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Aristotle on Technology and Nature

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Abstract: Due to the rapid development and ubiquitous impact of modern technology, many people feel that nature is in danger of becoming extinct. From the 13th century until today, philosophers and theologians have been seeking advice from Aristotle to define both nature and technology in a way that the former restricts the latter. In this paper, I reconsider three corresponding theses usually attributed to Aristotle. 1) Technology imitates nature, such that there is no place for authentic human creativity. 2) Technology in supplementing and completing nature fulfils but the inherent aims of nature. 3) There is an ontological hiatus between natural things and artifacts such that technology cannot reproduce or change natural things. I argue that 3) is inconsistent with 1) and 2) and that Aristotle's writings support none of the three theses in general. Instead, his proper concept of technology places little restrictions on technological innovation. While the putative ontological hiatus has been most influential in the history of chemistry/alchemy, Aristotle himself rather holds a relative distinction that he levels out just in the realm of chemistry. Moreover, the case of genetic engineering shows that current problems are beyond the scope of Aristotelian theory. Rather than presenting solutions, I argue that claiming Aristotle's authority to support criticism of modern technology does justice neither to Aristotle nor to the complexity of today's problems.

Introduction

It is nearly commonplace in philosophy that Aristotle held, if not formulated at first, the notion that technology imitates nature.[1] By taking Aristotle as the unquestionable authority in philosophical issues since the 13th century, medieval theologians and philosophers employed the notion for a conservative doctrine: technicians cannot and should not transcend the realm of Nature/Creation, unless they lose their proper methods, aims, and legitimization. Retrospectively, Aristotle's impact is sometimes considered the essential obstacle for authentic technological creativity that was to be overcome only in the Renaissance. Hans Blumenberg, for instance, in his famous article on the imitation of nature, states that Aristotle's theory of technology leaves

no place for authentic human creativity, for a 'human world', and thus prevented technological innovations.[2]

Such a view is at odds with the history of technology, however. Late medieval technology was indeed much more innovative than Renaissance technology, at least in quantitative terms of important inventions like mechanical clocks, windmills, furnaces, mineral acids, distillation *etc*.[3] While it is difficult to name technological Renaissance innovations of lasting importance, the mass of medieval (anonymous) innovations are not only important until today, it is also very difficult to interpret them in terms of imitating nature.

In this paper I will argue that such a view on Aristotle's concepts of nature and technology is at odds with his own writings too. For that reason, I will first reanalyze Aristotle's passages where he presented his ideas. We will see that he borrowed the notion of 'technology imitating nature' from his opponents, in order to prove that also materialists implicitly subscribe to a teleological concept of nature. Thus, his concept of imitating is explanative rather for his concept of nature than for his concept of technology and it implies little restrictions to technological innovation and authentic human creativity. Secondly, we will have a critical look at radical naturalistic interpretations of Aristotle, according to which technology can fulfil only the inherent aims of nature. Prominent as this reading is, it nonetheless ignores at least three central distinctions of Aristotle: the distinction between human purposes and the aims of nature, the distinction between ontological possibilities and the teleology of nature, and the distinction between artifacts and natural things. The third section deals with the opposite – though no less prominent – interpretation that Aristotle would have founded a fundamental ontological distinction between artifacts and natural things. That position was indeed most influential in the history of chemistry/alchemy. It is still prevailing in our common sense ontology when we distinguish between natural and synthetic substances. However, a closer look at Aristotle's 'Chemical Treatise', the forth book of *Meteorologica*, reveals that it is just the chemical realm from which Aristotle excludes such an ontological distinction. Finally, we will address the more speculative issue how Aristotle would have dealt with genetically manipulated living beings. In conclusion I will argue that all discussed views are guided rather by a conservative spirit of technology than by textual analysis, and that we need to found a critical view on technology today on totally different grounds.

