[18] Johnson, *Aristotle on Teleology,* 2
[19] Ibid

knowledge-involving. With Aristotle, on the other hand, we see no connection between teleology and the rational being. Rather, a telos in Aristotle is inherent in the natural thing, whether it be a rational human or another living being.

Allan Gotthelf notes this connection between teleology and nature when he says that "in almost every passage in which Aristotle introduces, discusses, or argues for the existence of final causality, his attention is focused on the generation and development of a living organism."[20] In examining mentions of the final cause in Aristotle's work, Gotthelf equates Aristotle's position on teleology to that of a position on biological irreducibility. In other words, he asks if the development of a mature organism can simply be the result of laws that dictate the material in the process of development, or must there be some reference to the end form that the mature organism takes on, i.e. a telos.[21] In examining Aristotle's work, Gotthelf concludes the latter and in doing so he puts Aristotelian teleology in agreement with biological irreducibility which I will discuss next.

Aristotle, himself, doesn't speak of laws – a familiar notion that we use in modern science – but instead talks of natures and potentials of things. All natural things (i.e. living things and the elements) have characteristic attributes and movements, i.e. their own nature as well as the potential to interact and affect other things besides themselves. Thus, processes are a result of things acting in accordance with their nature and/or an actualization of a potential.[22] In this language, the question of teleology and reducibility is then, "Can one give an account of the process of organic development solely in terms of element-potentials which make no reference to the overall outcomes of the process, viz., the form of the mature, functioning organism? Or must

[20] Gotthelf, *Teleology, First Principles, and Scientific Method in Aristotle's Biology*, 5
[21] Gotthelf, *Teleology, First Principles, and Scientific Method in Aristotle's Biology,* 7
[22] Gotthelf, *Teleology, First Principles, and Scientific Method in Aristotle's Biology*, 8-10

at least one of the potentials involved in the account be irreducibly a potential for the development's end, for an organism of that form?"[23]

Gotthelf claims that it is this question that we must answer in order to understand Aristotle's notion of teleology. After carefully reviewing each section in which Aristotle discusses the 'that for the sake of which,' Gotthelf argues that in Aristotle's works, there is indeed an irreducible potential in a developing organism, and thus organisms have a 'that for the sake of which' or a telos insofar as they have this potential.

We see support for this idea when Aristotle briefly considers a world where there is absolutely no teleology, i.e. living things don't have any intrinsic ends goals but rather are subject to outside forces that cause their motion. In *Physics*, he wonders why the nature of a living being should be any different from other processes we observe that are due to what we now consider physical laws (e.g. laws of gravity or laws of thermodynamics). In taking rain, for example, Aristotle says that rain falls because the water that was initially "drawn up must cool" and "what has been cooled must become water and descend."[24] Aristotle notes that this sequence of events is of the same sort as when a farmer's drought-ridden crops need water and rain suddenly falls. Importantly, the rain does not fall for the sake of the man's crops to grow, but his crops grow simply in consequence of the rain falling. In other words, the telos of rain is not for growing crops, but rather the falling rain is a coincidental benefit for that man's crops (or on the other hand, if it rains too much, it is a coincidental detriment to that man's crops). Aristotle then poses,

> "Why then should it not be the same with the parts in nature, e.g. that our teeth should come up of necessity – the front teeth sharp, fitted for tearing, the molars broad and

[23] Gotthelf, *Teleology, First Principles, and Scientific Method in Aristotle's Biology,* 11
[24] Aristotle, *Physics* in *The Complete Works of Aristotle*, 339.

> useful for grinding down the food – since they did not arise for this end, but it was merely a coincident result; and so with all other parts in which we suppose that there is purpose? Wherever then all the parts came about just what they would have been if they had come be for an end, such things survived, being organized spontaneously in a fitting way; whereas those which grew otherwise perished and continue to perish, as Empedocles says his 'man-faced ox-progeny' did."[25]

In this, Aristotle asks why natural changes, such as the way teeth grow, might not beneficial to the animal just by coincidence in the same way that when the rain falls it is beneficial to the man's crops by coincidence. In other words, just as the rain is not for the crops, we could say that the teeth is not for the benefit of the animal.

