MODERN BIOLOGICAL NEO-TELEOLOGISM VS. ARISTOTLE'S GENUINE TELOS

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ABSTRACT. *In the first half of the 20th century the attempt was made to banish all teleological thinking from biology. In the last few decades, several biologists and philosophers of biology have claimed that organisms may be considered teleological entities, spurring on a movement that can be described as 'neo-teleologism.' However, while biologists and philosophers of biology talk about 'teleology', it is not always clear what they mean by this term. This paper introduces the central ideas of the most influential neo-teleological approaches and compares them with the metaphysical fundaments of Aristotle's teleology. The main aim of the paper is to make clear that neo-teleologism and Aristotelian teleology are based on entirely different metaphysical assumptions. The latter, in contrast to the former, exemplifies the idea that living beings have an intrinsic nature and value.*
KEY WORDS: *Aristotle, teleology, telos, purpose, biological neo-teleologism, function, cybernetics, Neo-Darwinism, self-organization, value*

Contents

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Introduction

In the last few decades, several biologists and philosophers of biology have claimed that organisms may be considered teleological entities, spurring on a movement that is often celebrated as the renaissance of teleological thinking and that I describe as 'biological neo-teleologism'. While biologists and philosophers of biology talk about 'teleology', it is not always clear what they mean by this term.

In Aristotle's work *Physics* the term *telos* has a double meaning: *final state* on the one hand and *purpose*, *aim*, or *goal* on the other. In Aristotelian biology, the final state of living processes is something aimed at. In neo-teleological approaches the concept of 'telos' is understood as final-state-directedness, but here the final state of a material process is considered to be achieved by blind, deterministic, non-mental factors alone. Philosophy of biology gives to all neo-teleological approaches great credit for providing materialistic interpretations of 'purpose' and 'aim' without any reference to mental or psychical factors. According to Aristotle, in contrast, organismic final-state-directedness can never be the result of non-psychical mechanical forces. Aristotle would never assume that (blind) mechanistic processes would be able to produce something as ordered as even a single cell. Aristotle's biology is based on the presupposition that an organism is shaped by its soul (psyche). This does not, however, mean that Aristotle ascribes a human-like conscious mentality to biological processes.

In the first part of this paper I will outline the central ideas of the most influential neo-teleological approaches. It will become obvious that they are based on materialistic pre-assumptions. In the second part I will outline the metaphysical fundaments of Aristotle's teleology and make clear that such philosophy is based on the non-materialistic concepts of essence, soul, and good. In the last part I will summarize the main metaphysical differences between neo-teleologism and Aristotelian teleology and conclude that the latter, in contrast to the former, is based on the idea that living beings have an intrinsic nature and value.

1. ON DIFFERENT APPROACHES TO TELEOLOGY IN THE PHILOSOPHY OF BIOLOGY

In the first half of the 20th century the attempt was made to banish all teleological thinking from biology. In the last decades, however, several biologists and philosophers of biology have reintroduced teleological explanations into biology.[2] Though neo-teleological explanations often treat natural selection as sufficient to explain teleology, I will apply the term in a broader sense that includes different approaches introduced in succession since the 1940's [Cummins, 2002, p. 162]. However, the issue of teleology in contemporary biology is a very contentious and complicated subject. It is doubtful whether opponents are arguing over the same thing [Costa, 2008, p. 183–188].

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[2] Millikan, 1984; Neander, 1991; Griffiths, 1993; Kitcher, 1993; Godfrey-Smith, 1994; Allen and Beckoff 1995.

Philosophers of biology reject all forms of universal teleology or pan-teleology, the Aristotelian, Platonic, or Leibnizian consideration of the cosmos as a finally aligned totality. Neo-teleologism is confined to a specific biological variety of teleological reasoning – the 'special' or 'regional' teleology which merely refers to single living beings and not to global phenomena like the evolution of life or the whole cosmos. Special teleology can also be subdivided into 'inner' and 'external' teleology, the former focused on the growth of the entire organism, its elements, and their functional role, and the latter ascribing utility for something else to the organism as a whole. Modern philosophy of biology recognizes only special, inner teleology.

