Models of Explanation in Aristotle's Biology

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"Yet the Final Cause, or the Good, is more fully present in the works of Nature than in the works of Art." (Aristotle)

ARISTOTLE IS considered to be the first to have treated biological investigation as a scientific account of the living world. His biology was grounded on an epistemological foundation which he proposed in his *Posterior Analytics*. He also made use of analogies to find the appropriate model for the explanation of the biological phenomena that he was examining. In his *Parts of Animals*, he refers to the model of art as a good model of understanding the ways of nature. His explanation concerning heating and the blood concoction also draws attention to the model of cooking that he is using in order to understand digestion and growth. In *On the Soul,* he gathers the faculties of the soul under a geometrical model, inscribing the simplest into the more complex one. The aim of this paper is to explain how all these mod-

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els function and what kind of contribution they make to a better understanding of Aristotle's biology.

As a matter of fact, I'm following a line of interpretation that studies Aristotle's use of some models in explaining nature's mechanisms. The fundamental work in this field of investigation belongs to Wilfried Fiedler,[1] who was not the first to give an account on Aristotle's use of models of explanation, but who offers a consistent synthesis of the problem. Much earlier, Werner Jaeger, in his study "Aristotle's Use of Medicine as Model of Method in His Ethics"[2] was the first to draw attention to Aristotle's use of medical models in shaping his ethics. He was followed by Klaus Bartels[3] and by G. E. R. Lloyd,[4] with his study "The Role of Medical and Biological Analogies in Aristotle's Ethics."

Lloyd makes reference to the *Nicomachean Ethics* (1097 b 22) in pointing to Aristotle's problem as to *whether man as such has a function*, namely, an *ergon* of his own. He makes use of a twofold analogy by saying that man's situation should be judged in comparison with that of craftsmen (flute players and sculptors) in the case of which the good lies in *ergon* (in function). Also in the *Nicomachean Ethics* 1097 b 28, he states that man as a whole has a function in a way similar to that in which each of the parts of the body has a function. As a consequent thesis, the lower faculties of the *psyche* are excluded on the grounds that they are common to other creatures. According to Lloyd, "The analogy of the parts of the body has a certain plausibility, for Aristotle, because both biological and rational activity belong to faculties of the *psyche*. But what this tends to obscure is that whereas the function of the eye is not a matter of controversy, the same is not true of the functions of the rational part of the soul, and the questions relative to the latter, unlike questions concerning the function of an organ in the body may involve disputes about values."[5]

Aristotle defines *arête*, excellence, as both moral and biological. But still there is a gap between the physical excellence of the body and the human excellence of the soul. Nevertheless, when referring to natural excellence, he illustrates moral excellence. Therefore, as Lloyd states, "The presence of a series of biological and medical analogies in the ethical treatises is obvious enough, as also is the fact that Aristotle is generally aware that they *are* merely analogies. But what is rather less obvious, perhaps, is how far some of the ethical doctrines he advances depend, both for illustration and for support, on those analogies."[6] Finally, Lloyd suggests that there is a significant relationship between the way Aristotle conceives the scale of the perfect biological specimens and the scale of political governmental forms (likewise species).

Wilfried Fiedler dedicates the entire book to an elaborate approach to this subject, and he tries to map out all the instances where Aristotle was using the models in order to develop a personal theory on various subjects. In following

this line of research, I shall confine myself to the analysis of the significance of the model's theory in Aristotle's biology and especially in the first book of his *De partibus animalium*.

There is an important connection between *bios* (life) and *techne* (art) that arises in the biological treatises of Aristotle as a result of his investigation of the living world. In the history of philosophy, this connection bears the mark of Aristotle's struggle towards the first scientific understanding of the phenomenon of life in all its complexity. Our thesis is that he simply used the model of *techne* in reading the mechanisms of the living creatures, their inner structure, their generation, and their movements. Thus, by applying the model of *techne* to *bios*, Aristotle disclosed a sort of genuine meaning of biology as very close to biotechnology, bioethics and biopolitics. In fact, it is the relationship between *bios* and *techne* that gave birth to the first systematic biology in the history of science and at the same time to a range of problems that are still giving us food for thought.