Aristotle proceeds to say that it is impossible to hold this view. His argument follows that things are either by coincidence or for an end. He says that natural things come about in a regular fashion and "when an event takes place always or for the most part, it is not incidental or by chance."[26] Thus there must be something that explains the regularity of these events. If such regularity is not a result of coincidence, then natural things must be for an end, i.e. teleological. Thus, in Aristotle's teeth example, there is either a causal connection between the needs of the animal and the teeth or there is no connection and the teeth just happen to grow in a beneficial way. If it was the latter, how could we explain that the teeth grow in that way for thousands of animals? Thus, there must be a connection and this connection is seen in terms of a telos.

It is important to note, however, that with natural things, the final cause, or telos, is not the only explanatory factor behind such natural changes, and in fact, a thorough explanation of a natural change may require all four explanatory factors. While Aristotle poses that things with regularity must be teleological to an extent, often in nature, the other causes are identified with the final cause. Specifically, the formal (i.e. the form or arrangement) and final causes (i.e. the

[25] Ibid.
[26] Ibid, 341.

end or telos) often coincide. Nevertheless, Aristotle argues for the importance of and the priority of the final cause by giving an analogy to the building of a house. There is no way to explain how a house is built other than with reference to the end, i.e. the actual built house.[27] In the same way, in returning to our focus on the development of organisms as Aristotle does, we cannot properly view and understand a living being without reference to the end, i.e. the activities, behaviors, physical properties of what a living being of that kind is. Furthermore, since the outcome of organismal development is regular, it must not be by chance but rather for the sake of something, and that something is the organism itself.

Our understanding of Aristotelian teleology is thus as follows: Organisms have within them an irreducible potential according to which the organism develops. In other words, the product is more than the sum of its parts. This development is not a result of mere chance or the coincidence of interacting elements and potentials, but rather it is for the sake of the mature organism itself. This is the understanding of teleology that I will use going forth in this paper.

Teleonomy

A problem arises when biologists argue that there are more options of how outcomes come about than the two that Aristotle poses. As mentioned just previously, Aristotle offered that regular occurrences either happen as a result of coincidence or for the sake of something, concluding that organismal development is for the sake of something because something so regular could not be coincidental. Ernst Mayr sees a third option in that mechanisms can offer another explanation for the regularity of occurrences like organismal development. In contrast to Aristotle's simiplistic view of chemistry that was quoted above, we now have a thorough

[27] Falcon, "Aristotle on Causality"

understanding of chemistry and interacting biological parts which Mayr believes can be used to fully explain biological phenomena. Mayr does so by using the concept teleonomy, which he defines as processes or behaviors that owe their "*goal-directedness to the operation of a program.*"[28] In this section of the paper, I will provide a thorough look at the concept of teleonomy and contrast it with Aristotelian teleology, in order to ultimately argue that we need more than just and understanding of mechanisms and teleonomy and should not lose sight of teleology in our understandings of organismal biology.

Mayr is not the first person to use the word teleonomy as it was originally coined by British biologist Colin Pittendrigh (1918-1996). Pittendrigh invented teleonomy as an alternative to teleology when he came to the conclusion that biological adaptation was "obscured up to 1859 by its association with Aristotelian teleology." 1859 was, of course, the year that Darwin's revolutionary *On the Origin of Species* was published. This work provided, by way of the theory of natural selection, a manner in which adaptation was free of teleology and thus in line with the dominant scientific concepts at the time, such as those that are found in physics.[29]

At one point, biologists seemed to go out of their way to avoid teleological jargon, saying, for example, that the turtle came ashore *and* laid her eggs rather than the turtle came ashore *to* lay her eggs. However, teleological language was gradually accepted back into everyday language, which Pittendrigh criticized as he said,

> …It is unfortunate that the term 'teleology' should be resurrected and, as I think, abused in this way. The biologist's long-standing confusion would be more fully removed if all end-directed systems were described by some other term, like 'teleonomic,' in order to

[28] Mayr, *Toward a New Philosophy of Biology, 45*
[29] Pittendrigh, "Adaptation, Natural Selection, and Behavior," 392.