In the long history of philosophy of organism, a great deal of attention has been paid to special inner teleology, however, without considering it to be the only kind of natural teleology. In occidental philosophy of organism, for more than two millennia, the term *telos* kept its double meaning of both 'end,' or rather 'final-state,' on the one hand, and 'purpose,' 'aim,' or 'goal' on the other.

In neo-teleological approaches to the philosophy of biology, the concept of *telos* is understood exclusively as final-state-directedness of a material process that has been achieved by blind, deterministic, non-mental factors alone. Growth, embryogenesis, physiological processes, the search for food, achieving a certain geographic position (e.g., in the case of migratory birds) and final acts of behavior (e.g., in the case of mating) are considered to be typical examples of final-state-directed processes [Mayr, 1991, p. 61].

Researchers in neo-teleology carry forward an impression of Aristotelian telos as both final state and purpose. This impression is a major source of confusion in contemporary debates. The relevant literature is teeming with expressions like 'purpose,' 'aim,' and 'goal,' and less frequently, 'purposiveness.' Sorting out the confusion requires careful examination of the meaning of the terms 'purpose' and 'aim' in neo-teleology, an issue that leads us to three milestones in the twentieth century neo-teleology renaissance.

1.1. Cybernetics: reduction of teleology to negative feedback

In 1943, the founders of cybernetics – Rosenbleuth, Wiener, and Bigellow – published the article "Behavior, Purpose and Teleology," in which they argued for the rehabilitation of teleology. They used the term 'purposeful' to denote an act where "the act or behavior may be interpreted as directed to the attainment of a goal, namely, to a final condition in which the behaving object reaches a definite correlation in time or in space with respect to another object or event." [Rosenblueth et al, 1943, p. 18] In this definition, the term 'purpose' is coextensive with a special understanding of the expression 'final condition,' which in this context means 'final-state.' In cybernetics, the term 'aim' means 'final-state,' that is, the encounter between a behaving object (e.g., a missile) with a certain external object (e.g., a ship) – and this is merely a spatiotemporal event. Cyberneticists define teleologic behavior as the variety of purposeful behavior which reaches a final-state by means of a mechanism of *negative* feedback:

"We have restricted the connotation of teleological behavior by applying this designation only to purposeful reactions which are controlled by the error of the reaction – i.e., by the difference between the state of the behaving object at any time and the final state interpreted as the purpose. *Teleological behavior thus becomes synonymous with behavior controlled by negative feedback*, and gains therefore in precision by a sufficiently restricted connotation." [Rosenblueth et al, 1943, p. 23-24, italics added]

Cyberneticists identify information with the physical features of a material or energetic system (e.g. an electromagnetic signal) thus ignoring meaning and reference of the message that this system potentially caries. The operations of cybernetic devices do not have meaning and value for the automata themselves, but only for human beings who determine the 'goals' and 'purposes' of the devices. Therefore, cybernetic operations are void of semantics (meaning and reference): although a missile can process the electromagnetic signal of its radar in such a way that enables it to encounter a ship, the signal is void of meaning for the missile itself and so does the telos or purpose that it attains by processing the information of this signal. On the basis of this concept of purpose, that excludes every conceivable kind of first-person perspective, the behaving object does not have an *aim of its own*, as Hans Jonas correctly states [Jonas, 1997, p. 202]. Cybernetic theory is not able to count for the semantic aspects which underlie the design of cybernetic and information processing automata. This theory does not make any claims about the causality of the processes involved in creating, expecting, or evaluating the usefulness of cybernetic operations.

1.2. Neo-Darwinism: reduction of teleology to program

Some influential neo-Darwinists welcomed the non-metaphysical conception of purpose and telos that was provided by the cyberneticists. They adopted and developed cybernetic teleology further. The well-known biologist Ernst Mayr added that the mechanisms which orient the negative feedbacks towards a final-state and activate them are programs. Mayr, Jakob, and Monod are the best-known proponents of the program metaphor in biology [Mayr, 1991, p. 61; Jakob, 1993, p. 1–17; Monod, 1971]. They consider programs as genetic or behavioral algorithms that were generated in evolution and brought *selective advantages* to the organisms carrying them out.

