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# The Rise of Teleological Explanation in Early Modern Thought

## I. Mechanism and Teleology – Historical and Systematical Preliminaries

In modern times (from Copernicus, Kepler, Galileo, via Descartes and Newton, to Kant), philosophic-historical examination and classification of general metaphysical designs for explaining nature, man and the cosmos, including concrete questions and their individual processes, is commonly guided by the idea that nature is pervaded and determined entirely by one and the same paradigm of mechanism.

By 'mechanism' or, relatedly, by mechanistic explanation, is to be understood here the philosophical thesis that all things, events and processes of nature are to be explained only by the principle of effective causality and its special forms of natural law (e.g., inertia of mass, pressure and thrust, gravitation),[1] or, similarly, that all these occurrences are specifications of this single principle, and that the discovery of new laws of nature and the invention of new machines have one and the same basic idea. This theory includes silently the representation of physical

[1] Cf. Marx W. Wartofsky, *Conceptual Foundations of Scientific Thought. An Introduction to the Philosophy of Science* (New York: The MacMillan Company, 1968), 344 f.

matter as composed of insensible particles moving in conformity with certain general properties (size, space, impenetrability).[2]

This idea of the domination of mechanistic principles of explanation is coupled with the belief in the general quantifiability (measurability) and the precise mathematical (geometrical) solvability of the basic problems of several branches of natural science (physics, astronomy, medicine etc.).[3] Since the demonstration of the motion of natural bodies by means of mathematical concepts seemingly had been the most successful way of scientific explanation, all natural things and their interrelations in general could be understood as "having essentially to do with mathematical entities".[4] The advances within the area of mathematics (analysis, the discovery of the infinitesimal calculus) and experimental physics as well as the development in technology (calculating machines among others) fostered this belief. But on the other hand, rational mechanics did not succeed in becoming an overall predominant mathematical theory.[5] Nevertheless, with Descartes and Spinoza the use of the 'geometrical mode of demonstration', which had been borrowed from Euclid's 'Elements', comes into fashion in writing philosophical treatises. If one examines major classical works in the history of philosophy, which had become standard books during this period (Bacon: "Novum Organum", Descartes: "Principia Philosophiae", Newton: "Principia Mathematica" etc.), the impression of this dominating mathematic-mechanical method of explaining nature appears to be immediately confirmed. An indicator of the screening out of undesirable, seemingly unnecessary alternatives is the treatment of Aristotle, in particular of some special aspects of his "Physics". The continuously intensifying process of mechanization

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[2] Cf. Steven Nadler, "Doctrines of Explanation in Late Scholasticism and in the Mechanical Philosophy", in: *The Cambridge History of Seventeenth-Century Philosophy*, ed. Daniel Garber and Michael Ayers (Cambridge: Cambridge University Press, 1998), 529–531.

[3] I suggest this separation between the monopoly of the principle of effective causality in the foundation of nature and the mathematical translation of natural entities and relations although there exist other definitions of "mechanism". Donald Rutherford translates the doctrine of mechanism taught by those he calls "the new scientists" as "the view that all natural changes can be explained in terms of changes in the sizes, shapes, and notions of particles of matter alone, in accordance with necessary mathematical laws" (Donald Rutherford, "Innovation and orthodoxy in early modern philosophy", in: *The Cambridge Companion to Early Modern Philosophy*, ed. Donald Rutherford (Cambridge: Cambridge University Press, 2006), 26).

[4] Cf. Helmut Pulte, "Order of Nature and Orders of Science. On the Mathematical Philosophy of Nature and Its Changing Concepts of Science from Newton and Euler to Lagrange and Kant", in: *Between Leibniz, Newton, and Kant. Philosophy and Science in the Eighteenth Century*, ed. Wolfgang Lefèvre (Dordrecht–Boston–London: Springer 2001 (Boston Studies in the Philosophy of Science Vol. 220)), 61–92, esp. 62.

[5] Helmut Pulte, "Order of Nature and Orders of Science", 62.

supersedes the Aristotelian-Scholastic philosophy of nature and along with it the influence of Aristotle's instructive writings. This process had been prepared through a heterogeneous treatment of the Aristotelian tradition by Renaissance Philosophers.[6]

Under this assumption, it is surprising to note that non-mechanistic, purposive or final principles have found their way not just occasionally (as it seems to be the case with Newton or even with Descartes) into the works of metaphysics and of natural philosophy. This diagnosis indicates that the mechanistic way of explaining could be insufficient to fulfil the function of a universal principle; that, correspondingly, another kind of principle complementary to the first principle of mechanics was still needed that would be able to close significant explanatory gaps.

Just as astonishing, however, is the fact that the belief in the uselessness and replaceability of a teleological consideration of nature has still remained dominant into our technologically determined time, in spite of the enormous growth of natural science, especially of biology, in the interim. Apart from a few noteworthy exceptions,[7] it seems almost hopeless to give convincing arguments against this common prejudice which is firmly rooted in the philosophy of science and in the conception of science itself during the 19th and 20th centuries, and which is held by an obscure hostility that empirical-mathematical reasoning has against metaphysics; and also hopeless to legitimate philosophically the admission of teleology as a scientifically relevant type of theory. Along with this sceptical evaluation, it appears that there is no distinct idea of the definition and the use of the concepts of teleology and final cause in the

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[6] For the unity and diversity in writing and lecturing on Aristotle in the Renaissance, cf. Charles B. Schmitt, *Aristotle and the Renaissance* (Cambridge, MA: Harvard University Press, 1983); idem, *A History of Western Philosophy: 3. Renaissance Philosophy* (Oxford–New York: Oxford University Press, 1992), 60– 126; Charles H. Lohr, "The Sixteenth-Century Transformation of the Aristotelian Natural Philosophy", in: *Aristotelismus und Renaissance. In memoriam Charles B. Schmitt*, ed. Eckhard Keßler, Charles H. Lohr, Walter Sparn (Wiesbaden: In Kommission bei Otto Harrassowitz, 1988) (Wolfenbütteler Forschungen 40), 89–99; Cesare Vasoli, "The Renaissance Concept of Philosophy", in: *The Cambridge History of Renaissance Philosophy*, ed. Charles B. Schmitt, Quentin Skinner and others (Cambridge: Cambridge University Press, 1988), 55–74, esp. 69–73; Alfonso Ingegno, "The new philosophy of nature", in: *The Cambridge History*, ed. Schmitt and Skinner, 236–263; William Wallace, "Traditional natural philosophy", in: *The Cambridge History*, ed. Schmitt and Skinner, 201–235.

