# ARISTOTELIAN ENTELECHY AND MODERN BIOLOGY

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# АРИСТОТЕЛЕВСКАЯ ЭНТЕЛЕХИЯ И СОВРЕМЕННАЯ БИОЛОГИЯ

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*"Linnaeus and Cuvier (...) were mere schoolboys to old Aristotle."*
*Darwin*

**Abstract**. Aristotelian entelechy can reveal a number of very modern aspects of biology. The concept combines the achievement of a whole (holos) and of an ultimate purpose (telos), the purpose being a goal by construction internal to living organisms, as opposed to vitalism. This naturalist concept can be found, inter alia in embryology, cellular metabolism, genetics, the evolution of the species, and ultimately in the general evolution of living beings towards ever-greater complexity. The analysis of movements of living organisms and their complexity shows entelechy to be compatible with and complementary to Darwinian selection.

***Keywords***: Entelechy – Biology – Living being – Darwinian Selection – Purpose – Holos – Telos

***Contents***



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*"Линней и Кювье (...) это всего лишь школьники,*
*в сравнении с первоначальным уровнем знания Аристотеля."*
*Чарльз Дарвин*

**Резюме**. Аристотелевское фундаментальное понятие энтелехии в состоянии раскрыть самые современные аспекты биологии. Эта концепция сочетает в себе достижение целого (*холос*) и конечной цели (*телос*), и где цель являет собой целевую направленность к достижению необходимого результата посредством создания конструктивных систем *внутри* живых организмов, в отличие от витализма. Эта натуралистская концепция может быть найдена, среди прочего, в эмбриологии, внутриклеточном метаболизме, генетике, эволюции видов и, в конечном счете, в общей эволюции живых существ в русле процесса постоянно возрастающей сложности организации. Анализ движений живых организмов и сложности их организации демонстрирует нам, что концепция энтелехии совместима с дарвиновской теорией естественного отбора и дополняет ее.
***Ключевые слова***: Энтелехия – Биология – Живое существо – дарвиновская теория естественного отбора – Цель – Холос – Телос

***Содержание***



## Introduction

In 1932, William E. Ritter published an excellent article under the title "Why Aristotle invented the word Entelecheia"[2]. I shall be referring to this text as it shows the relevance and modernity of the Aristotelian concept of entelechy (*entelecheia* in Greek) when applied to modern biology, and even to other fields as well. While Ritter's paper is certainly not a recent publication, the approach is still relevant today.

[2] W. E. Ritter, Why Aristotle invented the word Entelecheia, *The Quarterly Review of Biology*, 1932, 7(4), pp 377-404.

I shall present this exemplary article, then show how the Aristotelian thesis as analysed remains, for other reasons, relevant in the contemporary world of biological thought.

## 1. What is entelechy?

To familiarise the reader with the philosophical concept of entelechy, we can start by summarising the meaning and scope of the Aristotelian term of entelechy. Entelechy is the very dynamics of a being, taking a being from potential to act to an act realised; it is the very nature of the being developing and achieving its own functionality, and through the web of relationships that comprise its internal structure, finding its own functionality and existential purpose (*telos*), at the same time as achieving functional fulfilment as a whole (*holos*).

## 2. Entelechy and Ritter

We shall look closely at Ritter's understanding of the same term. Ritter noted that Aristotle, as the founding father of biology [3] [4], was interested in procreation and development, which, quite logically, led to explore the question of the "determinate relation between what developing bodies are and do in a given developmental stage, [and] what they were and did in their preceding stages"[5]. This then leads to a comparison of entelechy as seen by Aristotle and the way it was viewed by a modern writer, the German embryologist Hans Driesch (1867-1941). For Ritter, Driesch's understanding of entelechy is fallacious, and for two reasons: firstly, because entelechy is seen as being equivalent to energy (*energeia*), and therefore, secondly, because while Driesch may recognise entelechy achieving completion in the whole (holos), he does not recognise any teleological aspect (telos) in it.

Ritter is correct in these observations, but it is important to focus on and extend his argument. When speaking of entelechy, the Aristotelian meaning must be used, but there must not be any confusion with entelechy as understood by proponents of vitalism as well as understood by Hans Driesch who turned it into an enigmatic "vital principle" devoid of matter and which could not be reduced to physical and chemical components. A clear distinction must be made between Aristotelian entelechy and such vitalism which is not compatible with modern science. This is an essential point to note.