The idea of the genetic program or genetic information is based on a concept of purpose that is reduced to mere function. Neo-Darwinist theoreticians of teleology say, for example, that wings develop in order to perform a function, leading to a positive selection of all its bearers which were progenitors of the bird embryo in question [Ariew, 2007, p. 179; Mayr, 1991, p. 75, 61]. The 'what for' questions and the 'in order to' replies typical of teleological language were retained. They refer, however, only to natural selection:

"The sense in which what-for questions and their answers are teleological can now be clarified. Put cryptically, we explain A's existence in terms of

A's function. More fully, A's existence is explained in terms of effects of past instances of A; but not just any effects: we cite only those effects relevant to the adaptedness of possessors of A." [Brandon 1990, 188]

The influential philosopher of biology Paul Griffith described this kind of neo-Darwinist teleological reasoning as follows: "where there is [natural] selection there is teleology."[3]

The neo-Darwinist idea of the genetic program or genetic information is based on the concept of information as it is introduced in cybernetics and information theory; in part, this makes it difficult to ascribe semantic aspects to this idea. Nevertheless this should be possible, since survival, reproduction, or death cannot be conceived of, without any reference to their meaning and value for the organisms, in question, themselves.

1.3. Modern biological functionalism: reduction of purpose to function

Not only neo-Darwinists use the term 'purpose' as being tantamount to the term 'function' but other biologists as well. Therefore understanding neo-teleologism requires also a critical examination of the biological concept of function. Most philosophers of biology make a distinction between two theories of function.

1.3.1. Etiological theory of function

Mainstream evolution theorists trace functions back to what they consider to be a key mechanism of evolution, i.e. natural selection. If organism O has a trait T that has a tendency to perform function F which contributes to the maintenance and propagation of the organism O, that trait T will probably become positively selected so that it is possible that function F appears again in the offspring of O [McLaughlin, 2005, p. 28-30; Wright, 1976, p. 81; Brandon 1990, p. 188]. In evolution theory the concept of function is closely related to that of adaptation. In the words of Kim Sterelny and Paul Griffiths: "The functions of a biological trait are those effects for which it is an adaptation." [1999, 221]. All functions of an organism are traced back to effects that occurred in the array of its ancestors and have been subject to natural selection. Evolution theorists refer to environmentally appropriate effects as naturally selected adaptations.

On the basis of the evolutionary approach the functions of organisms are adaptations "packaged together into larger units" that is to say in the organisms themselves [Rosenberg, 2007, p. 123]. Evolutionary explanations of function rest upon an implicit evaluation of functions: functions are positively selected adaptations because they are *beneficial* to organisms [McLaughlin, 2005, p. 29]. In modern biology something is regarded as contributing in favor of an organism if it increases its so-called 'fitness,' i.e. its probability to stay alive and its ability to propagate.

From the point of view of evolution theory a functional explanation is considered to be an explanation of the *origin* of a trait that performs a specific

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[3] Quoted by Toepfer [2005, p. 42] (my translation).

function. This approach to function is referred to as *etiological* because it explains function in terms of its origin, which means in this case its origin in the evolution of a species.

Although etiological theory is the orthodox view in the philosophy of biology it is not uncontroversial. A common criticism is that scholars began discussing biological functions long before the concepts of 'adaptation' and 'natural selection' as well as evolution theory in general were theorized [Sterelny and Griffiths, 1999, p. 221]. According to etiological theory a new trait that appears in an organism and is beneficial to it cannot have a function before it has a selection history, which means before a few generations pass by [McLaughlin, 2005, p. 30]. In other words, etiological theory does not capture the meaning of function that scholars who are not evolution theorists, for example physicians, have in mind when they talk about the function of an organ.