For many centuries, the statement that "art imitates nature" represented a guiding assertion for thinkers. In the Middle Ages, for instance, it became the cornerstone of many metaphysical arguments in various fields of knowledge such as theology, aesthetics, and politics. To give an example, in the thirteenth century, Thomas Aquinas answered without any hesitation to the question why monarchy should be the best political regime, by invoking the principle of "ars imitatur naturam." According to him, as everywhere in nature we see the rule of the one and the universe itself is ruled by one God, in politics— which is also an art— it is proper to follow nature, and therefore accept the rule of the one as the best. This widely accepted principle implies that, in theory as well as in practice, nature should be taken as a model for any kind of art, and that nature would provide the general key to understanding man's productions (theories and practices).

It is well known that this principle belongs to Aristotle but, more than just being its author, Aristotle was the first thinker who offered a comprehensive model of explanation for the system of nature that gave birth to the science of biology. Therefore, the first scientific paradigm of biology was born out of the Aristotelian model. In our view, the full paradox is that the model developed by Aristotle in explaining the system of nature and at the same time the model that remained throughout the centuries as the foundation of biology was the model offered by art (*techne*) itself. Here we have a short passage from the *De partibus animalium* (639b13–19)[7] which sets the stage of our inquiry:

> *Clearly the first is that which we call the* ***Final Cause****—that for the sake of which the thing is formed—since that is the* ***logos*** *of the thing—its rational ground,*

> *and the logos is always the beginning for products of nature as well as for those of art. The physician or the builder sets before himself something quite definite—the one, health, apprehensible by the mind, the other, the house, apprehensible by the senses; and once he has got this, each of them can tell you the causes and the rational grounds for everything he does, and why it must be done as he does it. Yet the Final Cause, or the Good, is more fully present in the works of Nature than in the works of Art.*

When Aristotle tried to understand how nature works, he simply took the art of producing a bed or a chair as a model of causality. This is how he arrived at his concept of a final cause, namely, that for the sake of which something grows and develops, which dominates his entire biology as structured from within by the model of arts. This thesis leads us to a case of "deconstruction" of the principle that "art imitates nature," because by trying to understand how art imitates nature, we are forced to take into consideration the possibility of accepting that the reverse would be true, namely, that the face of nature was shaped after the image of art, or, more precisely, that just before art could imitate nature, nature has already been understood and explained by Aristotle himself in terms of arts (*technai*).

Because using models to order different given facts is still one of the main enterprises of scientific thought, Aristotle acted as a true scientist when he made use of art as a model in explaining nature. In order to elucidate the situation of art as an explanatory model for the science of biology at its beginnings, it is appropriate to make a short summary of what is a model in the light of the theory of scientific knowledge; after that I shall be able to provide some pieces of evidence on Aristotle's use of art as a model for nature and to provide some arguments supporting the idea that he invented a frame of concepts or a conceptual model which consists of and also explains his own scientific biological language.

According to the epistemology of scientific thought, a model is a construction that is used to order a given set of entities belonging to various fields of experience into a system. To use an alternative expression, a model has an isomorphic action on the objects in question. The phenomena that scientific knowledge tries to explain do not completely fit into a given model, so it is obvious that a scientific model is not (and will never be) fully saturated. Nevertheless a model may be judged as being better than another if its isomorphism brings together a larger number of data or phenomena and if it possesses a stronger force to unify what could not be unified until that point. More or less, this is the way in which modern science uses the models and the

way the theory of knowledge configures their role. A model is therefore by no means a theory or a law but it makes possible a theory or some laws, and in this specific meaning it has a transcendental use.

Nowadays science often makes use of mathematical models, but in the history of scientific ideas the first models were used and invented by the Greek philosophers. Aiming at a universal theory of existence, their models were meant to function as saturated models; taking into account everything that occurs into the world, their ultimate goal was a general explanation of the world itself. In the beginning of the *De partibus animalium*, Aristotle acknowledges the preexistence of an ancient model of explanation for the works of nature. For the ones he used to call the *physiologoi* the world of the living creatures represented an interplay of elements, namely, *ta stoicheia*:

> *Now those who were the first to study Nature in the early days spent their time in trying to discover what the material principle or the material Cause was, and what it was like; they tried to find out how the Universe is formed out of it; what set the process going . . . assuming throughout that the underlying material had, by necessity, some definite nature:* ***e.g.*** *that the nature of Fire was hot, and light; of Earth, cold, and heavy. At any rate, that is how they actually explain the formation of the world-order. In like manner they describe the formation of animals and plants, saying (****e.g.****) that the stomach and every kind of receptacle for food and for residue is formed by the water flowing in the body, and the nostril openings are forcibly made by the passage of the breath. Air and water, of course, according to them, are the material of which the body is made: they all say that Nature is composed of substances of this sort.*[8]