Contrary to arguments put forth by Hans Driesch, Ritter saw the correct concept of entelechy as being based on the actualisation of potential (potential to act) and not on action alone (energeia). The telos in entelechy must not be confused with the "end" (the term used in English): the end, unlike entelechy, does not necessarily convey the concept of full achievement. In Aristotelian entelechy, the telos (or purpose) involves the idea of fulfilment, of a being achieving full development as a

[3] L. Bourgey, *Observation et expérience chez Aristote*, Editeur Librairie Philosophique J. Vrin, Paris, 1955.

[4] P. Pellegrin, *La classification des animaux chez Aristote: Statut de la biologie et unité de l'aristotélisme*, Les belles lettres, Paris, 1983.

[5] W. E. Ritter, *op.cit*, p 378.

final, functional whole. The telos is by definition related to the holos. Conversely, the holos cannot be accomplished without the telos. Ritter cites the example of a salamander with one leg cut off and grafted to its back: it may be whole, but it is not fully functional, lacking the telos dimension of the functional purpose of a living being endowed with complete life in accordance with its form.

## 3. Entelechy and Complexity

For Ritter, while such a concept of entelechy may preclude plurality, it is "not opposed to the idea of manifoldness and variety... it admits of all the complexity of vital phenomena"[6]. And in such complexity, "whole" and "complete whole" are not the same, as illustrated by the example of the salamander, *whole* with a grafted leg, and *complete whole* in its normal state.

Here we come to concepts that I have developed extensively in my theory of complexity in mosaic formation[7]. According to the theory, elements can sometimes be juxtaposed (as in the case of the salamander, with one leg grafted on its back having no functional capacity, but merely "juxtaposed" to the rest of the body), or elements may be integrated into a harmonious whole (e.g. a normal salamander). The model of complexity in mosaic formation as I have presented it is based on two fundamental principles: the *juxtaposition* of elements of the same kind, and the possible and subsequent *integration* of such elements into a harmonious whole where, as in a mosaic forming a work of art, the whole does not cancel out the autonomy of the component parts. This is well aligned with Aristotelian ideas of entelechy when related to complexity in living beings. The complexity of living beings should be seen as diversity within a unit supported by the holos and also containing the underlying telos.

## 4. Applications

While entelechy can easily be seen to apply to developing biological structures, it should be noted that Aristotle also used the term to describe purely physical phenomena. In his writings on meteorology, Aristotle cites examples of changing states, e.g. melting ice, and water becoming "air" (i.e. "vapour" for modern science); as Ritter points out, this was at a time when there was no knowledge of thermodynamics[8]. Yet Aristotle also uses the term of entelechy when speaking of light, but in circumstances so far removed from modern physics that the reference cannot be accepted as legitimate.

We shall move onto actual living systems, even though the distinction is not perfectly clear-cut. Aristotle considered that "living bodies (individual men by no

[6] *Ibid*, p 381.

[7] G. Chapouthier, *The Mosaic Theory of Natural Complexity – A scientific and philosophical approach*, Editions des maisons des sciences de l'homme associees, Collection interdisciplinaire EMSHA, La Plaine-Saint-Denis, France, 2018, ISBN: 9782821895744, http://books.openedition.org/emsha/200.

[8] W. E. Ritter, *op.cit*, p 383.

means excepted) came within the domain of physics"[9]. This is another way of saying, conversely and in general, that for Aristotle the physical universe had both biological architecture and biological logic[10]. The logic of the world is the logic of living beings: "Aristotle's whole philosophy is indeed a biological one"[11].

The examples given here are restricted to the field of contemporary science that is still in line with knowledge at the time of Aristotle. We shall not be commenting on Aristotle's view that entelechy is involved in reproduction, even though Ritter devotes a substantial part of his article to the subject, showing how Aristotle's fine reasoning endeavoured to have entelechy involved in reproductive processes, by linking (as could be done by common sense) the potential of the parent body with the final achievement of reproduction. Unfortunately his arguments are based on scientifically unsound ideas (the primacy of the male principle in reproduction, and without germline/soma separation). "As Aristotle had no knowledge of germ cells, it was, of course impossible for him to have any conception of heredity and genetics in the modern sense"[12]. In the cases we have chosen to cite here, there is no conflict between the findings of modern science and Aristotle's approach.