1.3.2. Dispositional theory of function

Dispositional or *propensity theory of function* challenges some of etiological theory's basic premises [Sterelny and Griffiths, 1999, p. 222; McLaughlin, 2005, p. 30). Dispositional or propensity theory of function can be traced back to the work of Ernest Nagel [1961]. An influential philosopher of biology, Peter Godfrey-Smith, explains that dispositional theory is based on the minimal assumption that "an object's function is what it is for." [2014, p. 62] A function of something is "the typical causal role that something has, especially its typical contribution to a larger and more complex system." [ibid.] Whereas etiological theory asks why a function has evolved in the past, dispositional theory asks what a trait contributes to a system in the present. A function is considered as the effect of something—its role in the causal chain of a system *now*. Stated simply dispositional theory asks what is the ability (disposition, propensity) of an element to do something. However, as Nagel makes clear, the system in question must be directed towards a final state that might be described as an aim [1961, p. 409f.]. The system must be an organism whose actions are directed towards survival and propagation [McLaughlin, 2005, p. 25; Sterelny and Griffiths, 1999, 222). As Sterelny and Griffiths say, "[a]ccording to the propensity theory, the functions of a trait are its adaptive effects", in other words: "[f]unctions are effects that increase an organism's propensity to reproduce." [Sterelny and Griffiths, 1999, p. 222] Throughout their analysis of dispositional theory, Sterelny and Griffiths offer insight into the 'mechanics' of biological thought after it has been occupied by Darwin's materialism. They argue that with respect to the function of those brain structures that enable humans to learn to read easily "[t]he propensity theory (…) asks whether people who can read typically have more offspring now than people who cannot read." [ibid.]

1.4. Theory of self-organization: reduction of teleology to biomolecular final-state-directedness

The lack of even a simple concept of organism remains a decisive weakness of neo-Darwinism. Neo-Darwinistic teleologism only considers single functions. But in

evolution a whole phenotype is selected, that is, a complex structure of mutually conditioning functions and elements. Two hundred years ago, in his *Critique of Judgment* [§65], Immanuel Kant emphasized this most essential aspect of the organism with his concept of the 'self-organizing being.' Because of the inability of neo-Darwinism to consider whole organisms, an organismic turn is currently taking place in the philosophy of biology in which dynamic systems theory (or the theory of self-organization) plays an essential role. The directedness of growth and other processes towards a certain final-state or an 'aim,' as it is often called, is understood as the outcome of the *self-organized* complex molecular dynamics of organisms. The proponents of this conception consider the organism as a self-organized dynamical physico-chemical system, the dynamics of which results in virtue of an extremely complex structure of interdependent positive and negative feedbacks between biomolecules [Christensen, 1996, p. 308f; Rosen, 1985, p. 173f.; Goodwin, 1989, p. 49–61]. Dynamic systems theory and theories of self-organization build the theoretical foundation of the fourth and most recent kind of biological neo-teleologism. From this perspective, the non-linear deterministic interactions between the organism's molecules constrain their own dynamics and thus give rise to a deterministic material phenomenon that is directed to a certain final state.

Theorists of self-organized physicochemical systems illustrate the dynamics of biological and organismic processes, such as metabolism and growth, by using an abstract space called a 'state space.' The course of the process is represented by a curve called a 'trajectory.' The dimensions of the state space represent the different sorts of molecules out of which the organism is made. Thus each one of the points on a trajectory through the state space provides a complete qualitative and quantitative description of the material composition that is physically present as the organism at a particular point in time.
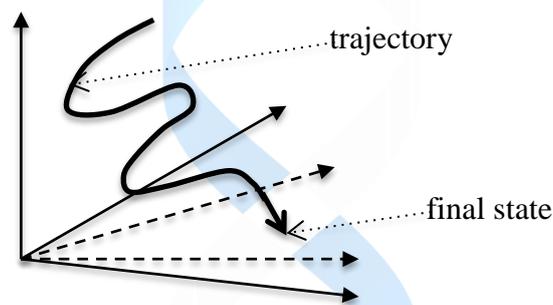

Fig. 1. The trajectory of a biological process in a state space.

Thus, the trajectory represents the succession of the states that the organism occupies in different points in time. In the theory of self-organization, the dynamics of a growth process is considered to be entirely determined by the material constellation of both the growing organism and the part of its environment with which the organism interacts. The final state of growth is reduced to what is physically present inside the organism as well as around it in the relevant part of its environment. In a nutshell: The final state of a biological process, is considered to be

entirely reducible to something physically present, the material constellation of the organism and its environment.