[7] Cf., among others, Fritz Krafft, "Zielgerichtetheit und Zielsetzung in Wissenschaft und Natur. Entstehen und Verdrängen teleologischer Denkweisen in den exakten Naturwissenschaften", *Berichte zur Wissenschaftsgeschichte* 5 (1982): 53–74; Eve-Marie Engels, *Die Teleologie des Lebendigen. Kritische Überlegungen zur Neuformulierung des Teleologieproblems in der angloamerikanischen Wissenschaftstheorie. Eine historisch-systematische Untersuchung* (Berlin: Duncker & Humblot, 1982); Wolfgang Kullmann, *Aristoteles und die moderne Wissenschaft* (Stuttgart: Steiner, 1998).

main-stream model of scientific explanation following Carl Gustav Hempel, who advocated allowing only a single pattern of theoretical explanation, i.e., the so-called "deductive-nomological explanation" by deductive subsumption under a certain type of general laws (of nature).[8] Causal explanation, then, claimed to be a variety of deductive-nomological explanation. Missing such general laws and failing to satisfy the requirement of empirical testability, "teleological accounts referring to entelechies are thus seen to be pseudo-explanations".[9]

The diversity and heterogeneity of problems and topics connected with teleological views, and their related modes of reasoning, have become difficult to see clearly nowadays. Wolfgang Stegmüller tried to differentiate the separate aspects and to arrange them conceptually.[10] However, his theoretical approach is rather formalistic and from the outset hardly orientated toward substantial problems possessing material relevance. "Teleological explanation" should make a relation from current happenings "to future states and events". Stegmüller calls such a mode of explaining, that is reduced exclusively to the aspect of time, "formal teleology". For him, it has no "final necessity" as a result; but rather it is the very abstraction from goals and purposes. A "real material" (substantive) teleology, in contrast, has to do with purposes as "intentions to act" very much in the sense of strict causality,[11] and presupposes a "purpose-setting" will. Every "causal because-answer" should, at the same time, be able to be transformed into an "in-order-to-answer". That means, however, nothing other than reducing final causality to efficient causality. The "causa finalis" (final cause) is interpreted as a special case of the "causa efficiens" (efficient cause). Natural processes independent

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[8] Carl Gustav Hempel, *Aspects of Scientific Explanation* (London: Free Press, 1965), 297–330; cf. Richard Bevan Braithwaite, *Scientific Explanation. A Study of the Function of Theory, Probability and Law in Science* (Cambridge: Cambridge University Press, 1953), chapter 10; Ernst Nagel, *The Structure of Science. Problems in the Logic of Scientific Explanation*, Second Edition (Indianapolis–Cambridge: Hackett Publishing Company, 1979) (First Edition, New York, 1961), 401–428 ("12. Mechanistic Explanation and Organismic Biology. I. The Structure of Teleological Explanation"); cf. the discussion on teleological arguments in: Ernst Nagel, *Teleology and other Essays in the Philosophy and History of Science* (New York: Columbia University Press, 1979), 275–294 ("A. Goal-Directed Processes in Biology").

[9] Hempel, *Aspects*, 304; cf. 325.

[10] Wolfgang Stegmüller, *Probleme und Resultate der Wissenschaftstheorie und analytischen Philosophie* (Berlin–Heidelberg–New York: Springer, 1969), 518 ff. (second edition, 1983, 676 ff.).

[11] "Jeder Fall von echter Teleologie ist zugleich ein Fall von echter Kausalität" ("Every case of real teleology is a case of real causality at the same time"); Stegmüller, *Probleme und Resultate*, 521; cf. Peter Rohs' critique on Stegmüller: "Ist jeder Fall von echter Teleologie ein Fall von echter Kausalität?", *Zeitschrift für philosophische Forschung*, Bd. 38 (1984), 39–54.

of human actions (e.g., biological developments) do not, in this view, amount to an explanandum of teleological explanation or rather, keeping with the analogy, they can only be expressed, for all practical purposes, in an imprecise teleological manner. "Entelechies" (actualities) should only then be able to be spoken about when thereby "thinking and willing beings are to be understood".[1] If the teleological aspect of the study of nature is reduced in a way that "real" teleology equals "motive causality", then, indeed, the presupposed purpose-setting will may appear in relation to nature as divine will, which allows teleology to be regenerated in the form of physic-theology, and leads to an awareness of the invalidity of teleology as metaphysics or "myth". It is then supposed to be a question of a mere "apparently material teleology".[2] But that there are also forms of explaining nature, that are to be taken quite seriously and cannot be denied easily within the framework of physic-theology, is something beyond that view.

In the following, I would like to show that from the viewpoint of the history of philosophy and scientific theory there were irrefutable factual reasons,[3] that made the search for teleological principles a matter of concern in the study of nature in the 17th century.[4] At the same time, that should not be taken to mean that those same factual reasons would still be scientifically relevant today and would be suitable as justifiable grounds for the use of teleological principles in natural science. Nevertheless, I will proceed by analysing concepts of causation and their preconditions sketching in a first step the origin of teleological thinking in the natural philosophy of Aristotle (II); in a second step, I will cite references from modern philosophical thought, from which it should follow that the upswing of mechanism pushed aside the achievement of Aristotle on the one hand, but on the other hand aroused the need for

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[1] Stegmüller, *Probleme und Resultate*, 523: "Wer heute so etwas behauptet, kann nicht erwarten, vom Naturwissenschaftler ernst genommen zu werden […]" ("Who, nowadays, claims such things, may not expect to be taken seriously by the scientist").

[2] Stegmüller, *Probleme und Resultate*, 522.

[3] Under "factual reasons" I do not understand plain empirical facts depending on a certain chronological order (cf. Nicholas Rescher, *Scientific Explanation* (New York: The Free Press, 1970), 66–72). Rather I think of different theoretical concepts and principles used as arguments to prove explanatory hypotheses about natural phenomena. Of course, such new concepts and principles were needed for the explanation of observations and questions resulting from experiments made by researchers of biology. In this way we find a theory of biogenesis in the philosophy of Leibniz, which takes into account those results considering genesis and decay of living beings.

[4] Cf. Jeffrey K. McDonough, "The Heyday of Teleology and Early Modern Philosophy", in: *Early Modern Philosophy Reconsidered*, ed. John Carriero, *Midwest Studies in Philosophy* 35 (2011): 179–204. Margaret Osler, "Whose Ends? Teleology in Early Modern Natural Philosophy", *Osiris* 16, 1 (2001): 151–168.

a conception of purposive causality in order to explain nature completely (III); in a further step, I will show that this development, which took place in the conflict between scientific-philosophical self-understanding and objective deficits of explanation within mechanism, led to a revival of the Aristotelian understanding of teleology in Leibniz (IV). Finally, I try to describe the ambitious step of natural research to the origins of life sciences through the post-Leibnizian and post-Wolffian periods of metaphysics in 18th century and the ambiguous references to ancient approaches to teleological explanatory conceptions of nature involved in that advancement (V).

## II. The Origin of Teleological Explanation in Aristotelian Natural Philosophy

Aristotle ranks as the intellectual creator of an elaborated, that is, philosophically founded theory of purposiveness of nature and, along with it, of teleological explanation.[5] In his natural-philosophical writings, essentially in the context of his system of causes in the "Physics", he conceives finality on the one side as a special type of causation (alongside material cause, formal cause and effective cause), and, on the other side as the essence of causality of nature in general.[6] Surely, the idea of final causality, which was introduced in order to answer to the question relating to all natural change – "On account of what?" –, had been discussed earlier, e.g., in Plato's "Philebos" (54). Regarding Aristotle, however, teleological

[5] On the discussion of the many interpretations of teleology in Aristotle's natural philosophy, cf. among others, Uwe Arnold, *Die Entelechie. Systematik bei Platon und Aristoteles* (Wien–München: R. Oldenbourg, O. J.: 1969); Anthony Preus, *Science and Philosophy in Aristotle's Biological Works* (Hildesheim–New York: Georg Olms Verlag, 1975 (Studien und Materialien zur Geschichte der Philosophie. Kleine Reihe, Vol. 1)), 3–20, 183 ff.; Richard Sorabji, *Necessity, Cause and Blame. Perspectives on Aristotle's Theory* (London: Duckworth, 1980), 155–174; Wolfgang Kullmann, "Different Concepts of Final Cause in Aristotle", in: *Aristotle on Nature and Living Things. Philosophical and Historical Studies. Presented to David M. Balme on his Seventieth Birthday*, ed. Allan Gotthelf (Pittsburgh: Mathesis Publications, Inc. / Bristol: Bristol Classical Press, 1985), 169–175; Allan Gotthelf, "Aristotle's Conception of Final Causality", in: *Philosophical Issues in Aristotle's Biology*, ed. Allan Gotthelf, J. G. Lennox (Cambridge–New York etc.: Cambridge University Press, 1987), 204–242.