> emphasize that the recognition and description of end-directedness does not carry a commitment to Aristotelian teleology as an efficient causal principle.[30]

Thus, Pittendrigh creates the term teleonomy in order to describe a process that has an end or goal in biology. Importantly, in distinguishing teleonomy from teleology, this quote highlights a flaw in Pittendrigh's understanding of Aristotelian teleology. He interprets teleology to be an efficient cause and thus mistakes it to be backwards causing, i.e. the end of a mature organism will guide and 'pull' the organism to develop and behave properly. If teleology were backwards causing it would be that the end or purpose of the living organism directly caused the proper development of that organism. Teleology fell out of favor for this exact reason, and so perhaps we cannot blame Pittendrigh for creating teleonomy in contrast to teleology to provide a manner in which a process could be understood as forwards causing and mechanistic, yet still goal-oriented process. Nevertheless, in reality, Aristotelian teleology is far from backwards causing. As discussed earlier, Aristotelian teleology, by our understanding of it, is not backwards causing but rather described as an irreducible potential that is present in living beings. What exactly we mean by this reducible potential will be explored later in this paper.

Nevertheless, despite Pittendrigh's misunderstanding of Aristotle, teleonomy and teleology are still quite different. What truly separates teleonomy from teleology is the mechanistic language that is used in teleonomy. Pittendrigh says that he "wanted a word that would allow [him]… to describe, stress or simply allude to – without offense – this end-directedness of a perfectly respectable mechanistic system."[31] And likewise, Mayr says, "Teleonomic processes are strictly causal and mechanistic."[32] Both refer directly to mechanisms to explain the end or goal which is in stark contrast to our teleology. Going back to Gotthelf's

[30] Pittendrigh, "Adaptation, Natural Selection, and Behavior," 394.
[31] Mayr, *Toward a New Philosophy of Biology,* 64.
[32] Mayr, *Toward a New Philosophy of Biology,* 60

interpretation of Aristotelian teleology, teleology is the idea that there is an irreducible potential within a living being that is essential to the activities involved in the maturation and behavior of the living being. The obvious words to focus on here are *irreducible potential* which stand in stark contrast to both Pittendrigh and Mayr's ideas of mechanisms that is essential to teleonomy in living beings.

In looking at the definition for teleonomy again as "*goal-directedness to the operation of a program,*" Mayr goes on to identify two parts to this program: a closed program which refers to the genetic material that is found in all living things and an open program which refers to additional information that is acquired through experiences such as learning.[33] [34] Thus, genes that dictate the development of seeing eyes are as much a part of the program as a gazelle fleeing from a lion after having learned through experience that lions are dangerous. Moreover, in regards to Mayr's understanding of a program, we should note that programs are dynamic. Programs are both affected by "sensory inputs" as well as "internal physiological states," which simply means that the behavior of an organism can be affected by its external environment as it reacts to stimuli.[35] Furthermore, because the point of the program is to achieve a certain goal, feedback loops and regulation are may be present.

We must next address what Mayr actually means by the word program. Thinking of the word program in the biological sense, one perhaps thinks of the often termed genetic program, which is indeed one way in which Mayr uses the term program. The central dogma of molecular biology certainly acts in a program-like manner, that is, there are specific instructions that are followed to go from genes to RNA to proteins. More modern understandings of genetics,

[33] Mayr, *Toward a New Philosophy of Biology, 45*
[34] Mayr, *Toward a New Philosophy of Biology, 49*
[35] Mayr, *Toward a New Philosophy of Biology, 51*

including chromatin accessibility and epigenetics, i.e. changes in the genome that are not due to changes in nucleotides of the DNA, are simply a more complex part of this program of gene regulation, but included in the program nonetheless.

On the other side we also have the open program. Mayr says, "Nothing could be more purposive, more teleonomic than much of the escape behavior in many prey species (in birds and mammals). Yet, in many cases the knowledge of which animals are dangerous predators is learned by the young who have an open program for this type of information."[36] This speaks to the idea that living beings of a certain kind have a specific potential to experience and learn certain things. For instance, the lion cub in the presence of buffalo can learn to go after this favored prey such that when it is a mature lion, it will continue to do so. Nevertheless, the cub can learn to prey on zebra as well, as it also has this potential in virtue of being a lion.

Interestingly, we may think at first that Mayr's open program is not a program in the same respect as his closed program. That is to say that the open program of experience and learning cannot be understood to the same extent as the closed program of genetic regulation in terms of the mechanistic manner that Mayr associates with teleonomy. Perhaps, the very notions of experience and learning suggest there is something more and one might claim that Mayr is mistaken when he tries to expand on Pittendrigh's term and include an idea of an open program. On the contrary, however, Mayr's understanding of an open program is no less mechanistic than an understanding of a learned computer. Modern computers, although completely mechanistic and program-based, are able to learn from mistakes and improve their performance. How then are computers distinguished from living beings? What is crucial to understand here is this idea of

[36] Mayr, *Toward a New Philosophy of Biology, 49*

improvement and performance insofar as computers only perform well with respect to our desires of them. This idea will be explained further in the following section.