2. TELEOLOGY IN THE WORKS OF ARISTOTLE

The second book of the *Physics* occupies a crucial position in Aristotle's theory of biological teleology that, from a present-day perspective, can be assigned to inner special teleology. In this text, Aristotle makes clear that the concepts 'final state' and 'purpose' – the Greek expression for 'purpose' is '*ou heneka*' (οὗ ἕνεκα) which means 'for the sake of which' – are mutually related and inseparable. The key query, however, is whether the Aristotelian term 'purpose' refers to an experiencing unity that strives to attain its aims. Neo-teleologically-minded biologists and philosophers tend strongly to interpret the Aristotelian concept of purpose in a functionalist manner [Ariew, 2007, p. 173] by overestimating the importance of certain passages in the second book of the *Physics* wherein Aristotle explains the final-state-directedness of certain biologic processes by their functions in the organism: "plants […] send their roots down […] for the sake of nourishment" [II, 8, 199 a28-29] and sharp teeth are located in the front of the mouth for the sake of tearing [II, 8, 198 b24-25]. Appropriately, Hans Jonas criticized this myopic restriction of Aristotle's thinking to functionality by reminding us that his teleology is only "in the second place a fact of structure or physical organization, as exemplified in the relation of organic parts to the whole and in the functional fitness of organism generally." [Jonas, 1997, p. 163][4]

Indeed, something beyond neo-Darwinian and modern biological functionalism is much more important to Aristotle's teleology. His worldview simply *forbids* considering a natural process controlled by blind, i.e., non-mental forces, as being able to achieve the kind of ordered result attained by an appropriately formed organic structure that serves the purpose of staying alive, like an organism or an organ, rather than degenerating into chaotic malformation [*Physics* II, 8, 198 b33 - 199 a28]. Aristotle applies to blind mechanistic processes the term 'automaton' (αὐτόματον), which may be translated as 'senseless in itself,' since 'maten' (μάτην) means 'in vain.' [*Physics* II, 6, 197 b22-31] He refers to all processes that are not grounded in any kind of mental purpose as 'automata.' Therefore, he would subsume all processes which we today consider to be regulated only by physico-chemical interactions under the category of 'automaton.' Accordingly, from his point of view, all phenomena of material self-organization constituting the fourth type of contemporary neo-teleologism would be cases of 'automatic' becoming. Automatic processes may sometimes look *as if* there were a purpose behind their movement: the roof tile that falls on somebody's head could have been thrown at him purposefully by someone else. As Hans Jonas has shown, Aristotle made a distinction between the "mere ending and internal 'end' of a movement." [Jonas, 1997, p. 203][5] In Aristotelian hylomorphism, the final-state of living processes is something both aimed at and purposed. From Aristotle's anti-mechanistic perspective only very rarely do blind

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[4] Translated by S.K.
[5] Translated by S.K.

forces lead to a final-state that could be considered a purposefully generated one. In contrast to modern physics, Aristotle thinks that in most cases automatic processes lead to chaotically disorganized final states. He would never assume that the non-psychic processes of self-organization would be able to produce something as ordered as even a single cell. As stated above this does not mean that Aristotle ascribes a human- or animal-like mentality to biological processes. In *Physics*, he says that a purposefully acting entity is only rarely conscious of its acting:

> "[I]t is absurd to suppose that purpose is not present because we do not observe the agent deliberating. Art does not deliberate. If the ship-building art were in the wood, it would produce the same results by nature. If, therefore, purpose is present in art, it is present also in nature" (II, 8, 199 b26-30).

Of course, in all arts purpose is present because the agent acts towards an aim. In other words, conscious action is only a seldom special case of purposeful end-directed action. Aristotle's understanding of teleology confirms Thomas Nagel's and Mark Bedau's position that one may talk of teleology only in connection with entities to which one can ascribe *values*, since an experiencing being is only directed towards something if that something is experienced as something valuable [Nagel, 2012, p. 97; Bedau, 1998, p.272f.].