Aristotle insists on the fact that this ancient model belonging to the pre-Socratic philosophers was centered on the material causality, so that the shape of every part of the animals received an explanation in terms of the cause from which (*to hoten*) they came into existence: for instance, that the stomach was supposed to be formed by water and the openings of the body by air. Aristotle criticizes this material model, along with the more subtle position taken by Democritus whose theory reduces the parts of animals to shape and color, but which ultimately resides in senses and once again in matter. But what is fundamental in his criticism is, according to our thesis, his constant reference to the models of art. In 640b20–24 he states: "It is not enough to state simply the substances out of which they are made, as *Out of fire* or *Out of earth*. If we were describing a bed or any other like article, we should endeavor to describe the form of it rather than the matter (bronze, or wood)—or, at any rate, the matter, if described, would be described as belonging to the concrete whole." As

to the opinion of Democritus, Aristotle (640b35–641a5) rejects it by making once again an analogy with the products of art: "Again, a hand constituted in any and every manner, *e.g.*, a bronze or wooden one, is not a hand except in name; and the same applies to a physician depicted on canvas, or a flute carved in stone. None of these can perform the functions appropriate to the things that bear those names. Likewise, the eye or the hand (or any other part) of a corpse is not really an eye or a hand."

The point that Aristotle is making here is that the form (*to eidos*) appears to be a better concept to explain the principle of generation (*he arche tes kineseos*). He continues by considering the fact that if we ask the carpenter how the bed appeared, we would feel that all the answers based on the material model are not sufficient, since he won't tell us that the bed came out of wood or from an axe. In other words, the carpenter should tell us that the bed was created by *tinos heneka*, namely, by the final cause or by its idea or by its preexisting essence (*he ousia*). Therefore, it is not the cause *from which*, but the cause *for the sake of which* that is decisive in the process of nature's genesis. In Aristotle's words (641a10–15): "he (i.e. the craftsman) will state the cause on account of which, he made the strokes he did; and that will be, in order that the wood might finally be formed into this or that shape."

The analogy with the model of the arts consists of the following instances: just like the builder has in his mind a plan for every house he builds, so nature gives birth to various parts of the individuals through a system of preexisting essences; this means for instance that "we have to state how the animal is characterized, i.e. what is the essence and the character of the animal itself, as well as describing each of its parts; just as with the bed we have to state its Form (641a16–18)." The idea of every product of craftsmanship (a chair, a bed, a statue, a house) consists in their art, which has to be learned by the craftsmen, and it is only afterwards that those realities are able to come into being. Therefore, the movement of their *genesis* and the order of their parts are basically predetermined by the content of their art which plays in this case the role of an essential cause (*ousia*).

Analogically, for Aristotle, man has certain parts because the process of its biological development is predetermined by what he calls "a scheme" (*to schema*) which represents man's being (*to anthropo einai*). The fact that man begets man is based on the existence of a project or an inner structure (*he ousia*) of what a man is. From his point of view, it is not sufficient to say that "man begets man" simply because there are men as individuals on earth: this would be the equivalent of saying that the builder would be able to build houses just because there are a lot of houses around, which consequently would imply that everyone who once saw a house could build one. It is true that man begets man and

lion begets lion, but Aristotle, operating within by the model of the arts, had the intuition that nature must have its own art of producing living entities. This because, as with a house, the parts of animals are not born and assembled from a preexistent animal without a certain plan that governs the whole process of coming into being, not by simply adding part after part like bricks in a wall. Instead, a future being develops according to a final cause that serves as an attractor factor:

> *So the best way of putting the matter would be to say that because the essence (**to anthropo einai**) of a man is what it is, **therefore** a man has such and such parts, since he cannot be a man without them. If we may not say this, then the nearest to it must do, viz. that there cannot be a man at all otherwise than with them, or, that a man should have them. And upon this these considerations follow: **Because** man is such and such, **therefore** the process of his formation must of necessity be such and such and take place in such a manner; which is why first this part is formed, then that. And thus similarly with all the things that are constructed by nature. (640a35–640b4)*

This description of the biological process of *genesis*[9] is parallel and consistent with the analogy offered by the model of building: "Even in the building the fact is that the particular stages of the process come about because the Form of the house is such and such, rather than that the house is such and such because the process of its formation follows a particular course: the process is for the sake of the actual thing, the thing is not for the sake of the process" (640a16–20).[10] The fact that the process of generation is for the sake of the actual thing must not be mistakenly understood in a bold determinist manner, since Aristotle put it quite clear that *the actual thing* is not something really existent or present as such, but rather a future being, so that what is here at stake is the generation process oriented by the preexistent essence.