Embryology, the science of individual development and potential living beings, provides a philosophical link with ontology, the knowledge of the being, but with obvious reference to development, "the coming-to-be, of an individual fowl or frog"[13]. It is thus an ideal domain for the expression of entelechy. When Aristotle compares a work of nature to a work of art, he is implicitly showing the telos that must be contained in the work of nature. In both cases, there is potential which is realised to achieve fulfilment. In a more specific example, an embryo is produced through epigenesis, a process requiring sequenced development of different organs that will ultimately make up the final organism: "the completed man consists of a great number of parts which have successively come-to-be"[14], the parts having to comprise "not an assemblage, but a unified whole"[15]. Here we find the terminology which I used to describe complexity in mosaic formation, the distinction between an "assemblage" (i.e. "juxtaposition" of elements with little or no integration) and a "unified whole" (i.e. an "integrated" whole). The same entelechy can of course apply to non-human living organisms, and to the component parts of a living organism and which themselves may go through a process of integration: "the femur or liver or stomach or brain, for example, each has his own entelecheia"[16].

Another example cited by Ritter is cellular metabolism, with a number of different chemical reactions usually contributing to (directed towards) a function at an intracellular level, even though they are often subjected to opposing chemical

[9] *Ibid*, p 385.
[10] K. Khroutski, All-embracing (triune) medicine of the individual health: a biocosmological perspective. *J. Future Studies*, 2010; 14(4):65–84.
[11] W. E. Ritter, *op.cit*, p. 386.
[12] *Ibid.*, p. 398
[13] *Ibid.*, p. 386
[14] *Ibid.*, p. 389
[15] *Ibid*, p. 389.
[16] *Ibid*, p. 390.

reactions that can have a modulating effect. Through the interplay of cellular metabolism, which is one of the most striking expressions displayed by an organism as it lives, the body can "be and do just what it is and does"[17]. Here is evidence of entelechy being omnipresent in life.

## 5. The modern promises of entelechy

Aristotle obviously cannot be criticised for developing ideas within the framework of the limited knowledge of his time, and therefore for not having seen the hypotheses that are the basis of modern biology. His system obviously cannot be criticised for omitting changing species and the theory of evolution; indeed, it took many centuries for biology to reach that stage. Nor can he be criticised for not going beyond hylomorphism to develop a theory of relations as they form, as was done much later by the French philosopher Simondon[18]. It would be impossible to imagine Aristotle embarking on an overall and structuralist vision of relationships between parts, as the structuralists[19] did in modern times. (Any number of further examples could be given.)

Examining the mater closely, it can be seen that entelechy already contained the initial nucleus of many hypotheses used in modern biology, and not only in the fields of embryology and metabolism as mentioned above. Entelechy did contain the potential for living beings, or even physical entities, to be seen as undergoing constant change, the idea of constructive relationships, of achievement on the path to fulfilment of a final cause, as now seen with many examples in modern science. It has already been seen that entelechy, when applied to physical phenomena, e.g. the different states in the water cycle, can be considered as suggesting a concept similar to modern thermodynamics.

We shall now look at biological systems. While Aristotle's theories on heredity are considered to be false in the light of modern knowledge, as he overstated the genetic function of the male germline, it is still possible for modern theories on genes to fit the concept of entelechy. It is now known[20] that in the course of what could be described as geological eras, introns are duplicated in silent areas of the genome, producing identical introns which then undergo mutations and end up as complex clusters. If and when the clusters become functional, they can develop into exons and give rise to a new characteristic of the organism. The characteristic will then remain or disappear in later generations depending on Darwinian selection, depending on whether or not it provides an advantage to the organism concerned. For complexity, it can be said that the introns initially form juxtaposed groups that subsequently form integrated groups. In Aristotelian terms, it can be said that the potential contained in the juxtaposed introns tends to a complete and final whole emerging with a new

[17] *Ibid*, p 398.
[18] J.H.Barthélémy, *Simondon ou l'encyclopédisme génétique*, Presses Universitaires de France, Paris, 2008.
[19] J. Piaget, *Le structuralisme*, Presses Universitaires de France, Paris, 1996.
[20] S. Ohno, *Evolution by Gene Duplication*, Springer Verlag, Munich, Germany, 1970.

characteristic. Thus the cluster of introns is fully accomplished and transformed into exons, and is, with both holos and telos, a manifestation of entelechy.