In the first clearly formulated theory of teleology, as presented in the works *Physics* and *On the Soul*, the concepts of 'aim' or 'goal,' 'end' and 'purpose' denote inseparable aspects of one and the same thing: they designate essential elements of the '*eidos*' (εἶδος), or the form or the biological species to which a single living being belongs. In Aristotelian metaphysics 'eidos' is considered to be formal causality that is a non-material causal factor. In his seminal work *De Anima* (*On the Soul*) Aristotle says both that all processes occurring in a living being are determined by its *soul* (psyche) and that the soul is the 'eidos' or the formal cause of a "natural body having in it the capacity of life" (II, 1, 412 a 19-21). By 'life' Aristotle means "the power of self-nourishment, independent growth and decay" (ibid. a 14-15). Accordingly, the growth of an organism is not determined by its material constitution but by its soul, particularly by the part of its soul that Aristotle calls the 'vegetative soul' (threptikon) (III, 11, 434 a 22-25). As Aristotle says in *Physics*, the formal cause of a being is intrinsically connected with its efficient and final causes (II, 7, 198 a 24-27). It is the eidos or vegetative soul of a growing organism that directs growth towards a particular final state. In other words, in Aristotle's biology the agent of growth (and nourishment), the *vegetative soul*, is not reducible to something physically present such as the material constellation of the growing organism. Thus, in sharp contrast to contemporary materialistic neo-teleologism, *an essential feature of Aristotelian teleology is that teleological becoming is determined by a causal factor that is not reducible to what is physically present*.

There is another essential feature of Aristotle's teleology that contrasts sharply with modern neo-teleologism, especially with the latter's neo-Darwinistic and functionalistic version. Neo-Darwinism, etiological, and dispositional theory of

function *reduce the welfare of an organism to its mere physical maintenance (survival) and numerous descendants*. In contrast Aristotle's concept of purpose is built on the conviction that the final state of a particular natural process is something *good* for that very process: "[T]he Good is that at which all things aim (τἀγαθόν, οὗ πάντ᾽ ἐφίεται)" [*Nicomachean Ethics*, I, 1094a 1], "the Supreme Good seems to be something final (τὸ δ᾽ ἄριστον τέλειόν τι φαίνεται)." [ibid., I, 1097a 25-30] Accordingly, final states at which the soul of an organism aims are good for that very organism. Each organism is something good in itself because thanks to its soul and essence it has *intrinsic value*. From Aristotle's perspective the purpose of being able to learn to read is not about producing numerous offspring but to contribute to a person's happiness (εὐδαιμονία) which is a value in itself rooted in the *noetic soul* of the human.

The philosopher and scientist Mark Bedau rightly noted that "we are unsure whether teleological notions apply in roughly the same cases as those in which we are unsure whether value notions apply." [Bedau, 1998, p. 272f.] This statement relating teleology with value is fully applicable to Aristotelian considerations of organismic teleology.

Conclusion

Philosophy of biology gives all four neo-teleological approaches great credit for providing interpretations of the concepts of 'purpose,' 'aim,' and 'telos' without any reference to mental factors. Philosophers of biology differentiate sharply between versions of special internal teleology divested of all psychical or mental connotations and others which assume mental factors. Contemporary philosophy of biology credits all forms of neo-teleologism for developing a new form of teleologism, by adopting teleological language and applying it to biological fact without referring to any form of essence or soul (psyche). According to philosophers of biology, only *non-psychical special internal teleology* comes into question for biology, thereby distancing themselves from many philosophers, including Aristotle, as the Figure 2 shows. The common denominator of all four approaches is that they serve the development of a new form of teleologism, allowing biology to use teleological language without neglecting contemporary scientific metaphysics which remains essentially materialistic. Cybernetics, neo-Darwinism, and theory of self-organization *consider the final state of a process, to be determined by something physically present: negative feedback, genetic program, self-organized material structure*.
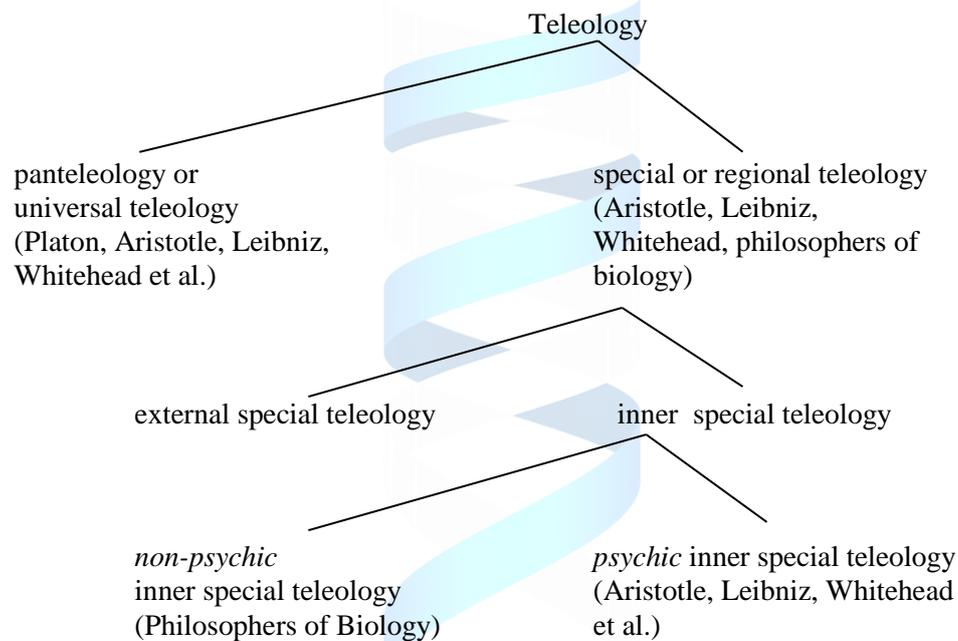
Teleology