As he considers the result of nature's movement as being a future thing, Aristotle is forced to make a distinction between theoretical science and natural science, which creates a sort of contradiction with the previous classification of sciences from the *Metaphysics* 1025b ff. There he had already established that theology, mathematics and physics (the science of nature) are the three theoretical sciences followed by the category of practical sciences and that of productive sciences. But in the *De partibus animalium* he draws a quite clear distinction between theoretical science and natural science (*physike episteme*): "Howbeit, the method of reasoning in Natural science and also the mode of necessity itself is not the same as in the Theoretical sciences . . . They differ in the following way. In the Theoretical sciences, we begin with what already *is* (*to on*); but in Natural science

with what *is going to be* (*to esomenon*)" (640a1–4). The opposition resides therefore in the tenses that Aristotle uses to underline the difference: the participle form of *to be*, once in the present tense, namely, *the fact of being now*, and once in the future tense, namely, *the fact of being as future*.

It is obvious that as long as we think of nature as the set of given entities already in plain existence and having a certain shape and movement, the science of nature should be considered a theoretical science, since it is about what already *is*. But what is the difference if one thinks of the generating process that appears to be close to a *productive* action?

In the earlier considerations we have seen that Aristotle established that generation should be judged from the point of view of the form or the final causality in analogy with the model of art. He continued the description of how art functions with the conclusion: "Art is the *logos* of the article (*to ergon*) without the matter" (640a32–33). Of course, art is a productive science, in his view, but only as far as the activity of producing objects through an agent (a craftsman) is concerned, since by itself art does not set anything in movement. This means that Aristotle conceives art as a collection of forms which are embodied in matter only by the craftsman's movements and skills. So to say, the only moment when a statue, for instance, is part of a generation and growth process is exactly when it is carved and polished by the carver, and it stands forever still. The form is inside, but the carver does not exercise the art of statuary in it anymore: using a metaphor, someone could say that every piece of art is born dead since that thing that moved it for a short time, namely, the carver and the art, is now gone without anything else to replace it as a final cause attractor. But in the middle of the process, the carver, the art and the statue just about to be finished are one single reality and they offer a glimpse of the productive force of the four causes altogether at work.

If one follows this model of art to its ultimate implications, one will not agree with A. L. Peck's opinion that the opposition between theoretical sciences and the science of nature is made by Aristotle "because he is considering Nature as a craftsman whose craft or science belongs to the third class—the *productive* sciences."[11] That is simply because the products of art cease to be a future thing after they are completed, while the products of nature remain a future thing up to the point of their death since it is only then that the final cause ceases its continuous action.

Another reason for which there is no real contradiction between the classification of sciences from the *Metaphysics* and the passage from the *De partibus animalium* is that the science of biology, in our case, as a part of the *physike episteme*,[12] does not study the processes of generation looking to reproduce them.

On the one hand, the science of nature is about the investigation of the causes that concern natural science. On the other hand, the passage is about the method of reasoning in relation with the object of study. Indeed, nature is certainly productive, but its productivity does not extend to the science of nature (at least not at the time when Aristotle was writing). Aristotle is simply implying that while the theoretical science (mathematics, for instance) uses the absolute necessity in its demonstrations (since its objects are present and without matter), the science of nature has to take into account a generic object with a matter whose final form is continuously in the making (as something which will be) and, consequently, the necessity of the demonstration is only hypothetical.

This kind of hypothetical necessity is linked with the central concept of the final cause and the feature of a future being, of the object of biology: "Thus, we say, *Because* that which is going to be—health, perhaps, or man—has a certain character, *therefore* of necessity some particular thing, *P*, must be, or must be formed; not *Because* P is now, or has been formed, *therefore* the other thing (health or man) of necessity is now or will be in the future" (640a4–7).[13] So the majority of the productive processes are confined by the necessity that is imposed by the final cause. In the specific case of the natural genetic processes, Aristotle will conclude with the teleological principle that "whatever Nature makes she makes to serve some purpose" (641b12–13).