Another example of a modern thesis in alignment with entelechy is the theory of evolution. Here the shift is from individual, ontogenetic potential (already noted as corresponding closely to Aristotelian theses) to collective, phylogenetic potential. While the mechanics of natural selection is blind and never finalised, it can still be reconciled with the parallel occurrence of other processes leading to apparent linearity in certain groups of living beings. This linearity, which has been described as orthogenesis, was, in our theory of complexity in mosaic formation, explained by universal processes of juxtaposition and subsequent integration of initially juxtaposed elements. If such locally directional evolution can be recognised for certain lineages (e.g. for the development of the encephalon in the vertebrate lineage), it is then possible to hypothesise that in such a framework there can be action through a holos and a telos combining to achieve a complete form, i.e. in this example, a species with strong cephalic development.

A degree of precaution is required here to avoid leaping to the conclusion that human beings are the obvious fulfilment of such a process, to avoid falling into the trap of a man-oriented process as in the misguided "anthropic principle"[21]. In the case we are dealing with here, there is no evidence to show that the human brain is biologically "superior" to the dolphin brain or elephant brain. In fact, when judged on moral criteria, human action could provide evidence for the opposite argument.[22] Human beings have clearly acquired original and specific cultural features, but this does not endow humans with a position of privilege in a strictly biological context. There was no evolutionary path which *necessarily* led to the specific biological organisation of the human being. The evolutionary development of the brain of vertebrates could have been quite different, not necessarily producing a hominoid, but another quite different being, and not necessarily chimpanzee-like in appearance. Given the wide range and variety of anatomical shapes and forms on the planet Earth, it is amazing that advocates of the anthropic principle should imagine that evolution, whether on Earth or elsewhere, leads to the one special form of naked ape known as a human being. The blind process of Darwinian selection and the random diversity produced by it are clearly relevant here, and telos alone cannot be the sole explanation for everything.

## 6. Orthogenesis moving towards greater complexity

Looking beyond the orthogenesis of only one specific case of genetic lineage, it is possible to consider entelechy in a broader scope encompassing all living organisms, and leading, *ipso facto*, to greater complexity. I have propounded this

[21] B. Carter, Large number coincidences and the anthropic principle in cosmology, in M. S. Longair (ed.), *Confrontation of Cosmological Theory with Astronomical Data*, Dordrecht, Reidel Publisher, 1974.

[22] A. Schopenhauer, *Parerga & Paralipomena*, CODA Editions, Paris, 2005.

thesis in previous publications[23], and if the thesis is valid, then identical properties should be observed in separate groups once a certain level of complexity is achieved, or similar characteristics should appear in quite distinct groups with properties having the same architecture of complexity. Such cases can be observed in nature, as will be seen with a number of examples.

Once a certain level of complexity has been achieved, *mobility* occurs in many species that can thus adapt more efficiently to their environment. The adoption of mobile behaviour can be seen in evolved unicellular organisms, in siphonophores and in cephalopod molluscs. After achieving a given level of complexity, *homeothermy* is developed, providing greater stability of processes in living organisms. In aquatic environments, the water sometimes stabilises the temperature, but on land, homeothermy can be observed at three distinct stages: with mammals, with dinosaurs/birds and with social insects (if an insect colony can be accepted as a homeothermic being). The development of electromagnetic skills (e.g. sight which is more accurate than the other senses) often occurs at a later stage in many different genetic lineages, e.g. vertebrates, cephalopod molluscs, and social hymenoptera. With the emergence of integrated communities (colonies or societies), extended communication is a final-stage development in many lineages, e.g. vertebrates and insects. There is also the use of artefacts to extend natural skills, i.e. using instruments or tools to increase the potential of physical organs, as occurred with various groups of vertebrates, with social insects and cephalopod molluscs. Many other such examples could be cited.

Here again, such evolution does not and cannot preclude the parallel and systematic processes of Darwinian natural selection leading to the disappearance of biological entities unable to adapt to their environment.