Thus, as just illustrated above, the problem with seeing teleonomy in living beings is that it conflates the differences between living and non-living things, essentially bringing back the mechanistic school of thought from the early modern period. For example, Mayr directly compares the goal-directedness of living beings to a machine when he says, "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."[37] Our take on Aristotelian teleology in this paper, applies exclusively to the development of living beings in so far as they develop for the sake of that mature living being with an irreducible potential as part of this development. A comparison of life to a programmed computer highlights the very *reducibility* of teleonomy that we do not have in teleology. A more in depth look at the differences between a computer and a living being, such as a plant or person, will be given in the upcoming section of this paper in which we will ask if there a role for such Aristotelian end-directed processes in a modern biology that is filled with mechanistic language and inquiry? The answer, I will argue, is yes.

The Need for Teleology in Modern Biology

We have traced teleology as it relates to the sciences throughout history in the western world and have seen that it has largely fallen out of favor with the rise of modern science and has instead been replaced by the reducible concept of teleonomy first by Colin Pittendrigh and later by Ernst Mayr in biology. In positing teleonomy in terms of programs and mechanisms,

[37] Mayr, *Toward a New Philosophy of Biology,* 31

teleonomy is placed precisely in oppposition to Aristotelian teleology. Nevertheless, now I will discuss why we should bring the concept of teleology back into our mechanistic centered understandings of science and biology and why Mayr's teleonomy is not enough.

First and foremost, teleology is necessary in biology because it gives us an idea of what something *is*. Importantly, this is different than what something is like. For example, we say that a chicken simply *is* a chicken in contrast to when we say what a chicken is like we say that a chicken has a beak, feathers, lays eggs etc. When we talk of what something is, we talk of what it means to be that successfully developing organism in ways that are beyond the basic characteristics of that organism, and furthermore beyond the mechanistic understanding of such an organism.

This is illustrated if we note the difference between how we understand the success in the development of an organism and the failure in the development of an organism. If an organism fails to develop properly, say the chicken does not develop its wings entirely, with the help of modern science, we want to determine the cause directly behind this lack of proper wing formation. This cause, for example, could be identified as a deficiency in protein level due to the mutated gene Y. Thus, it seems that this characteristic of the chicken is reducible to the single gene Y. And insofar as wing formation is reducible to gene Y, why shouldn't all other characteristics be reducible to other genes? In fact, this is what the Human Genome Project set out to do. Completed in 2003, the Human Genome Project identified all genes and their functions in the human genome.[38] Such a case is a perfect example of Mayr's teleonomy insofar as the genetic program of humans was identified and such a program lead to the proper development or end of a human. However, if we are to adopt Mayr's view and understand humans as beings that

[38] "All About The Human Genome Project"

are reducible to their genes we would have the mechanistic view of living beings that is prevalent throughout modern science and be missing something about *what humans are*. Teleology in biology is what brings us to understand what this something is that we would be missing and we will see this in discussion of Thompson's life-forms later in this paper.

Moreover we can only truly discuss failure of an organism in the first place when we are able to reference what a successful organism is. In other words, how are we to know the case of a failed organism if we do not know the case of a successful organism? In our understanding in the case of a successful organism, teleology is crucial. A successful organism is not simply one that is statistically typical of the species. This is nicely demonstrated in the mayfly species in which the majority of mayflies do not survive to reproduce, yet a mayfly that *does* reach reproduction is not a failed instance of mayfly despite its being an unusual instance. It is quite the contrary, in fact, as reproduction is part of what it *is to be* a mayfly. Instead, we need teleology to properly understand what it is to be a mayfly, i.e. a successful instance of a mayfly, which will again be discussed in a following section.