Driven by the model he used, namely the analogy with art, Aristotle describes nature in terms of a determinism of the final cause. Just like in art, where a bed or a chair is not meant to have wheels or to fly, for instance, in nature there can never be purposeless functions or material variations. Just as the purpose of the bed is completely different from that of a chair, the cause for the sake of which each of them is made is also completely different for each case. Things should be the same with the different species of animals: man and lion, lion and ants, snakes, and so on. Therefore there cannot be a scale of development from one into another simply because their essence is always a different one.

The statement "whatever Nature makes she makes to serve some purpose" implies that everything in nature should be explained in terms of purpose, goal or scope—there is not much room for chance apart from the question of monstrosity which he treats in terms of material excess. But if art is the logos of crafted products as form or as final cause, then what is the role and the meaning of nature for its own products and ultimately what is the radical difference between the two realms?

The concept of nature (*physis*) is twofold, in Aristotle's view: "The term *nature* is used—rightly—in two senses: (a) meaning *matter*, and (b) meaning *essence* (*ousia*), the latter including both the Efficient cause and the End" (641a 26–28). In parallel with the model of art, as we have already shown, Aristotle approach-

es the nature of the living world rather as *essence* than as *matter*. This is not to say at all that he ignores the importance of matter, but he evidently endeavors to consider a whole new point of view upon the method of research. And in his view the essence is more equivalent to the form of the thing than to any other cause. Therefore, Aristotle identifies the soul as the fundamental form of all nature's products, a form that splits the structural connection between art and nature.

As Lloyd[14] already observed on the first count, Aristotle's theory of soul provides the framework for his zoology: his psychological doctrines have a strong influence on his views on biological phenomena. On the second count, he wants to clarify the tensions between his account of living creatures and the doctrines of definition and form. Lloyd rightly points out the strategic importance of psychology to "the truth as a whole" and of course in understanding nature. If the soul is a principle for animals, it follows that we have here a biological orientation of the psychological discussions. And indeed in *De partibus animalium* (641a17) Aristotle is actually saying that "the form of any living creature is soul" and he continues by observing that "at any rate, when its Soul is gone, it is no longer a living creature, and none of its parts remains the same, except only in shape, just like the animals in the story that were turned into stone." And he continues with the observation that the only thing that differentiates philosophy from the study of nature is that *physike* cannot study the whole soul, given the fact that *nous* is somehow apart from natural matter. But since matter has to have a potentiality for life, the matter within the body is not just inert stuff, because it includes a certain proximity to life.

Therefore, in *De anima* (412b6), Aristotle makes his wellknown comparison based on the body–soul analogy with the wax and shape of a seal, concluding that one needs not to distinguish between shape and wax because they are one. But still the soul is that for which the body exists (*De partibus animalium* 645b19). Another difficulty is represented by the fact that most faculties are based on the *interdependence* between body and soul, with the exception of reason, which apparently does not engage any bodily organ.

In our opinion, one must distinguish between two senses of soul in Aristotle's treatment of this notion. On the one hand we have the soul as an object of psychological studies, where it is defined in close connection with the body as its first actuality. On the other hand, the soul is that principle which holds together the living world and envelops the serial order of nature's specific complexity. Besides that, the soul as a principle of life differentiates the object of nature from the object of art, since, as Aristotle had already put it, when death occurs and the soul is gone the body itself is like turned into stone, quite like a statue: all its faculties and all its organs are deprived of their function lacking the principle that set them in motion. At the beginning of the second book of his

Physics (we are following W. D. Ross's commentary[15]), Aristotle clarified that the fundamental distinction between the products of nature and those of art is made by "the internal power of originating movement"; while natural living things have this power within themselves, the products of art always suppose an external agent and, of course, they have no growth of their own.

A slight difficulty appears here, given the fact that it would be more precise to say that natural living things have indeed the power to initiate movement by themselves, but only if they were already somehow generated. It might be that Aristotle acknowledged this difficulty and he tried to solve it by bringing into discussion the idea of spontaneous generation, inasmuch as at its lowest level the living thing is brought to life not by an pre-existent agent (also external), but through the involvement of the *primum mobile* (*protos ouranos*), which is a cosmic agent. This is also probably alluded to in that line from his *Physics* (194b13) where it is said that the human being is born from a human being and from the sun.