1. Technology imitating nature[4]

The most quoted passage of Aristotle's 'doctrine' is the second book of *Physica*, in particular 194a13ff. and 199a8ff. What strikes first is that Aristotle just mentions the sentence 'technology imitates nature' without giving any reason for it. Instead he seems to refer to a common sense statement and uses it as a premise for his own argumentation. From that we may already suppose that the sentence, as it stands, can hardly be termed a doctrine of Aristotle, like his proper doctrines of nature (theory of elements, past and future eternity of the universe, geocentric cosmos, and so on) for all of which Aristotle provides detailed reasons of his own.

A closer look at the context of argumentation reveals that in both passages of *Physica II* Aristotle's main concern is with nature and the science of nature and not with technology. The whole book intends to refute sort of 'materialistic' philosophy that does not consider both forms and aims of nature (he names Empedocles, Democritos, and Anaxagoras). The parallel passage in *De partibus animalium* I.1 639b ff. makes clear that he argues also against the Hippocratean school. Philosophers of nature, so the first mentioned passage in *Physica II*, should not only study matter but also the forms of natural things because both are important to understand nature. The second passage points out the teleological constitution of nature, *i.e.* that nature follows aims, and says that philosophers of nature should analyze nature in terms of means and ends.

Aristotle argues for both theses in a similar way by taking as premise in both cases a structural analogy between natural and technological production. As technicians are guided by aims and are concerned with both matter and form of their artifacts, so philosophers of nature should be concerned with aims of nature as well as with matter and form of natural things. While the structural analogy is actually a central doctrine of his own, Aristotle tries to prove that also his materialistic opponents, at least implicitly, hold the analogy and are forced to draw his conclusions regarding nature. The central idea is that the thesis 'technology imitates nature' presupposes the analogy; everybody who subscribes to that thesis implicitly presupposes also the philosophical significance of forms and aims in nature.

We have some evidence from Plato that the concept of technology learning from or imitating nature had many followers among ancient empiricist and materialist philosophers.[5] In fact, the concept of 'learning from nature' was basic in the Hippocratean medical school.[6] And Democritos even offered an historical account of technological inventions in claiming that, for instance, house-building and weaving were first invented by imitating swallows and spiders building their nests and nets, respectively.[7] Aristotle obviously refers to these traditions by repeating Democritos' examples.[8] He argues that

physicians and architects are concerned with both matter and forms of their artifacts[9] and that they are unquestionably guided by aims. If they actually imitate nature as the materialists claim, then they can so do only because nature itself is composed of matter and forms and guided by aims. Hence, also materialists implicitly agree to the importance of forms and aims in nature.

Aristotle himself does not object to the thesis that technological inventions are occasionally guided by imitating nature, but he also acknowledges the role of chance (*tyche*).[10] Moreover, he states that technology sometimes supports and surpass nature in producing new things that nature cannot produce on its own.[11] In both cases, technicians are guided by human purposes.[12] Hence, Aristotle strongly rejects the idea that every technological production imitates natural production in the sense of exactly copying natural products and processes. Instead his intention is to establish a much more general concept of reproducing nature based on his structural analogy: The rational procedure of artificially producing material things for human purposes corresponds to the teleological process of natural production for natural purposes. Since the teleology of nature is more stringent than human rationality, the former is exemplary for the latter.[13] Without the exemplary teleology of nature there would not be any human purposive activity and hence no technology.[14] Thus, *human technology imitates natural teleology on the general level of directivity and purposiveness*.[15]

It is important to note that the structural concept of imitation does not place constraints on technological creativity concerning new products, procedures, and goals. It only explains the common sense opinion that technology is a rational enterprise directed towards goals, without saying anything about the specific goals of technology. Constraints only show up in specific but trivial cases. If the technological product corresponds to a natural product, then it is to be made the very same way as nature does. According to Aristotle, there is one directional way to make a certain product from certain materials; given that disturbing factors are excluded.[16] In technology as well as in nature, the way is directed step-by-step by the final goal.[17] Hence, if and only if a certain natural thing is reproduced by men, then it is made the same way as by nature. And in turn, if a house were a natural product, as Aristotle counterfactually assumes for the reason of analogy, then it would be built by nature the very same way as it is built by men.[18]