Before doing so, however, one last point I want to make on failure is in noting the difference between failure in a living organism and that in a mechanism such as a computer. Computers have no inherent goals or purposes within them – they simply follow the laws of physics in a mechanistic way. The only goals they have are those that we, as people who have made and use the computer, impose upon them. Thus, when a computer fails, it only fails at accomplishing the goal you set for the computer and nothing more. On the other hand, I will argue that a living being has a goal or telos regardless of purposes we, as humans impose on them. For example, the telos of a stalk of corn is not to grow well and be sweet for our

consumption, although this may be a purpose for which we grow the corn, but the corn itself has an inherent telos insofar what it is to be a stalk of corn.

What exactly is this telos in living beings, though, whether the living being be a stalk of corn or a human? To bring back our understanding of Aristotle, teleology in living beings invokes some irreducible potential that is seen in the mature organism. This irreducible potential, then, is something that is unique to organisms that separate them from non-living artifacts. Here we can also bring back the vitalist-mechanist debate of the early modern period. Though I will refrain from saying that there is a physical vital spark that is present in living beings that distinguishes them from non-living artifacts, I will say that there is this irreducible potential or telos that living beings have that is lacking from non-living artifacts. In other words, living beings are irreducibly instances of forms of life. We deny the mechanist claim that living beings are simply complex machines that are organized in certain ways and instead claim that living beings have their own telos – regardless of our use for them, such as in the corn example above – that is distinguishable from the ends of non-living artifacts.

To get clearer on this telos and irreducible potential, we can look briefly to Aristotle and his idea of natural kinds, but more importantly we can look to Michael Thompson and his notion on the form of life. Ultimately, I believe that this irreducible potential can be equated to Thompson's life form.

Living beings have certain characteristics or certain forms of what they are. It is precisely for this reason that we are able to identify organisms with mutations as those that have gone wrong as was just previously discussed. Genetic mutations happen frequently within an individual organism, however most of these errors are cleaned up and thus don't affect the end organism. Nevertheless, when a mutation persists, we come under the impression that such an

organism is not capable of living their life to the full extent in the same way that the rest of their species does. This idea of characteristic forms is found in both the ancient philosophy of Aristotle as well as in the modern philosophy of Michael Thompson. To better understand this and the role it plays in teleology, we will take a closer look at these notions of kinds and forms.

Aristotle had a notion of natural kinds in which individual living things belong to natural kinds, which include species and genus. Further, for Aristotle, these primary substances that make up natural kinds are able to reproduce, such that "A tree begets a tree, a bird begets a bird" in contrast to "a bed does not beget a bed." A lion then, is a natural kind, as is a zebra for example.[39]

While the idea of natural kinds has ancient origins, contemporary philosophy Michael Thompson invokes a similar concept when he writes on the form of life. Thompson strongly argues for a life-form that in all living things that goes beyond the mechanistic activities that are present in living beings. He presents characteristics that are frequently attributed to living things in modern biology textbooks, including complex organization, homeostasis, growth and development, adaptation, receiving and conversion of energy, response to stimuli, and reproduction.[40] He then goes through a few of these characteristics and demonstrates how they are not particular to living things. For example, photosynthetic leaves and concrete both take light energy from the sun and convert it to chemical energy and heat respectively. Photosynthetic leaves, though, he says, are alive in a way that concrete is not. Another example examines the

[39] Vella, *Aristotle: A Guide for the Perplexed,* 44
[40] Thompson, *Life and Action,* 34

budding of plants and the melting of ice, both of which are response to the stimulus of warming weather, however, once again the plant is alive whereas the ice is not.[41]

It is true that in both of these examples, the subjects can all be viewed at a molecular basis, thus suggesting a casual, mechanistic explanation for the change that would be in line with Mayr's teleonomy in living beings. The difference, Thompson argues, lies in answer to the question, 'What happens next?' As he says,

> In learning of the various cellular processes unearthed and described in biochemistry… one is inclined to think, It's all getting boiled down to chemistry and physics, isn't it?... But it is interesting that if the only categories we have to apply are those of chemistry and physics, there is an obvious sense in which *no such succession of goings-on will add up to a single process*.[42]

For a non-living artifact such as the concrete, what happens next to the concrete depends precisely on its environment. If it snows, the concrete will freeze, and if there's an earthquake, the concrete will crack. For a living organism, however, what happens surely depends somewhat on its environment, but there is tremendous dependence on what the living thing is, and more so what it is for the species to which the individual organism belongs. Thus, to be alive is to have a certain form of life, or as Thompson likes to say, a life-form, that is distinctive to a biological species. Living things, therefore, cannot just be things that do characteristic actions that are prominently found in what we take to be alive.