[6] Aristotle, *Physics* II.3 (194a27–30; 195a15–26); *De Partibus Animalium* I.1, (641b10–642a1). Cf. Wolfgang Kullmann, *Wissenschaft und Methode. Interpretationen zur aristotelischen Theorie der Naturwissenschaft* (Berlin–New York, Walter De Gruyter, 1974); Kullmann, *Aristoteles und die moderne Wissenschaft*, 255–312.

reasoning is spread out in many contexts of his work.[7] It is based as an instrument of scientific consideration on the structure of syllogism.[8]

Until today, the problem how the four types of causes are interconnected and how they relate exactly to the other aspects and different cases of causation, sketched in Aristotle's "Physics", has remained unsolved. Nevertheless, the essential topic, that plays the decisive role for rejection or acceptance of teleological founding of nature, seems to be clear. In his "Physics" (II.1), Aristotle demonstrates his concept of nature as the first principle of variation in such a manner that all the things coming to existence by nature have the source of change "within themselves" and therefore don't need any external impetus or actor (which, however, is the case in technics).[9] Thus he rejects the view that mechanical chains of causes and effects predominate in (sublunary) nature. The necessity of a divine author as well has no justification. According to "Metaphysics" (XII.2), matter is "potentially" the origin of all change and differentiation in nature. It involves in a way the potential for formation and motion of natural beings. At the same time, Aristotle remarks – similar to Leibniz later on – that the different manifold of natural things can't rise by homogeneous stuff.

The beginning of natural change is not set by divine creation, but it results from an uncreated, autonomous urge or desire for generation and development inherent in natural beings. In "Physics" (III, 1–3), Aristotle defines variation as "entelechy". This is a key term in understanding his theory of final causality. It is opposed to the concept of "dynamis" and relates firstly to the total process of change on a natural being that includes a moment of self-activity. Secondly, it signifies even energy ("Energeia"), which constitutes as impulse for activity a moment of the total process. However, "entelechy" doesn't mean – as often has been claimed – mere perfection or "coming to an end",[10] but rather self-acting realization of a form that already exists potentially. It is expressed in the permanently end- or form-guided self-realization of natural beings. Hence it follows that natural beings don't vary accidently, but according to the final destination inherent in a rudimentary way in themselves. In this way, for example, the growth of a plant is the realization of the natural tendency, which already contains the potential for formation of its specific properties as well as for the stages of evolution until procreation,

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[7] *Metaphysics* XII; *Physics* III; *De Anima* II; *De Caelo* II; *De Generatione et Corruptione* II. Cf. Kullmann, *Aristoteles und die moderne Wissenschaft*, 255–312.

[8] Aristotle, *Posterior Analytics* II.11.

[9] Although apart from this intrinsic principle all natural beings have within themselves a source of being changed by others (*Metaphysics* V, 12, 1019a15-16; cf. Allan Gotthelf, "Aristotle's Conception of Final Causality", 210–211).

[10] Cf. Wolfgang Kullmann, *Aristoteles und die moderne Wissenschaft*, 263 ff.

and finally until death. Certainly, final destination is not sufficient to complete the form. In addition to this, "entelechy" as continual process of variation combines the origin and the end of this proceeding. In this way, it constitutes the link between the simple possibility of variation and the finished action. Variation only will happen, if "entelechy" effects on itself. Thus, productive activity is an essential quality of "entelechy".

In the rather complicated third chapter of "Physics" concerning the process of variation, Aristotle makes a distinction between that on which change happens (or to which change is directed) and that which actually effects this change (this would be "energeia"). Accordingly, there are two variants of the significance of "entelechy", which are identical with regard to the process of variation, that is, they are essentially one and the same activity. This is because both moments belong to variation: the first is the realization of the variable, and the second is the action of the same entity as the cause of variation. Whereas the first is an activity of being acted upon (it is acting insofar as it receives an effect as transformation), the second is the activity of the acting (it is acting insofar as it effects on the variable). Both are inversely different from each other, like "the road from Thebes to Athens" and "the road from Athens to Thebes" (202b 13 f).[11] In this analogy the point of departure and the destination are only reversed. The road from Athens to Thebes equals potentially that from Thebes to Athens (because they are equidistant from each other), but not in reality. For, the conditions for traveling are different from each other, depending on the choice of the town for departure. But in abstract ideality, both movements are identical with regard to a third, i.e., "the road from Thebes to Athens *and* from Athens to Thebes". Their equality occurs only under the condition that there is only one way in thought. Analogically with that movement on the ancient Greek road, entelechy as acting activity and as passive activity are the same in relation to the varying process as a whole. Their difference only is one of the point of view. The result of the suffering activity is called "happening", the result of active activity, however, "work".

An also quite difficult passage in "Physics" is 200b 26 ff. On the basis of the demonstrated differentiation, this passage can be interpreted perhaps in the following way: on the one side, what is called "mere entelechy" means the active variation itself, which refers exclusively to what effects variation (abstracted from the substance on which alteration happens); on the other side, entelechy in conjunction with "dynamis" means only another aspect of reflection (not another kind of entelechy), that is to say, it includes the variable that changes only potentially with regard to itself.

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[11] Cf. the discussion in: Sarah Waterlow, *Nature, Change, and Agency in Aristotle's Physics* (Oxford: Clarendon Press 1982, paperback 1988), 182–183.

Aristotle presupposes these grounding determinations, which he has advanced in "Physics" (III.3) regarding the correlation of the conditions of realization ("entelecheia") and the principle of potentiality ("dynamis"), to some systematic investigations in his biological writings.[12] This concerns the explanation of the parts of living beings and of the processes forming these parts, above all his theory of procreation and evolution of animals. In the progenetive act, the seed, from which a living being develops, on the one hand potentially is a matter of the procreator in conjunction with the begotten. On the other hand, it includes as well an active moment of realization as a reference to what is variable.[13] In this concern, sperm is the substratum of a form that reproduces itself by procreation. But this intrinsic principle of organism (the realizing activity and the form) does not suffice to explain procreation and development of a living being. Aristotle therefore takes into account the dependence of animal genesis on external conditions of life (biotope, nutrition and digestion).[14] In consequence, the primary teleological context of causation and reasoning is not closed completely in itself. In the animal writings, the main criterion for classification of living beings according to species does not follow from empirical locating of typical properties alone, but from the functions of the limbs, that must be considered teleologically by means of concepts.

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[12] Cf. Richard Sorabji, *Necessity, Cause and Blame*, 155–174; Allan Gotthelf, *Aristotle's Conception of Final Causality*, 204–242; Allan Gotthelf (ed.), *Aristotle on Nature and Living Things* (Pittsburgh: Mathesis Publications, Inc., Bristol: Bristol Classical Press 1985); Wolfgang Kullmann, Sabinde Föllinger (ed.), *Aristotelische Biologie: Intentionen, Methoden, Ergebnisse*, Akten des Symposions über Aristoteles' Biologie vom 24.–28. Juli 1995 in der Werner-Reimers-Stiftung in Bad Homburg (Stuttgart: Steiner, 1997 (Reihe: Philosophie der Antike 6)); Horst Seidl, *Beiträge zu Aristoteles' Naturphilosophie* (Amsterdam–Atlanta, GA: Rodopi, 1995 (Elementa-Texte 5)), 114 ff.