Coming back to the two descriptions of the soul, one as a general principle of nature and the other as the first actuality of a body having potentiality for life, in his treatise *De anima* (II,3,414b–415a15) Aristotle advances a model of explanation of the latter based on a mathematical analogy with geometrical figures. As it is easy to observe that the triangle is enveloped as a possibility within a square (and so on with all the other geometrical figures), Aristotle applies this observation to the soul's faculties (such as eating, desire, sensibility, locomotion, imagination and thought) according to the stated rule that "always the prior is potentially enveloped in what follows it." For instance, as a triangle is potentially enveloped in a square, in the same way in the faculty of sensibility is potentially enveloped the faculty of eating, since there cannot be an animal that has the capacity to feel but not that of eating. Therefore, the soul's capacities are inscribed one into another, the simplest and the fundamental ones being inscribed as a sort of a sequence into the more complex ones. Then, at the level of each faculty appears the same sequence obeying the same law. If we are talking about sensibility, then the functions included within this faculty are set in this kind of order where the presence of one function is conditioned by the presence of the prior and more fundamental one: the sense of touch is the underlying term for the possibility of all the others, since there is no living creature that could see but not touch. Therefore, the soul is described by this system of a serial order which successively envelops different faculties and functions within each, from simplicity to complexity.

An animal's parts are organs that serve the faculties of the soul, so that they could function. As a conclusion, one might said that Aristotle had in mind the idea of a perfect inclusion of the faculties and of the parts by extending the logic of many-folded differentiae at each level of the living world. As it has

been remarked by Lloyd, "The theory of the essential parts of the animal, corresponding to vital faculties, provides an important heuristic tool and an articulating schema for much of his zoological work."[16] In the same chapter from the *De anima* where Aristotle envisaged the sequential model of the soul's system, he also observed that the living world is to be differentiated through the serial enactment of the soul's system of faculties: some living beings enact only one of them, others a few more, while one species, namely humans, enact all the faculties. Therefore, the soul as a principle of life in general (form of any living creature) is nothing but the general system of the given possibilities that can be enacted (*energeia*) to various degrees by the living world.

Depending on the elements of matter (earth, water, air, fire) and on the combinations of the primary pairs of opposites (hot–cold, dry–wet) and also depending on the enactment of the principle of the soul, Aristotle defines animals by "a conjunction of a plurality of differentiae" (*De partibus animalium* 643b12). The definition of animals is compared then with the definition of the triangle (643a27), where Aristotle holds that one should not define a triangle by saying that its internal angles sum to two right angles. The explanation of this rather obscure remark—Lloyd commented on the geometrical illustration given above stating that "the application of this principle in zoological kinds is not as clear as it might be"[17]—is that Aristotle wants to suggest that one cannot have a logical definition of an animal, but only a sort of material definition: a physical triangle is composed of three sides of a certain length, so that one can think of sorts of different physical triangles which can be grouped by their shape and common features, just like the animal species. It is undoubtedly true that by their logical definition all triangles have their internal angles equal to two right angles: namely, that an animal is something that possesses perception (653b22), but the way in which they make use of this capacity is relevant for their description as species. Lloyd rightly observes that "the *modalities* of those faculties in different kinds of animals"[18] give us the possibility to differentiate them by methods of reproduction, modes of locomotion (organs of locomotion), and ways of nutrition. Instead it is our suggestion that, by taking only the faculties of the soul (to the basic ones) into account, animals can be gradually reduced to a certain unity, while coming down the ladder one encounters more and more multiplicity; therefore, to be more precise, the soul might count as a principle of unity, while the *material modalities* (parts and organs) might count as one of multiplicity, with the exception of the last faculty which is the intellect and which does not have a specific organ. But the thing is that multiplicity constitutes the *actuality* of the biological world (*Historia animalium*), while unity is a mere *possibility*, even if Aristotle struggles to *save the phenomena* by saying that in each group the differences are only in degree (more or less).