panteleology or
universal teleology
(Platon, Aristotle, Leibniz,
Whitehead et al.)

special or regional teleology
(Aristotle, Leibniz,
Whitehead, philosophers of
biology)

external special teleology

inner special teleology

non-psychic
inner special teleology
(Philosophers of Biology)

psychic inner special teleology
(Aristotle, Leibniz, Whitehead
et al.)

Fig. 2. Different kinds of teleology.[6]

The comparison between Aristotle's biology and biological functionalism deserves particular attention because it reveals essential differences between Aristotelian teleology and modern neo-teleologism. Biological functionalism differs strongly from Aristotle's understanding of purpose in three respects. First, while in Aristotelian teleology purposes are causes of effects, etiological theory reduces purposes to effects. Second, etiological approach reduces purposes to events of natural selection. Since Darwinian evolution theory is radically anti-essentialistic, from an Aristotelian perspective such events must be regarded as contingent because they are without any activity that is governed by the essence (eidos) of an agent. It is noteworthy that ascribing contingency to evolutionary events is not necessarily bound to the Aristotelian mode of thought. In evolution theory the appearance of new traits that might become positively selected is considered to be a highly random process. Third, and most important, the common denominator of both etiological and dispositional theory of function is, as already said, that *they equate the wellbeing of an organism with its mere physical maintenance and numerous descendants*. In contrast Aristotle's concept of purpose is built on the conviction that the final state of a particular natural being is something *good* for that very being.

Since modern biology is based on materialistic denial of soul and essence their objects can only have extrinsic value, i.e. value for other objects. While, for Aristotle, the causality of natural beings is determined from 'within' them, i.e. from their own essence, in the modern sciences causal relations are determined extrinsically. This is due to a simple reason: there is nothing to have an 'inside', an essence. In Aristotle's cosmos all natural beings have an *intrinsic nature* which endows them with a *genuine*

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[6] This diagram is based on ideas of Toepfer [2004, p. 36f] and Mahner and Bunge [2000, p. 348].

telos: a final state that serves their own purpose that is rooted in their own essence (eidos). Not only is their being determined intrinsically but also their becoming is always oriented to an aim that is good for them. The final state of a natural process corresponds with its intrinsic value. Apparently, Aristotle's metaphysics is firmly established on an indissoluble connection of ontological and ethical principles. Modern science is intrinsically and essentially grounded on the rejection of that very connection. This leads to the reduction of value to a quantity, such as the number of descendants.

Obviously, other than modern biology, Aristotle's metaphysics provides an appropriate basis for the elaboration of a bioethics and environmental ethics that ascribe intrinsic value to living nature itself − an urgently needed development in our century.

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