[13] *De Partibus Animalium* I.1; *De Generatione Animalium* II.5; *De Anima* II. Cf. Wolfgang Kullmann, "Zum Gedanken der Teleologie in der Naturphilosophie des Aristoteles und seiner Beurteilung in der Neuzeit", in: *Zum teleologischen Argument in der Philosophie. Aristoteles – Kant – Hegel*, ed. Jürgen-Eckardt Pleines (Würzburg: Königshausen und Neumann, 1991), 162 ff.

[14] See therefore: Jochen Althoff, "Aristoteles' Vorstellung von der Ernährung der Lebewesen", in: *Aristotelische Biologie*, ed. Wolfgang Kullmann, Sabine Föllinger, 351–364.

## III. The Rejection of Aristotelian Teleological Principles by the Mechanistic-Mathematical View of Nature and Science

The Aristotelian understanding of nature had been for a long time the source of the conceptual means that could be used in constructing a theory of science, e.g., in medicine. Until early modernity, the canonical writings of the Aristotelian Galen (130–201) belonged to those textbooks,[15] from which the basic knowledge for the study of medical science (specifically of anatomy) had been acquired. At the beginning of modernity – starting with Galileo – the substantial influence that Aristotle had on scientific explanation and philosophical thought, was nearly lost, although there were a few remarkable exceptions here with regard to Galileo and Descartes.[16] In general, no adequate place could be found for Aristotelian (teleological) principles of natural philosophy within mechanistic conceptions.

The progress in science on the one hand and the development of natural philosophy on the other were mutually dependent.[17] Philosophy sought to reflect and to substantiate the conceptual assumptions of novel scientific discoveries and problems, because its main interest was to explain neither nature in general, nor living nature in particular, but to find and to reflect the natural and mathematical laws beyond the successful development of technology. Conversely, scientifically orientated theorists strove to integrate the results of studies from natural philosophy into their own theories and to put them into effect as methods. As a result, such philosophical elements marked an understanding of science that rejected ancient models in a specific manner.

From the viewpoint of the predominant scientific understanding, which depended among other things on the success or failure of experimental physics, Aristotelian natural philosophy was subjected to manifold changes in the course of its impact on intellectual evolution in Europe and these caused shifts in the interpretation of terms. Included

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[15] For the definition of the literary generic term of "textbook", cf. Charles B. Schmitt, "The rise of the philosophical textbook", in: *The Cambridge History*, ed. Schmitt, Skinner, 792–804.

[16] See below.

[17] It can be regarded as an open problem whether it is adequate to the history of science to contrast the picture of a new "natural science" in 17th century with the either progressive or traditional metaphysics and natural philosophy in a way which allows to talk about an impact of new developments of science on the course of early modern philosophy (cf. Donald Rutherford, *Innovation and orthodoxy*, 11 ff.). For, the question would be, where outside of philosophy and how "natural science" had been established and organized?

in this changing evaluation was the theory of purpose, in part with conflicting results: from ignorance and disparagement to acceptance and idealization.

In his treatise "Il saggiatore" (1623), Galileo (1564–1642) established by means of a new vocabulary of scientific language a strong mathematically oriented natural philosophy that replaced Aristotelian physics, especially the meaning of motion as alteration (growth and decay), even though he is bound up in Aristotelian thought on other points.[18] Despite of the fact that a critical view on Galileo's treatment of Aristotelian thought reveals the rejection of essential areas of Aristotle's natural philosophy, one has to concede that Galileo's knowledge on Aristotle's writings was on a high level. As is well known, he studied some important topics in detail. So, his critique on Aristotle cannot be read simply in a negative sense, but also as an affirmative attempt to understand the thinking of the Stagirite. Nevertheless, this way did not lead him to precise results based on systematic analysis.[19]

Francis Bacon (1561–1626) as a representative of modernity disrupted the Aristotelian philosophy of nature by explicitly excluding the concept of purpose from the canon of the four causes and banishing it as the means of explanation from science.[20] Certainly, he did not give up the aspect of teleology absolutely. Within the realm of human action, it retains its justifiability and is incorporated into his theological understanding of the world. Physics is bound to nature which is ruled

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[18] Cf. Wilfried Kuhn, *Ideengeschichte der Physik. Eine Analyse der Entwicklung der Physik im historischen Kontext* (Wiesbaden: Springer, 2001), 132–180. Cf. Jürgen Wiesner (ed.), *Aristoteles. Werk und Wirkung. Paul Moraux gewidmet*, Vol. II, *Kommentierung, Überlieferung, Nachleben* (Berlin–New York: De Gruyter, 1987). Cf. Michael Hunter (ed.), *Archives of the Scientific Revolution: the Formation and Exchange of Ideas in Seventeenth Century Europe* (Woodbridge: The Bydell Press, 1998).

[19] For detailed information, look William A. Wallace's differentiated study on Galileo's Aristotelism, in: "Aristotelian Influences on Galileo's Thought", in: *Aristotelismo Veneto e Scienza Moderna*. Atti del 25. Anno Accademico del Centro per la storia della traditione aristotelica nel Veneto. Vol. I, ed. Luigi Olivieri (Padova: Editrice Antenore, 1983), 349–378; cf. Robert Schnepf, "Zum kausalen Vokabular am Vorabend der 'wissenschaftlichen Revolution' des 17. Jahrhunderts – Der Ursachenbegriff bei Galilei und die 'aristotelische' *causa efficiens* im System der Ursachen bei Suárez", in: *Kausalität und Naturgesetz in der Frühen Neuzeit*, ed. Andreas Hüttemann (Stuttgart: Franz Steiner Verlag, 2001) (Studia Leibnitiana, Sonderheft 31), 15–46.

[20] "Recte ponitur; *Vere scire, esse per Causas scire*. Etiam non male constituuntur causae quatuor; Materia, Forma, Efficiens, et Finis. At ex his, Causa Finalis tantum abest ut prosit, ut etiam scientias corrumpat, nisi in hominis actionibus" (*Novum Organum*, Book II, in: *The Works of Francis Bacon. Faksimile-Neudruck der Ausgabe von Spedding, Ellis und Heath* (London 1857–1874. Stuttgart-Bad Cannstatt: Friedrich Frommann Verlag Günther Holzboog, 1963 (1858)), 228 (Aphorism II)).

by divine providence.[21] Bacon's new program of science attacks the conventional authority of philosophers of antiquity. He turns decidedly against Aristotle reproaching him for having ignored empiricism, when he laid the foundation for his understanding of nature; and therefore his knowledge of nature seemed to be useless for man and a hindrance for scientific progress.[22] Bacon rejects Aristotle's demand on the scientist to determine purposive causes in all areas of natural research. For him, teleological questions and arguments are not only useless to knowledge concerning nature, but even injurious, having stagnated the development of science and technics. Nevertheless, we must state that Bacon has been the originator of a program of science which, if carried out consequently, achieved a goal opposed to that program, namely the necessary adoption of end-directed explanations which he himself considered as unserious.