The complete sequence of differentiations would be: soul–differentiations–faculties–differentiations–functions–differentiations–organs/parts–differentiations–species of living beings–differentiations–plants and animals–differentiations–species–differentiations–individuals. Now, it is true that the present research has come to somewhat of a paradox here, because we know that in Aristotle's theory the soul is *the first actuality* while the body is the possibility (soul is like form, body is like matter). If so, how is it that when the unity of the living world is concerned, the principle of soul offers only a potential unity, while matter describes its actual multiplicity? Lloyd has rightly observed that bricks or stones "have the characteristic they have whether or not they are incorporated in a house"[19] while the material parts of the living creatures do not occur separated from the being itself. Even if zoology is a sort of holistic science, the principle of soul is not one and the same with the soul as *the first actuality* of a body, simply because the totality of the matter in the universe is not a body like the piece of stone ready to be carved. The human being appears to be indeed the synthesis of all the capacities of the animals, but, unlike the matryoshka dolls, all the other animals are living only potentially inside him.[20] Therefore one can agree with Lloyd's suggestion that the artifact model is the one that provides for Aristotle the distinction between matter and form, but it is also a vitalistic model very close to hylozoism that provides their unity.

OUR FINAL conclusion is that Aristotle investigated nature from the perspective of art, establishing a model of explanation—the final cause, the hypothetical necessity, the essence, the soul—based on that isomorphism he saw between art and nature. Consequently, long before art could imitate nature, the science of nature was already imitating art.

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Notes

1. Wilfried Fiedler, *Analogiemodelle bei Aristoteles* (Amsterdam, 1978), 265–266: "Die Techne ist das für Aristoteles beste und naheliegendste Modell, nach dem man sich das Wirken der Natur vorstellen kann."
2. Werner Jaeger, "Aristotle's Use of Medicine as Model of Method in His Ethics," *Journal of Hellenic Studies* 77 (1957): 54–61.
3. Klaus Bartels, *Das Techne-Modell in der Biologie des Aristoteles* (Tübingen, 1966).
4. G. E. R. Lloyd, "The Role of Medical and Biological Analogies in Aristotle's Ethics," *Phronesis* 13 (1968): 68–83.
5. Ibid., 72.
6. Ibid., 81–82.

7. Aristotle, *Parts of Animals*, trans. A. L. Peck (Harvard, 1993), 57. This translation will be used throughout this study.
8. Ibid., 63–65.
9. Aristote, *De la génération et la corruption*, trans. Morwan Rashed (Paris, 2005), XV–XVI; the translator declares that it is the science of biology that gave the full meaning to the category of genesis for Aristotle and that, in fact, "il faut donc prendre à la lettre la description d'un corpus physico-biologique unitaire présentée par Aristote dans le prologue des *Météorologiques*."
10. Aristotle, *Parts of Animals*, 59.
11. Ibid., 58, n. *b*.
12. Aristotle, *De Motu Animalium*, trans. Martha Craven Nussbaum (Princeton, 1978), 108: "The biological works are the necessary completion of the course of inquiry that began with the Physics."
13. Aristotle, *Parts of Animals*, 69.
14. G. E. R. Lloyd, *Aristotelian explorations* (Cambridge, 1996), 38.
15. Aristotle, *Physics*, ed. W. D. Ross (Oxford, 1936), 24.
16. Lloyd, *Aristotelian explorations*, 52.
17. Ibid., 56.
18. Ibid., 57.
19. Ibid., 59.
20. James G. Lennox, *Aristotle's Philosophy of Biology* (Cambridge, 2001), 178: "He appears to have seen every individual of a kind as having every feature of every structure quantified . . . precisely, and to have viewed every kind from the most extensive to the most specific as a range of potential quantifications for the next more specific kind."

Abstract

Models of Explanation in Aristotle's Biology

There is an important connection between *bios* (life) and *techne* (art) that arises in the biological treatises of Aristotle as a result of his investigation of the living world. In the history of philosophy, this connection bears the mark of Aristotle's struggle towards the first scientific understanding of the phenomenon of life in all its complexity. Our thesis is that he simply used the model of *techne* in reading the mechanisms of the living creatures, their inner structure, their generation, and their movements. Thus, by applying the model of *techne* to *bios*, Aristotle identified a sort of genuine meaning of biology as very close to biotechnology, bioethics and biopolitics. In fact, it is the relationship between *bios* and *techne* that gave birth to the first systematic biology in the history of science and simultaneously to a range of problems that are still giving us food for thought.

Keywords

Aristotle, biology, art, model, explanation, animals