Moreover, another aspect that we can take away from Thompson's notion of life-form is the idea of certain processes being for certain capacities of the organism. Our understanding of a shark having nourishment, for example, involves the distinct function of its eating, which may look different from other types of organism's function of eating. Thompson illustrates this by

[41] Thompson, *Life and Action,* 40
[42] Thompson, *Life and Action,* 41.

proposing the existence of a new kind of shark that looks and acts almost identical to actual sharks that we know of today. However, one major difference is that the sharks we know of today chase after fish and engulf them for nourishment in a process we call eating, these new sharks, or quasi-sharks, make no nutritional use of these fish and instead, the fish is simply taken in, broken down, and released. While this process looks exactly like eating from the outside, we would be mistaken to call it eating as there is no nourishment occurring with the intake of these fish in this quasi-shark. As Thompson puts it,

> "We can readily enough imagine the genesis of a novel kind of shark – one nourished, not by the flesh of smaller fish, but by plankton and the like… We may suppose, these newly developed sharks or quasi-sharks can sometimes be seen to chase after smaller fish and incorporate them. No part of this flesh ever enters the blood-stream… The operation looks very much like the hunting, munching and swallowing that actually existing sharks go in for, and no doubt some of the genetic basis of the latter will have carried over to the former. Someone might take the movement for the same sort of thing, and call it eating; but it is clear that it isn't eating. When we call something eating, then we appeal to something more than is available in the mere spectacle of the thing here and now"[43]

This example serves to demonstrate the difference between what an organism is like and what an organism is. The actual shark and the quasi-shark have many shared characteristics, such as similar genes, similar modes of swimming and taking in fish, yet they are inherently different in terms of what they are because of their different life forms. Our recognition of the actual shark and the quasi-shark's specific manners of eating as a form of nourishment, along with recognition of other such processes, collectively create the life-form and enable us to distinguish between the two.

Furthermore, we are able to say that with respect to the two different sharks, the same behavior of taking in fish has a different telos that goes along with these differing life-forms. That is, the real shark takes in fish for nourishment whereas the quasi-shark takes in fish for

[43] Thompson, *Life and Action,* 55

another reason. Without understanding the difference in ends between the two sharks' behavior, one would be missing an important distinction between the two beings and a fundamental misunderstanding of what they are.

Lastly, perhaps another way to think about these two types of sharks is to invoke another of Aristotle's notions of essential and accidental properties. In regard to the first shark, the taking in of fish is an essential property, i.e. a property that it must have, because the taking in of fish is equivalent to nourishment which this shark needs in order to sustain itself. The fact that the quasi-shark displays the same behavior of taking in fish is simply an accidental property, i.e. one that the quasi-shark has but that it does not need. If the quasi-shark lost its ability to take in fish, it would not be losing its capacity for nourishment like the real shark would be. Thus, we can relate these to ideas of the life-form and telos as essential properties of beings are crucial to what they are, their life-form, and their telos.

To relate Thompson's notion of life-forms as well as the Aristotelian notion of natural kinds that was previously discussed to teleology is straightforward. A key part of Aristotelian teleology is the irreducible potential or nature of the living being as proposed by Gotthelf. But what are we really saying when we consider the telos of a living being as an irreducible potential? Just as a potential has the power to be actualized, the life form can be actualized in the living being in the form of the development and behavior of the living being. This potential is irreducible just as this development and behavior cannot be reduced to mere mechanisms without losing perspective of the life form of the being. Thus, the telos is the natural kind or life form of living beings insofar as the organism develops and lives in the manner that is proper to its kind. For example, the telos of a sunflower is its living according to its life form such that when we

ask Thompson's question of "What happens next?" we can give proper answers, perhaps related to photosynthesis and seed dispersal, etc., as the seedling grows into a mature plant.