Descartes (1596–1650) finally breaks the hegemony of Aristotle. In his "Principia Philosophiae" (1644), he sketches the "model of automatic organism", that is, the idea that all living beings – except man – are to be considered to be soulless (insensitive) machines:[23]

> I freely acknowledge that the only matter that I recognize in corporeal things is whatever can be divided, shaped, and moved in every possible way – which is what geometers call "quantity" and take as the object of their demonstrations. Furthermore, the only aspects of this matter that I shall take into account are just these divisions, shapes and motions; and even with regard to them I won't admit as true anything that hasn't been

[21] "And although the highest generality of motion or summary law of nature God should still reserve within his own curtain, yet many and noble are the inferior and secondary operations which are within man's sounding" ("Valerius Terminus", Chap. 1, in: *Works*, Vol. III, 221). Concerning Bacon's reform of natural philosophy see in particular the comprehensive study of Stephen Gaukroger, *Francis Bacon and the Transformation of Early-Modern Philosophy* (Cambridge: Cambridge University Press, 2001).

[22] See for this, Stephen Gaukroger, *Francis Bacon*, 39 f, 81, 106–112; cf. also Jürgen Klein, "Bacon's Quarrel with the Aristotelians", in: *International Society of Intellectual History Conference "Quarrels, Polemics, and Controversies"*, Trinity College, Cambridge, 26–29 July 2001. Donald Rutherford, *Innovation and orthodoxy*, 21–26.

[23] See Daniel Garber, "Descartes' physics", in: *The Cambridge Companion to Descartes*, ed. John Cottingham (New York: Cambridge University Press 1992), 286–334 (esp. 303, 321–322); Alex Sutter, *Göttliche Maschinen. Die Automaten für Lebendiges bei Descartes, Leibniz, La Mettrie und Kant* (Frankfurt a. M.: Athenäum, 1988), 41 ff.; Ann Wilbur Mackenzie, "A word about Descartes' Mechanistic Conception of Life", *Journal of the History of Biology* 8, 1 (1975): 1–13. As Donald Rutherford comments on the abolishing of natural forms and Descartes' change to mechanism: "Apart from human minds, the natural world is a complex machine devoid of purpose, thought, or feeling" (Rutherford, *Innovation and orthodoxy*, 27).

> drawn from indubitable common notions in such an evident manner that it's fit to be regarded as a mathematical demonstration.[24]

Regarding Descartes' relation to Aristotelian natural philosophy, some critical remarks should be added here. First, when he assures his readers, not to have used any principle of natural explanation being in disharmony with Aristotle, he obviously is wrong. For, Aristotle in no way did reduce teleological arguments to mechanistic ones. Even in the "Meteorology" (I, 7), to which Descartes refers in an affirmative manner (citing from the original work),[25] one has to state that it was not the aim of Aristotle – as, however, it was that of Descartes – to confirm an analogy between the reasons for the unperceivable and the preconditions of that to be perceived. On the contrary, Aristotle claims that "we have given a sufficiently rational explanation" of unobservable things, if we have reduced them to things assumed to be possible (τὸ δυνατὸν). "Possible" things and observable things are not synonymous. Second, Descartes is not in accordance with Aristotle, when he claims that the end of natural philosophy would be to explain natural phenomena:

> That's all that is needed for practical applications in ordinary life, because medicine and mechanics – and all the other arts that can be fully developed with the help of natural science – are directed only towards the phenomena of nature, i.e. towards items that are sense-perceptible. Do you think that Aristotle achieved more than this, or at least wanted to do so? If so, you are wrong. At the start of his Meteorology 1:7 he says explicitly, regarding his reasons and demonstrations concerning things not manifest to the senses, that he counts them as adequate so long as he can show that such things could occur in accordance with his explanations.[26]

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[24] Translation by *Jonathan Bennett 2010–2015* (based on the edition by John Cottingham, Cambridge University Press), 44. (Nam plane profiteor me nullam aliam rerum corporearum materiam agnoscere, quam illam omnimode divisibilem, figurabilem & mobilem, quam Geometriae quantitatem vocant, & pro objecto suarum demonstrationum assumunt; ac nihil plane in ipsa considerare, praeter istas divisiones, figuras & motus; nihilque de ipsis ut verum admittere, quod non ex communibus illis notionibus, de quarum veritate non possumus dubitare, tam evidenter deducatur, ut pro Mathematica demonstratione sit habendum (René Descartes, "Principia Philosophiae", P. II, No. 64, in: *Oeuvres de Descartes, publiées par Charles Adam & Paul Tannery*, Vol. VIII-1 (Paris: Léopold Cerf, 1905), 78 f.).

[25] René Descartes, "Principia Philosophiae", IV, § 204, in: *Oeuvres*, Vol. VIII-1, 327.

[26] *Jonathan Bennett 2010–2015* (based on the edition by John Cottingham, Cambridge University Press), 70. (Hocque etiam ad usum vitae sufficiet, quia & Medicina, & Mechanica, & caeterae artes omnes, quae ope Physicae perfici possunt, ea tantum quae sensilia sunt, ac proinde inter naturae phaenomena numeranda, pro fine habent. Et ne quis fortè sibi persuadent, Aristotelem aliquid ampliùs praestitisse, aut praestare voluisse, ipsemet in primo Meteorologicorum, initio capitis septimi, expresse testatur, de iis quae sensui non sunt manifesta, se putare sufficientes rationes

Third, Descartes conflicts with Aristotle through the opinion that the "Substantial Form" could be reduced to sensual quality.[27]

Fourth and finally, he differs from Aristotle substantially in comparing works of art (technics) – as, for example, clockworks – with products of nature, like trees.[28] He argues that causal explanation of organisms' transformation and growth is to be understood like that of machines, because only the latter is observable through human cognition by its magnitude; and therefore, the scientist had to draw a conclusion from observable bodies to invisible parts, which would be still material. In this way, the growth of a plant would be nothing else but the aggregation of invisible corporeal substances, although this could not be demonstrated strictly (because of the lack of empirical proof).[29]

Up to the days of Newton (1643–1727), the Aristotelian teleology of nature, which had been rejected from the standpoint of a mechanistic understanding of nature, underwent no fundamental change. What position do the Newtonian teachings on nature take towards teleological reasoning?

Newton's philosophical considerations emerge most clearly in the four "rules of philosophizing" ("Regulae Philosophandi") at the beginning of the third book of the "Principia" and in the propositions of the "General Scholium", which was attached to the third book as from the 2nd edition (1713, first published in 1686). The "rules of philosophizing" remind one remotely of the "Regulae" of Descartes inasmuch as they are supposed to determine the scientific method for knowing nature. As in the three books altogether, Newton claims to proceed mathematically when setting up these rules too, that is, in a certain sense all of his principles of physics are mathematical principles. The designation as mathematical is also brought about by him applying the geometrical manner of representation to his work, that is, his theorems are derived from definitions and axioms as in the "Elements" of Euclid.

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& demonstrationes afferre, si tantùm ostendat ea ita fieri posse, ut à se explicantur. (René Descartes, "Principia Philosophiae", IV, § 204, in: *Oeuvres*, Vol. VIII, 327)).

[27] René Descartes, "Principia Philosophiae", IV, § 198, in: *Oeuvres*, Vol. VIII, 321–323.

[28] Idem, "Principia Philosophiae", IV, §§ 203–204, in: *Oeuvres*, Vol. VIII, 325–327.