## 7. Purposes

While phenomena involved in orthogenesis as observed in living organisms, and including broader orthogenesis of living organisms developing greater complexity, may suggest that entelechy exists at their level, such entelechy does, however, appear to be restricted by the very limits which the blind mechanics of Darwinian selection imposes on the telos. The conclusion shall therefore focus on the status that can be given to such limited purpose in the context of biology today. What is the status of this telos as seen by a modern-day biologist? Is it possible to reconcile Aristotle's telos and Darwin's blind, natural selection?

On a metaphysical level, the telos within entelechy can probably be an answer to the often lively and controversial debates in science addressing the question of the ultimate purpose. There are different types of purpose: one is based on the belief in the existence of a god, arguing that the ultimate purpose is the decision of a higher being, i.e. God, intervening directly in the workings of the universe. In strong opposition to this are the modern, materialistic, scientific arguments refuting the idea

[23] G. Chapouthier, *The Mosaic Theory of Natural Complexity – A scientific and philosophical approach*, *op. cit.*

of a god intervening in nature, and arguing that the universe operates autonomously without any outside intervention.

Yet Aristotelian purpose is just that: on a completely different level, the level where living beings are built, and it remains within a context of naturalism. Entelechy is the very essence of life as it occurs, the very development of hidden potentials achieving their ultimate expression in functional accomplishment. The purpose observed is thus inherent in the functioning of the organisms concerned. Telos here is what I have referred to in previous publications as "purpose through construction"[24], not requiring intervention from any outside agent, and this is an essential point. Such purpose is compatible with all premises, be they materialistic, spiritualistic or metaphysical, theistic or atheistic, given that it is both clearly *outside the scope of metaphysics and within the scope of science*. Most importantly, such purpose is fully compatible with the blind processes of Darwinian selection, and therefore with the principles that govern modern natural science. Blind selection cannot explain everything, and directional processes (e.g. as argued for complexity in mosaic formation) allow this purpose through construction. This purpose can include telos in the building of living organisms, or even, if the Aristotelian hypothesis that the logic of the cosmos is the logic of living organisms, can apply to the overall architecture of the universe. Such construction-based telos remains compatible with the existence of random processes in nature, and the existence of Darwinian selection in biology.

The same reasoning can be used for the beginnings of life and macromolecules. With the existence of carbon as a binding atom, able to form bonds with other atoms, it is possible to build macromolecules which are then the direct result of carbon chemistry, and could be described as "carbon entelechy". This is why carbon macromolecules can be found in other parts of the solar system[25] and quite possibly everywhere in the cosmos.

## Conclusion

The living world evolves, as can be seen by comparing before and after. It carves a path between temporarily complete structures that stand as stages on that path. These structures are macromolecules, cells, organs, organisms, populations, and species, comprising key points in achieving and combining holos and telos. They are the stages arising from entelechy which, in parallel with random and blind Darwinian processes, are the underlying elements in the evolution of life. In the present paper, designed to show Aristotelian entelechy and its modern biological perspectives, we have seen the need to avoid two major stumbling blocks: non-Aristotelian entelechy based on vitalism whereby the principle of life cannot be explained by the laws of

[24] G.Chapouthier, L'évolution vers la complexité: finalité par construction, *Arch. Int. Physiol. Biochem.*, 1986, 94(4), pp 95–100.

[25] A. Bardyn *et al*, Carbon-rich dust in comet 67P/Churyumov-Gerasimenko measured by COSIMA/*Rosetta Monthly Notices of the Royal Astronomical Society*, Vol. 469, Suppl_2, 2017, pp S712–S722, https://doi.org/10.1093/mnras/stx2640 ; A. Bardyn. *Characterisation de la matiere organique contenue dans les particules de la comete 67P/Churyumov-Gerasimenko par spectrometrie de masse avec l'instrument COSIMA de la sonde Rosetta*. Universite Paris-Est, 2016, https://tel.archives-ouvertes.fr/tel-01584559/document

physics and chemistry, and anthropocentric entelechy which, ironically, sees human beings in the specific anatomical form of the chimpanzee as being the one and only fulfilled result possible in the evolution of the species.

When these two erroneous paths are avoided, modern biology stands with two epistemological and complementary bases: Aristotle's entelechy and Darwin's natural selection.

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