Next, we will touch on the important difference between teleology in individual organisms and that of evolution which I alluded to early on in the paper. One reason leading to the rise of mechanistic thinking in the early modern period was due to Darwin's theory of natural selection. As discussed previously, with the theory of natural selection, teleology was seen as unnecessary and outright wrong in science because evolution *just happened*. Random mutations occurred in organisms that proved to be successful in the environment that the organism was in and after many generations a new species emerged. The theory of natural selection offered an alternative to the then popular view that there was a God or higher being that was the ultimate reason for which natural things had purposes or ends. But since new species were now believed to emerge from old ones simply from the happy coincidence of a specific mutation in a specific environment, any idea of some cosmic teleology was discarded. We are left then, with Mayr saying, "Evolution is purposeless, organisms and their parts are not *for* anything, and teleology is an illusion except in cases where an intelligent agent is making choices for reasons."[44]

Mayr was right to claim that there is no teleology in evolution exactly for the reasons just mentioned, i.e. that mutations are entirely random and the ability of a mutated organism to thrive and populate new generations is heavily reliant on the specific environment that that organism is in. Thus, there is coincidence involved, and if we recall Aristotle who said that things either happen for the sake of something or by chance, evolution by natural selection would fall into the latter category of happening by chance.

[44] ibid

Our interpretation of Aristotelian teleology, however, that was provided by Gotthelf has no mention of cosmic teleology. The subject is entirely in the individual organism and more specifically, in the development of the organism. We can say, then, without contradiction that evolution is not teleological while at the same time claiming that the development and behavior of individual organisms are teleological.

Note that with this claim, Mayr's statement that was just mentioned, i.e. "Evolution is purposeless, organisms and their parts are not *for* anything, and teleology is an illusion except in cases where an intelligent agent is making choices for reasons," is both correct and incorrect.[45] The first half that claims that evolution is purposeless and has no teleological status is correct as just discussed above. The latter half, that teleology is only present in intelligent agents, is false as I argue that there is teleology in living beings insofar as there is an irreducible potential by way of a life form.

Lastly, I want to briefly offer a view that critique's Mayr's rejection of teleology and his replacement with teleonomy. Mayr has received some criticism for his rejection of teleology, including that by Menno Hulswit who claims the Mayr rejects teleology based on false assumptions on the nature of evolution.[46] These assumptions are as follows: 1) Goals have to be specific, 2) teleology implies a determined, straightforward development to a fixed end, and 3) final causation implies a backward causation (i.e. future events influence past events).[47] Hulswit believes that Mayr was wrong to understand teleology in this way. Goals, he says are in fact always general, at least to a degree. Furthermore, teleological processes can be flexible and are not necessarily determined by a straightforward, fixed process. Lastly, Hulswit argues that while

[45] ibid
[46] Hulswit, "Teleology: A Peircean Critique of Ernst Mayr's Theory," 198.
[47] Hulswit, "Teleology: A Peircean Critique of Ernst Mayr's Theory," 200-201.

Mayr is right in refuting the possibility of backwards causation, this refutation does not necessitate a refutation of final causation as well.

I agree with most of Hulswit's critique of Mayr insofar as we understand teleology from an Aristotelian perspective as was interpreted in this paper. With regards to the first objection, that goals do not have to be specific, the telos or goal that was considered in this paper is that of a properly developing organism as it takes on the appropriate life-form of its species. The life-form of an organism is in no way specific as it is not simply a description of what an organism is like. Rather the life form is a complex set of capacities and activities that satisfy Thompson's question of "What happens next?" as was discussed earlier. Thus, if Mayr understood teleology to be of specific goals, then he surely would miss how teleology is present in living beings.

I also agree with the third objection, that Mayr wrongly interpreted a rejection of the possibility of backwards causation to necessitate a rejection of final causation. In finding an alternative to backwards causation, Mayr (or Pittendrigh before him) proposed teleonomy which provided a path for which the end or telos to be seen as being forward caused by way of a program. Mayr's introduction of a program gave way to a mechanistic view of living beings as being reducible to genes and molecular biological processes. As Mayr was unable to see, we are able to reject backwards causation, i.e. telos as an efficient cause, while at the same time maintain that there is a telos in living beings if we once again adopt Thompson's notion of a life form.

I left Hulswit's second objection for last because Hulswit misinterpreted Mayr when Hulswit claims that Mayr wrongly understood teleology to imply a straightforward path to a determined goal. Mayr, in fact, understood feedbacks to be an important part of reaching a goal. This is seen in Mayr's explanation of the closed and open program of his teleonomic definition.

Feedbacks are present in the closed program because the genetic program is full of regulating mechanisms and feedbacks are present in the open program – which I previously argued was not of the same nature as Mayr's closed program and did not fall neatly under his teleonomic definition – as learning is a result of feedback loops.