[29] I fully agree with Stephen Gaukroger, who points out that "this kind of approach is, of course, wholly qualitative and speculative, but it does have a definite content: it shows a clear commitment to a micro-corpuscularian form of explanation, in stark contrast with Aristotelian natural philosophy" (*Descartes' System of Natural Philosophy* (Cambridge: Cambridge University Press, 2002), 172). The conclusion, which must be drawn from this interpretation is, indeed, with the words of Gaukroger, that "these objections show the mechanical underpinnings of Descartes' approach to micro-corpuscularianism, and, even though those underpinnings might not be so evident in the kind of matter-theoretic approach he adopts in the cases we have looked at, it is there in reserve, so to speak […]" (*Descartes' System*, 173).

These rules are based on simple – one could say, naive-sensory – ideas and their inductive generalization; e.g., the same causes must be attributed to equal effects: "Thus to the breathing of man and animal, to the falling of stones in Europe and America, to the light of fire in the stove and on the sun […]".[30]

The metaphysical assumption of the so-called "eternal truths" (essences of things originally produced by God's wise understanding) is rejected by Newton; but he even accepts hypotheses only in the form of propositions that are able to be confirmed by experience. In his mind, they are not absolutely invariable; their content of truth is expressed by a degree of probability.

Had Newton on the one hand intended, in opposing the Aristotelians, to banish definitions of the essence of things from science as being occult qualities,[31] he was, on the other hand, confronted with the task of explaining scientific concepts, like gravitation, electricity, magnetism, and so on. Therefore, he was obliged to operate with such conceptual constructions, whose use he originally aimed to avoid. He thought, he could solve the methodical difficulties connected with this, first, by relating such concepts of natural science (like gravitation) to general laws of nature and not to occult qualities (definitions of essence as causes), and second, by defining things through these laws and having the truth of natural laws be a result of facts of observation. The general principles of motion should, however, be derived empirically from the phenomena of nature.[32]

In Newton's doctrine of nature, elements occur that may be considered as contradicting his rigorously mechanistic view on nature. As a far-reaching conclusion turns out, namely, the dependence of his empirical theory of nature on metaphysics to a high degree; this theory is

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[30] (My own translation), Regula II: "*Ideoque Effectum naturalium ejusdem generis eaedem assignandae sunt Causae, quatenus fieri potest*. Uti respirationis in Homine & in Bestiâ; descensûs lapidum in Europâ & in Americâ; lucis in igne culinaris & in Sole; reflexionis lucis in Terrâ & in Planetis", in: *Isaac Newtoni Opera Qae Exstant Omnia. Commentariis Illustrabat Samuel Horsley*, London, 1782, Reprint Stuttgart-Bad Cannstatt, 1964, Vol. III, 2.

[31] "[…] Occult qualities put a stop to improvement of Natural Philosophy, and therefore of late years have been rejected. To tell us, that every species of things is endowed with an occult specifick quality, by which it acts and produces manifest effects, is to tell us nothing […]" (Isaac Newton, "Optics, or, a Treatise of the Reflections, Refractions, Inflections and Colours of Light", in: *Opera*, 1964, Vol. IV, 261).

[32] "[…] to derive two or three general principles of motion from phaenomena, and afterwards to tell us how the properties and actions of all corporal things follow from those manifest principles, would be a very great step in philosophy, though the causes of those principles were not yet discovered [...]" (Isaac Newton, "Optics", in: *Opera*, Vol. IV, 261).

imbedded in teleological terminology. It may be supposed that the central category of the Newtonian explanation of nature, that is the concept of mechanically effecting cause, requires a non-empirical constituent part of the theory for its completion; otherwise a gap would remain in explaining nature. This supposition becomes manifest with the surprising use of teleological arguments (including the concept of purposiveness) and the flight into the concept of God.[33] Thus, despite of his insisting on the general validity of the basis of observation and of mechanical causality, the Leibnizian conclusion to permit two independent complementary principles of nature seems to be unavoidable. In the "General Scholium" of the "Principia", Newton concedes, in some way, a physic-theological justification to mechanically effecting nature. He thinks to be in accordance with some philosophers of antiquity, like Thales, Pythagoras, Anaxagoras and others, when he claims that God is present at all times and everywhere, and this not only virtually but substantially. Therefore, he is equal to himself being "entirely eye, entirely ear, entirely brain, entirely arm, entirely the force of perception, of understanding and of acting, but in no way bodily, but in a way, that is totally unknown to us". Nature as a whole is interweaved with God. He is characterized as the omnipresent agent, the first cause of motion. All things move and exist in him. Even for the discovery that contributed to Newton's fame, that is gravitation (as the universal effective force of matter, by which bodies tend towards others), it must be true that gravitation cannot be considered as a phenomenon of mere inanimate matter, but that there is a need for an intellectual source. Of course, Newton concedes, that he is unable to state this cause:

> That gravity should be innate, inherent and essential to matter, so that one body may act upon another at a distance through a *vacuum*, without the mediation of any thing else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking, can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers.[34]

One possible answer to this and similar questions concerns the doctrine of God. Just as the universal order can't be reasoned and sustained

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[33] I do not see that consequence as a simple reaction of compatibilism which may be a typical attitude for a range of representatives of early modern philosophy (cf. Donald Rutherford, *Innovation and orthodoxy*, 32–33)). Rather it should be interpreted as an objective necessity for a full explanatory system of nature.

[34] Isaac Newton, letter to Bentley, 2, 25,1692/3 (*Opera*, Vol. IV, 438); cf. Isaac Newton, letter to Bentley, Feb. 11, 1693 (*Opera*, Vol. IV, 441).

without the assumption of an intelligent creator of the universe, the way of function of organisms and even general gravitation are unexplainable by mechanical causes alone. It is necessary to resort to a first, non-mechanical cause as the invisible (unobservable, empirically unascertainable) and thereby undeterminable first reason of natural explanation. Since the lawful relations in nature are specific elements of the universal order that is directed by God, the divine creation of the world can be concluded from those regularities. The planetary motions, e.g., are unconceivable without the recourse to a supernatural, intelligent cause:

> To make this system, therefore, with all its motions, required a cause which understood, and compared together, the quantities of matter in the several bodies of the sun and planets, and the gravitating powers resulting from thence.[35]

Similarly, Newton teaches in the "Scholium Generale":

> But it is not to be conceived that mere mechanical causes could give birth to so many regular motions, since the comets range over all parts of the heavens in very eccentric orbits […]. This most beautiful system of the sun, planets, and comets could only proceed from the counsel and dominion of an intelligent and powerful Being.[36]

The planetary system presupposes an intelligent divine power as the origin of celestial harmony:

> […] the diurnal rotations of the sun and the planets, as they could hardly arise from any cause purely mechanical, so by being determined all the same way with the annual and menstrual motions, they seem to make up that harmony in the system, which […] was the effect of choice, rather than chance.[37]

According to Newton, nature can't continue at all independent of the influence of God. He is not only the creator, but also the preserver of the

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[35] Isaac Newton, letter to Bentley, Dec. 10, 1692 (*Opera*, Vol. IV, 431).

[36] *Newton's Philosophy of Nature*, Selections From His Writings, Edited and Arranged with Notes by H. S. Thayer, Introduction by John Herman Randall, Jr. (New York–London: Hafner Press, 1953), 4th printing 1974, 42 (Et hi omnes motus regulares originem non habent ex causis Mechanicis; […] Elegantissima haecce Solis, Planetarum & Cometarum compages non nisi consilio & dominio Entis intelligentis & potentis oriri potuit. (Newton, *Opera*, Vol. 3, 171)). For the discussion of the significance of the *General Scholium* see: J. Bernard Cohen, "A Guide to Newton's *Principia*", chapter 9, in: Isaac Newton, *The Principia: Mathematical Principles of Natural Philosophy*, transl. by I. Bernhard Cohen and Anne Whitman (Berkeley: University of California Press, 1999).