2. Technology supplementing and completing nature

Of course, houses are no natural products. They are made by human activity for human needs and ends alone. In what sense then shall we interpret Aristotle's sentence that technology supports nature in supplementing and completing what nature herself leaves imperfect?[19] Does Aristotle consider things such as houses as inherent aims of nature, being achieved by the help of human skills only? Is clay, for instance, striving towards bricks to become parts of houses for human beings? Such a radical naturalistic interpretation would completely miss Aristotle's concept of teleology of nature that actually restricts natural processes and tendencies to mere reproduction of her own forms.[20] Instead, technology completes what nature leaves *imperfect according to our human purposes*; *i.e.* the only standards of technological perfection of nature are human purposes.[21] The radical naturalistic interpretation simply ignores Aristotle's claim for human purposes on which the structural analogy is essentially grounded. However, Aristotle himself leaves no doubt on that point in saying that we human beings take everything as means for our own purposes, such when, for instance, craftsmen produce new materials from natural materials or at least process natural materials for their own purposes.[22] On the other hand, human purposes belong to the realm of natural purposes indirectly – Aristotle says 'in a second meaning' –, in as far as human beings, with all their needs, are themselves products and ends of nature.[23]

Hans Blumenberg, one of the main modern proponents of the radical naturalistic interpretation, tries to find evidence in Aristotle's theory of potentiality. He claims that nature according to Aristotle would be the realm of all possibilities.[24] From that, Blumenberg correctly infers that technology cannot transcend 'nature', *i.e.* the realm of all possibilities, but only realizes 'natural' possibilities. Indeed, to say that technology makes possible what is ontologically impossible would mean to claim a strange and self-contradictory magic. While Aristotle himself gives nowhere Blumenberg's definition of nature explicitly, it is a matter of discussion if we may interpret Aristotle's fourth definition of nature, *i.e.* primary matter,[25] in terms of possibilities, since he considers elsewhere matter as being in the mode of potentiality.[26] Anyway, such a concept is quite distinct from Aristotle's main definition of a natural thing: something that bears its own principle of motion in opposition to artifacts that are generated by outward causes, *i.e.* by technicians.[27]

Blumenberg seems to identify Aristotle's ontological concept of potentiality with his metaphysical concept of teleology of nature, in order to conclude that natural aims would determine the realm of all possibilities (incl. artificial changeabilities). However, natural aims correspond only to a subset of ontological possibilities, such as natural changes are only a subset of all

possible changes. It is a central thesis of Aristotle's general theory of movement and change that to every change in a certain direction corresponds a possible change in the opposite direction. Throughout his writings on nature, Aristotle tells us that matter, the substrate of change (*hypokeimenon*), always bears opposite potentialities.[28] If we pick up, for instance, a stone, then this movement is against the stone's natural aim, but it is certainly not against its ontological possibility. Because Blumenberg overlooks this basic distinction as well as Aristotle's claim for human purposes, he comes to the wrong conclusion that technology would necessarily serve only natural teleology in Aristotle's view.[29]

3. The 'ontological' distinction between artifacts and natural things

According to Blumenberg interpretation of Aristotle, technology produces the same things as nature; they differ only in that technology is effective from outside whereas nature is effective from inside.[30] Blumenberg seems to level out any ontological difference between artifacts and natural things. On the other hand, there is also the opposite interpretation that Aristotle would have founded a fundamental distinction between artifacts and natural things.[31] According to that reading, all technological capacities to imitate nature are radically diminished. At best, artifacts bear a superficial resemblance to natural things, but that does not concern the ontological difference.