While I agree with most of Hulswit's points here, perhaps it is most important to note that Hulswit believes these are false assumptions on the *nature of evolution*. If the focus of Hulswit and Mayr was on biological evolution, then we can see how the concept of a mechanism-based teleonomy came to fruition. Evolution, as I have argued, is not teleological in the same way that I have argued organismal development and behavior is teleological.

Conclusion

In this paper, I have provided a brief history of the development of teleology with respect to the history of science with particular focus on Mayr's refutation of teleology in biology. The origin of teleology is often associated with Aristotle's final cause and helped explain the development of an organism from embryo to adult insofar as this development was irreducible to its parts. Aristotle's notion of an intrinsic teleology present in living beings was the dominant view before Descartes' mind-body dualism revolutionized our way of thinking to understand a body not as something that has an intrinsic teleology, but rather it is simply affected by other matter and forces. Teleology was further displaced from biology with Darwin's theory of natural selection from which evolution was understood to occur in a mechanistic way. From this, the mechanist school of thought developed which saw living beings as the consequence of a collection of certain mechanistic activities. However, other philosophers, those called vitalists,

disagreed and argued that there must be a non-physical force that induces life in a living being and makes it essentially different than non-living things.

More recently, Ernst Mayr, a famous evolutionary biologist, proposed a rejection of teleology in favor of his own form of teleonomy, or goal-directedness due to a program. While Mayr assumed teleonomy to be compatible with Aristotelian teleology, an understanding of Aristotelian teleology insofar as it is an irreducible potential that provides the development and behavior of an organism to be for the sake of that organism proves Mayr to be wrong. Thus teleonomy is not able to replace teleology in biology without the subsequent consequence of biological reductionism.

For Mayr to be right and for us to accept teleonomy as a replacement of Aristotelian teleology in biology, we would need to assume the mechanist point of view from early modernity that the division between living and non-living things is non-existent. Furthermore, we would need to assume that there is no natural kind or life form, but rather a continuum of types of living beings. Along those lines, in order to have a concept of success, we would have to turn to a catch-all criteria for all things, perhaps one of fitness and survival.

To view living things in terms of teleonomy, distorts our understanding of what it means for an organism to be alive. To truly understand an organism, we have to understand it for more than what it is merely like and understand it for what it *is.* This notion is captured in Thompson's idea of the life form which I argue is the same as the irreducible potential, and hence telos, that is found in living things. The life-form is what explains living beings, of the typical instance of their kind, to have certain capacities and activities that are present beyond those that are simply dependent on their surrounding environment. All species have a distinct life-form which is an idea that is similar to Aristotle's notion of natural kinds.

Importantly, this life-form is different from the vital spark that the vitalists believed gave living things life. There is no one thing that makes an individual alive, but rather there is an encompassing form or way of life that is unique to different groups of beings. The question is not, "What does something have?" to make it alive, but rather if we, again, return to Thompson, "What happens next?" For something to be alive is to be able to answer this question of "What happens next?" with an understanding of a natural form and telos that is present in the activities and behavior of the individual of a group. (And note that this is different than, say, answering "What happens next?" with a computer because we as people have given one specific computer a purpose and program).

To understand living beings as having a telos provides us insight into what a successful organism of that species or kind is. Without teleology, mutations in organisms would not be understood as wrong but rather just a variation of a similar organism. Living beings are fragile in the sense that things can go wrong in their activity, i.e. life form or telos. In contrast, inanimate mechanisms do not have a life form or telos and thus lack this fragility as we cannot speak of things going wrong beyond disobeying the purposes which we may impose on them.

In explanations of failure in living beings, we often resort to mechanistic explanations. However, this is not to rid of a teleological view of the organism. In fact, Aristotelian teleology offers a top-down view that gives unity to these bottom-up explanations that arise when we see living beings as straying from their life form. In dealing with patients, doctors, for example, have a holistic view of the person and what it means to be human which aids them in understanding the problems that are occurring at a lower level within the patient. Thus, in practices such as these, Aristotelian teleology is appropriately incorporated. It is theoretical biologists such as Ernst Mayr, or perhaps philosophers of science, who are more removed from the subject matter

itself and thus may fall into denial of actual notions of teleology in the sciences. An embracing of teleology by these biologists would provide an awareness that is proper to living beings as such and allow them to fully understand living beings as such, and in doing so may address some questions of animal and plant ethics.

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