[37] Isaac Newton, letter to Bentley, Dec. 10, 1692 (*Opera*, Vol. IV, 433).

universe. Only his intelligence guarantees the stability of the planetary system, the general order of nature and of the whole universe. From time to time he even has to intervene into our solar-system to preserve its order. Accordingly, the ability to alter natural laws at will is also attributed to God. Conversely, God is also recognized through nature:

> We know him only by his most wise and excellent contrivances of things and final causes; we admire him for his perfections, but we reverence and adore him on account of his dominion, for we adore him as his servants; […].[38]

The conclusions about God attained by understanding nature in no way are a simple accessory, but a necessary constituent of Newtonian natural philosophy:

> And thus much concerning God, to discourse of whom from the appearances of things does certainly belong to natural philosophy.[39]

With these determinations, on the one hand, Newton integrates elements of physic-theology into his theory of nature; on the other hand, he anticipates a teleological, not absolutely necessary (causally determined) structure of nature, as it will be worked out later on, for the first time systematically, by Christian Wolff (1679–1754) within the tradition of Leibnizian philosophy. Newton holds the opinion that the variability of natural phenomena just can't be explained by strictly causal mechanism. This insight is coupled with the problem of the relation between determinism and freedom, and correspondingly between mechanism and purposiveness in nature:

> Blind metaphysical necessity, which is certainly the same always and everywhere, could produce no variety of things. All that diversity of natural things which we find suited to different times and places could arise from nothing but the ideas and will of Being necessarily existing.[40]

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[38] *Newton's Philosophy of Nature* ([4]1974), 44 (Hunc cognoscimus solummodo per proprietates ejus & attributa, & per sapientissimas & optimas rerum structuras & causas finales, & admiramur ob perfections. (Newton, *Opera*, Vol. III, 173))

[39] *Newton's Philosophy of Nature* ([4]1974), 44–45 (Et haec de Deo; de quo utique ex Phaenomenis disserere, ad Philosophiam Naturalem pertinet (Newton, *Opera*, Vol. III, 173)).

[40] *Newton's Philosophy of Nature* ([4]1974), 44 (A caeca necessitate metaphysica, quae utique eadem est semper & ubique, nulla oritur rerum variatio. Totum rerum conditarum pro locis ac temporibus diversitas, ab ideis & voluntate Entis, necessario existentis, solum modo oriri potuit (Newton, *Opera*, Vol. III, 173)).

In other words, it was the action in accordance with a rational aim (by God), that produced the manifold and order of all natural things. Thereby, a fatalistic view on nature would be averted.

The limitations of their own mechanistic principles of nature and of their explanatory extent in favour of natural sciences, is surely one of the most remarkable concessions made by Newtonian natural philosophy:

> […] the main business of natural philosophy is to argue from phaenomena without feigning hypotheses, and to deduce causes from effects, till we come to the very First cause; which certainly is not mechanical: and not only to unfold the mechanism in the world, but chiefly to resolve these and similar Questions [that means, questions about the cause of gravitation and about the functioning of organisms; WE].[41]

Thus, mechanistic causality by itself leads with necessity to the postulate of a primary, absolute cause that produces effects purposively. It's the nature of force in itself, which needs an aim or a form in order to qualify for determination at all. This consequence is not motivated essentially by the Christian view of life, but it results objectively from the limitations of mechanism. At this point, a contradiction within the Newtonian program of a purely empirical (inductive) reasoning of nature, free from metaphysics, obviously comes to light. This contradiction may be characterized in the following way: there arise necessarily (that is, by systematic reasons) deficits in explanation from demand and defence of an empirically orientated theory of nature. Although mechanism is advocated, it becomes necessary to adopt non-empirical doctrines or theories including concepts of non-mechanical causes as a condition for well-founded natural philosophy.

As we have seen, Newton explicitly denies the mechanical character of a "very first cause". Such cause would be the logical consequence of the structure of causal chains, because each member of such chains, interpreted as effect, requires another cause, and such in an infinite regression. So the thinker in nature is forced to allow, against his own assumptions and pretentions, to insert a teleological principle which is in the first position cause and effect in one and the same respect and at the same time. Only a purpose-directed thinking can fulfil such necessity. I'm talking here about causes as ends in nature itself, not as mere ideas or programs in the hands of a supernatural actor as his own practical purposes. This is even the case in Newton's natural philosophy. This theory starts with Leibnizian revision of Cartesian theory of matter as equipped with the capacity of self-movement through active (spontaneous) forces.

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[41] Newton, "Optics", in: *Opera*, Vol. IV, 237.

Therefore it would be wrong to maintain that God can still be regarded as an efficient cause even in the case of the first spiritual cause of motion.

## IV. Leibniz and the Rediscovery of Aristotelian Principles of Natural Philosophy

In contrast to Newton's more casually than conceptually made confession to non-mechanical causation of nature, Leibniz opens the discussion on adequate principles by adopting central aspects of Aristotle's insights in scientific explanation. For what reason does he want to rehabilitate Aristotelian substantial forms and to cleanse it of scholarly misuse? He criticizes the textbook tradition (Aquinas, Albertus Magnus, Suarez), because of the underlying misunderstanding concerning central aspects of Aristotle's writings. There were some French and English thinkers (e.g., Arnauld, Boyle), who had tried to destroy and eliminate the concept of *substantial form* from metaphysics. Others, like Ralph Cudworth[42] (1617–1688) and William Harvey[43] (1578–1657), in contrast, noted the remarkable output of Aristotelian principles of natural philosophy.

Leibniz's aim in scientific research is to get a reliable universal principle, first, in order to reform metaphysics systematically, and second, to gain a rational basis for the causal explanation of nature and science. In the midst of 1680s he creates his "New System of Nature",[44] which he

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[42] Ralph Cudworth, *The True Intellectual System of the Universe*, London 1678 (Faksimile-Neudruck, Stuttgart-Bad Cannstatt: Friedrich Frommann Verlag Günther Holzboog, 1964); cf. Andreas Hüttemann, "Über den Zusammenhang zwischen *plastic natures*, *spirit of nature* und dem Naturbegriff bei Cudworth und More", in: *Kausalität und Naturgesetz*, ed. Andreas Hüttemann (Stuttgart: Franz Steiner Verlag, 2001), 139–153, esp. 139–140, 147–153.

[43] William Harvey, *Exercitationes de generatione animalium, quibus accedunt quaedam de partu, de membranis ac humoribus uteri et de conceptione* (London, 1651); *Disputations touching the generation of animals*, transl. with introduction and notes by Gweneth Whitteridge Boston: Blackwell Scientific; St. Louis, Missouri: distributed in the United States of America by Blackwell Mosby Book Distributors, 1981. Cf. Angelo Capecci, "Finalismo e meccanicismo nelle ricerche biologiche di Cesalpino e Harvey", in: *Aristotelismo Veneto*, ed. Olivieri, Vol. I, 477–507. Cf. Walter Pagel, "The reaction to Aristotle in seventeenth-century biological thought", in: *Science, Medicine and History. Essays on the Evolution of Scientific Thought and Medical Practice written in honour of Charles Singer*, ed. E. Ashworth Underwood (Oxford–London–New York: Oxford University Press, 1953), Vol. I, 489 ff, spec. 501 ff.