Historian of science Reyer Hooykaas considers Aristotle's distinction to be responsible for a lasting ontological hiatus between natural and artificial substances.[32] He quotes Galen who distinguished between genuine material combinations made only by God or Nature and mere mixtures of particles made by human beings.[33] Ontological distinctions that actually exclude technological reproduction of natural substances were widespread throughout the history of Latin alchemy.[34] The most important source was Avicenna's *De congelatione et conglutinatione*, a short treatise that was wrongly inserted into the fourth book of Aristotle's *Meteorologica* by the translator Alfred of Sareshel and then habitually attributed to Aristotle by medieval writers. Even until the second half of the 19th century the majority of chemists subscribed to vitalism in claiming an ontological hiatus between artificial substances and substances from living beings.[35] In addition, we may state without exaggeration that such a distinction, *e.g.* between natural and artificial vitamin C, is still deeply rooted in our common sense ontology until today.[36]

We cannot clarify the entire history here, but we may try to settle the Aristotelian origin in terms of his own writings. The first point to be

acknowledged is that Aristotle divides up the realm of material things and movements into three parts according to three different principles of motion and generation: natural things, artifacts, and occurrences by chance (*tyche*) or by spontaneity (*automaton*).[37] However, he considered chance and spontaneity accidental[38], secondary causes[39], or privation of the other two causes[40]. Thus, if we focus on natural things and artifacts, as Aristotle himself does in *Physica II.1*, the main difference is that the former have their principles of generation and motion inside, whereas the latter, insofar as they are artifacts, are generated only by outward causes, *i.e.* by human aims and forms in the human soul.[41] Natural products (Aristotle mentions animals and their parts, plants, and the four elements)[42] move, grow, change, and reproduce themselves by inner final causes, *i.e.* they are driven by purposes of nature. Artifacts, on the other hand, cannot reproduce themselves. Without human care and intervention, they vanish after some time by loosing their artificial forms and decomposing into (natural) materials. For instance, if we bury a wooden bed, then it decomposes to earth or changes back into its botanical nature by putting forth a shoot.[43]

The last example makes clear that both artifacts and natural things are composed of the same material basis according to Aristotle. Moreover, since the elements are natural bodies (see above), all material artifacts are composed of natural things; *i.e.*, from the perspective of the material basis artifacts are natural things. Aristotle's distinction between artifacts and natural things is indeed grounded on a certain *perspectivism* that is deeply rooted in his pluralism of causes. We need to consider two distinctions concerning causes: (1) Form and aim as the generating causes of a thing may lay either within the human soul, *i.e.* technology, or within nature (see above). (2) Formal and final causes are to be compared with material and efficient causes concerning their respective significance to the generating procedure.[44] According to Aristotle, both distinctions are rather unproblematic if we consider non-homogeneous objects such as drinking bowls, saws, and boxes on the one hand, and plants, animals, and their functional parts, on the other.[45] In these cases, forms and aims are dominant causes and unambiguously assigned either to technology or to nature. Problems arise, however, with homogeneous bodies like metals and ores where it is difficult to determine forms and aims. Though he considers also homogeneous bodies somehow embedded in natural teleology,[46] Aristotle points out that their dominating principles of generation are material and efficient causes *i.e.* heat and cold.[47] Therefore, his distinction between natural things and artifacts based on forms and aims as generating causes actually fades just in the realm of homogeneous bodies, *i.e.* in the realm of chemistry.

If we reproduce natural materials or even produce new materials for human purposes by chemical technology, these procedures are without doubt

technological. According to Aristotle however, there is no ontological difference between these products and natural products, because both in chemistry and in nature the dominant principles of generation, *i.e.* material causes and efficient causes, are the same. Hence, he does not hesitate to treat naturally and artificially produced materials together without making any difference in his 'Chemical Treatise', the fourth book of *Meteorologica*.[48] The significance of this book to an understanding of Aristotle's concept of nature and technology comes from the fact that it is Aristotle's *only* treatise in which technological processes are described in detail and explained systematically.

All material substances are composed of the four elements; their coming-to-be and passing-away are caused by the interaction of the same elemental qualities (heat and cold as active qualities, wet and dry as passive). Regardless of their origin, Aristotle classifies all materials through the same scheme of empirical concepts, and he explains differences in properties in terms of the same theoretical account of elementary composition. He does not discuss transformations of substances (like digestion, concoction, ripening, boiling, broiling, roasting, melting, solution *etc.*) in terms of natural or technological procedures. Instead, he sorts them according to what he considers the efficient and material causes as well as to similarities in the course of change. It makes no difference, says Aristotle, if heat is effective in the body of an animal or in an artificial vessel; in either case the cause is the same;[49] and correspondingly the type of transformation is the same.[50] Whether certain materials result from technological or natural production does not matter as long as they have the same properties. Aristotle uses the same names for substances like gold and silver, independently of their natural or metallurgical origin, and he considers them throughout as the same substances.

In conclusion, we have no reason at all to consider Aristotle as authority for the ontological distinction between natural and artificial substances. On the contrary, while he holds a kind of distinction regarding complex objects (unlike Blumenberg), he clearly rejects such a distinction regarding material substances (unlike Hooykaas and many medieval writers).

Let us now analyze more clearly Aristotle's distinction between natural and artificial complex objects. In what sense can we call the distinction ontological? They differ, as we have seen, in that aims and forms as generating principles are either inside the objects or in the human soul. Things like houses and saws are unproblematic artifacts, because here forms and aims as the generating causes are authentically human and definitely not inside any material thing.[51] What about, for instance, plants in horticulture or animals in agriculture? Shall we consider, for instance, a hedge planted by men to break the wind as an artifact or as a natural thing? Aristotle himself does not explicitly deal with this case, but, as we have seen above, he clearly holds to perspectiv-

ism with regard to that distinction. As far as the hedge has been intended to become a windbreak, it is an artifact. As far as the hedge is a naturally grown plant, regardless of its place and human use, it is a natural thing. Hence, if we expect an ontological distinction to divide the material world unambiguously into artifacts and natural things, Aristotle has nothing to tell us about that.

Even more hypothetically, we may ask whether a genetically manipulated plant that is capable to grow and reproduce itself is an artifact or a natural thing in Aristotle's view. I think that his perspectivism allows us to say that the plant is an artifact only inasmuch as it is intended to fulfil human needs, like any other cultivated plant. Once the genetic manipulation is finished, the plant with all its descendants have their moving and generating causes inside; thus, we could consider them natural things according to Aristotle. What is indeed beyond the scope of his theory, is that the original generating cause of living beings can lie outside the corresponding biological species at all. Since all living species eternally exists and reproduce themselves,[52] Aristotle's theory left no place for foreign causes, neither for evolution, nor for human gene manipulation, let alone divine creation.

Conclusion

Given the great authority Aristotle has had for many philosophers and theologians in the course of history, it is no surprise that many have sought his advice concerning the frequently debated issue of nature and technology. Since the issue has been (and is still) overshadowed by normative reasoning, Aristotle's writings had to serve various ethical justifications such that different, even incompatible, interpretations showed up. It was the aim of this paper to clarify Aristotle's concepts as presented by himself in various textual contexts.

We have first pointed out that Aristotle neither coined nor held the concept of 'technology imitating nature' as a restricting thesis about technology. Instead, since the concept was widely used before by his materialist opponents to explain human technological innovation, he tried to prove that even those materialists implicitly subscribe to a teleological constitution of nature. Aristotle used the received concept to hammer down the teleology of nature in analogy to the undoubted rationality of technology. Thus, it serves to explain rather his concept of nature than his concept of technology.

Against a radical naturalistic interpretation of Aristotle's concept of technology according to which the latter would only fulfil the aims of nature, we have then pointed out that Aristotle clearly acknowledged authentic human purposes different from direct natural aims. Technology supplements and

completes nature according to human purposes, which are not necessarily natural aims. The naturalistic interpretation simply ignores Aristotle's ontological case for counter-natural movements as well as his ontological distinction between artifacts and natural things according to their different principles of motion.

While the radical naturalistic interpretation subscribes to the unity of nature, history of science has it that a mainstream reading of Aristotle held a strict ontological hiatus between artifacts and natural things based on different principles of motion. Oddly enough, this reading has been most influential in the history of alchemy and chemistry, such that the distinction between natural and synthetic substances dominates our common sense ontology until today. However Aristotle himself, while actually claiming the distinction concerning most complex bodies, obviously disregarded the distinction just in the realm of homogeneous substances, because the dominating principles of motion are basically the same in either case. Again, a position has later been attributed to Aristotle that he himself explicitly rejected.

Finally, we addressed the more current problem whether Aristotle would have considered cultivated and genetically manipulated plants and animals either as natural things or as artifacts. Pressing as the question as such may appear for many of us, Aristotle's own writings give no evidence that there would be a simple either-this-or-that solution within his conceptual framework. Moreover, we must admit that the case of genetic engineering definitely goes beyond the scope of Aristotle's framework, as it is the case with biological evolution and divine creation.

Due to his position as an authority in philosophical issues, much has been attributed to Aristotle that he had never written – there is an enormous amount of pseudo-aristotelian medieval manuscripts of many branches of science – or even explicitly rejected in his authentic writings. As concerns technology, many conservative arguments have been put forward with reference to Aristotle. These arguments seem to support either the interpreter's conservative attitude concerning technology or the historiographic myth of a technological Renaissance revolution as a result of an anti-Aristotelian movement. However, there is not a single place in the entire authentic *corpus aristotelicum* where Aristotle explicitly places contraints on human technological creativity, beyond the trivial limitation that technicians must start with raw natural products and can do only what is ontologically possible. There is nothing in his writings that restricts or forbids technological processes and products just because they do not belong to the realm of nature, unless they do not sensibly serve human purposes.

Since the days of Aristotle, things have changed drastically. Technology has become influential on nearly every aspect of western culture such that we need to reconsider the substantial way we see nature, technology, and our-

selves. Today philosophers of technology are challenged to reflect this development critically from a point of view that is both independent of fashionable attitudes and familiar with technical details. The fact that Aristotle does not much help in this regard because he did not foresee thousands of years of technological development does not diminish his innumerable merits.

Notes

[1] In the present paper, I use the term 'technology' for what Aristotle and Plato called *techne* or sometimes *poietike*. While 'useful art' would perhaps be a better term, I prefer to avoid the confusion with fine arts (see Footnote 4) and the terminological suggestion that technology would always be useful. Plato's view of technology and his impact on Aristotle are excluded from the present paper, because that is the subject of a complementary paper 'Plato on Technology and Science' (in preparation).

[2] Blumenberg 1957, p. 274-5.

[3] *Cf.* White 1962; Crombie 1995, Vol. I, Sect. 4.

[4] I strictly distinguish technology from fine arts as Aristotle and Plato did, although their terminology is not always distinct. Thus, I do not refer to Aristotle's different theory of *mimesis* as presented in his *Poetica*. Much confusion emerged from the fact that the Latin 'ars' and English 'art' were used to denote both technology and fine arts.

[5] Plato, *Nomoi* X, 899aff.

[6] *Cf.* Kube 1969, p. 45; see his note 22 for a list of references to the *Corpus Hippocraticum*.

[7] Fr. D154; perhaps the oldest extant source for the exemplary role of nature is Herakleitos fr. D112.

[8] *Physica* 199a25; *cf.* also Ross 1955, p. 529.

[9] *Physica* 194a23ff.

[10] *Ethica Nicomachea* 1140a18ff., *Metaphysica* 1032a29.

[11] *Physica* 199a16, *Protreptikos* B 13 (edition by Düring 1969).

[12] *Physica* 199a35; see also below Sect. 2.

[13] *Protreptikos* B 13.

[14] *Ibid.*

[15] *Protreptikos* B 13-14, *Physica* 199a10; Hans Wagner, in his commentary on *Physica* p. 456, has first pointed out that Aristotle's concept of *mimesis* should be interpreted in terms of such a structural reproduction; *cf.* also Strohm's commentary on *Meteorologica* IV, p.225; and Fiedler 1978, p. 271.

[16] *Physica* 199a33 ff.

[17] *Physica* 199a8.

[18] *Physica* 199a12ff.

[19] *Protreptikos* B 13, *Physica* 199a16.

[20] *Cf.* Wagner 1972, p. 481

[21] *Cf.* also Schadewaldt 1960, p. 917; Bartels 1965, p. 277; Bartels 1966, pp. 49f.

[22] *Physica* 194a33f., see also *Protreptikos* B 12. Theophrastus was even more detailed in distinguishing between two different kinds of human purposes: practical aims versus aesthetical aims (*phantasia*), *cf. De lapidibus*, 60, 349.7-10.

[23] *Physica* 194a35; *cf.* also *Protreptikos* B 16 for the thesis that humans are the most perfect living beings made by nature.

[24] "Natur ist der Inbegriff des überhaupt Möglichen." (Blumenberg 1957, p. 273).

[25] *Metaphysica* 1014b 26ff.

[26] *E.g. Metaphysica* 1042a27, 1069b15, 1071a10.

[27] *Metaphysica* 1015a13, *Physica* 192b12.

[28] *E.g. Metaphysica* 1042a32ff. 1069b14, 1070b12, *Physica* 217a22ff. *De generatione et corruptione* 314b and *passim*.

[29] "Der Kern der aristotelischen Lehre von der techne ist, daß dem werksetzenden Menschen keine wesentliche Funktion zugeschrieben werden kann. Was man die 'Welt des Menschen' nennen wird, gibt es hier im Grunde nicht. Der werksetzende und handelnde Mensch stellt sich in die Konsequenz der physischen Teleologie: er vollbringt, was die Natur vollbringen würde, ihr – nicht sein – immanentes Sollen." (*op. cit.*, p. 274-5).

[30] "Techne und physis sind gleichsinnige Konstitutionsprinzipien, das eine bewirkt von außen, was das andere von innen zustande bringt." (*ibid*).

[31] For a recent reformulation *cf.* Gloy 1995, vol. I, p. 26: "Dieser fundamentale Unterschied zwischen natürlichen und künstlichen Gegenständen ist konstitutiv für alle Aristotelischen Naturbegriffe; [...] für den Naturbegiff überhaupt seit seinem Ursprung und hat sich durch alle Zeiten hindurch bis heute bewahrt."

[32] Hooykaas 1947/8, p. 640.

[33] Galenus, *Opera omnia*, ed. Gesner, Lugduni 1550, vol. I. p. 40 A.

[34] *Cf.* Newman 1989, Obrist 1996.

[35] The pseudo-historical tale that Wöhler would had refuted vitalism in the 1820s was already rejected by McKie (1944); see also Lipman (1964), Brooke (1968), and Russell (1987) for vitalism and anti-vitalism in the second half of the 19th century.

[36] Some sociological evidence is provided by Werth 1991 and Karger 1996.

[37] *Metaphysica* 1032a12, 1070a6.

[38] *Metaphysica* 1065b26ff.

[39] *Physica* 198a1ff.

[40] *Metaphysica* 1070a8.

[41] *Metaphysica* 1032a32.

[42] *Physica* 192b9.

[43] *Physica* 193a12.

[44] *Meteorologica* IV, 390b10ff.

[45] *Ibid.*

[46] *Meteorologica* IV, 389b10ff.

[47] *Meteorologica* IV 390b12 and throughout this book.

[48] *Cf.* Düring 1944, Happ 1965.

[49] *Meteorologica* IV, 381a10.

[50] *Meteorologica* IV, 381b2. Note that this point is also of central importance to the history of philosophy of science. Aristotle equally deals with natural and technological products and processes in the realm of chemistry, and the whole tradition of alchemy should follow him in that regard. Thus, it would be wrong to claim that only 'Galilean' experimental physics first leveled out the difference between phenomena in 'nature' and phenomena in artificial contexts of experiments. Historians of science know anyway that the difference was nonexistent in antique experimental physics, *e.g.* Archimedes' statics, Ptolmaios' optics, etc.

[51] That is, by the way, the exact reason why the thesis of the ontological difference between artifacts and natural things is incompatible with the restrictive interpretation of imitation that ignores authentic human purposes (s.a.).

[52] *De generatione animalium* 731 b 35.

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