[44] First published in the *Journal des Scavans*, 1695, with the title: "Systeme nouveau de la nature et de la communication des substances, aussi bien que de l'union qu'il y a entre l'ame et le corps", in: *Die philosophischen Schriften von Gottfried Wilhelm Leibniz*, ed. Carl Immanuel Gerhardt, 7 Vols. (Berlin 1875–1890. Nachdruck Hildesheim: Olms, 1961–1962), Vol. IV, 477–487.

discussed in the course of time with other well-known scientists of his days, especially with Antoine Arnauld (1612–1694).[45] The main thesis is that substance is an agent; it is mind, not matter or stuff. Pure abstract matter, however, is not animated but completely inactive and dead. Leibniz situates the first principle of action in nature, not just – like Newton – in divinity. Altering in this distinct way the meaning of substance as it was determined by Descartes, enables Leibniz to regard natural things as living individuals and to explain their movement and variation with the help of purposiveness. Leibniz claims to analyse and to clarify the traditional concept of substance. He rejects particularly the attribute of spatial extension as a characteristic of corporeal substance, for it was exactly this rigid quality that had determined the mathematical interpretation of nature and its laws, and that had led to errors[46] and unwanted limitations[47] regarding the solution of problems in mechanics, especially those referring to the explanation of motion. He searches for the principles of a "true unity" in order to reestablish the "First Philosophy" (or Metaphysics) as the basic science, that the philosophers called for from the time of Aristotle. In Leibniz's view, the conventional systems, with which he competed (Cartesianism, Occasionalism, Atomism, Scholasticism), had failed to solve this problem. Unity defined in this way, couldn't be constructed by matter alone, because this was understood as being an aggregate and thus essentially as a discrete plurality. All the many and the material conversely had to be based on this first unity. Substance is simple, that is, an indivisible unity. Taken in this general, abstract determination, however, it would be vague or empty; further, it would be undistinguishable from other substances. But since the substances, which he later on (around 1696) called "Monads", must be distinctive from each other because of their individuality, a principle of inner differentiation was required, that could not be identical in meaning with the plurality of parts. Leibniz saw the solution to this difficulty in providing substance equipped with a primitive force. He was able to take up their qualities and aspects entirely from the Aristotelian concept of "entelechy", to which he turned certainly from 1667 (at first, however, just hesitatingly).[48] A large published edition of Leibnizian manuscripts

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[45] Gottfried Wilhelm Leibniz, letter to Arnauld, 4,30,1687, in: Gottfried Wilhelm Leibniz, *Die philosophischen Schriften*, Vol. II, 96 ff.

[46] For example, concerning Descartes' laws of motion in: *Principia* II, §§ 46–52 (*Oeuvres*, Vol. VIII, 68–70); Gottfried Wilhelm Leibniz, *Specimen dynamicum* I, § 15, ed. and transl. by H. G. Dosch, G. W. Most, E. Rudolph (Hamburg: Felix Meiner Verlag, 1982), 28–33.

[47] E.g., with regard to the statement that living beings, with the exception of man, do not possess a soul.

[48] Cf. Enno Rudolph, "Die Bedeutung des aristotelischen Entelechiebegriffs für die Kraftlehre von Leibniz", in: *Leibniz' Dynamica. Symposion der Leibniz-Gesellschaft in der*

sheds more light on the fact that Leibniz got his knowledge about Aristotelian philosophy mainly through the original writings of the Stagirite, in detail, through the biological books and through the "Physics", and, in consequence, that he did not only adopt thoughts from late-antique or early-medieval commentary tradition.[49]

In analogy to the soul, he conceived the primitive force as a primary activity, which aims to generate all modifications (perceptions) of the simple form of substance by itself, thus forming a uniform whole. It is consistent with this when he stresses in his "Monadology" (§ 17) that the perceptions of substance are unexplainable mechanistically, because mechanistic explanations would treat the substance as an aggregate and confuse coming to be and passing away with combining and separating parts. In contrast to that, Leibniz favours a dynamic understanding of substance, which he applied then to the theory of organic natures.

The importance of the Aristotelian concept of entelechy, according to Leibniz, consists in that it seems to be a suitable and adequate means for explaining spontaneous change through itself.[50] In contrast to the scholastic commentaries on Aristotle, Leibniz interprets entelechy not as a mere faculty that still requires an external impulse, in order to become efficient, but as the first principle of realization. It is the nodal point between the bare faculty and the productive activity itself.[51] Although the primitive force existing in every corporeal substance is declared to be the ultimate reason for motion in matter, and although it possesses striving and appetite ("conatus", "appetitus") to develop its own action autonomously, it has been placed in substances by the divine act of creation.

The whole conception of monads presupposes the validity of the purposive principle, expressed by the concept of entelechy.[52] Notwith-

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*Evangelischen Akademie Loccum, 2. bis 4. Juli 1982*, ed. Albert Heinekamp (Stuttgart, 1984 (Studia Leibnitiana, Sonderheft 13), 49–54; Theodor Ebert, "Entelechie und Monade. Bemerkungen zum Gebrauch eines Aristotelischen Begriffs bei Leibniz", in: *Aristoteles*, ed. Jürgen Wiesner, Vol. II, 567 ff; Enno Rudolph, "Entelechie, Individuum und Zeit bei Leibniz", in: *Zeit und Logik bei Leibniz. Studien zu Problemen der Naturphilosophie, Mathematik, Logik und Metaphysik*, ed. Carl Friedrich von Weizsäcker, Enno Rudolph (Stuttgart: Klett-Cotta, 1989), 101–126.

[49] Cf. Gottfried Wilhelm Leibniz, *Sämtliche Schriften und Briefe*, Hrsg. von der Preußischen Akademie der Wissenschaften, Berlin 1923 ff. Reihe VI: Philosophische Schriften, Vol. IV (1677–1690), Berlin 1999.

[50] Leibniz's use of the term of "entelechy" is documented, e.g., in the following of his writings: "Monadologie" (§§ 14, 18); "Systeme nouveau" (3), in: Leibniz, *Die Philosophischen Schriften*, Vol. IV, 473; "Specimen dynamicum" (1695), I (1), (3), (11); "Essais de Theodicée" (§ 87), in: Leibniz, *Die Philosophischen Schriften*, Vol. VI, 149 f.

[51] "De primae philosophiae Emendatione, et de Notione Substantiae", in: Leibniz, *Die Philosophischen Schriften*, Vol. IV, 469.

[52] Cf. Gottfried Wilhelm Leibniz, *Monadologie*, §§ 14, 18. I widely agree to the interpretation of Zev Bechler, *Newton's Physics and the conceptual structure of the*

standing that, the relation of this concept to the matter of physics, which is prominent in "Specimen dynamicum" (1695), Part I, is problematic. I can't deal here with the contradictions and difficulties resulting from that with the relation to the foundations of metaphysics. A particular problem concerns the definability of organic and inorganic nature, and correspondingly of body and soul. But, among other things, it can be deduced from the new Leibnizian definition of substance as a true unity that the substance autonomously produces the order of its perceptions and the order of those parts of the body, which are combined with it. In other words, substance is self-organizing. The organism of a living being is the product of substantial activity. Differences of species result exclusively from a certain degree of potential evolution or perfection of substance. These differences are predetermined through the creation of substances and remain unalterable until their supernatural destruction. Therefore, it is impossible that further species will spring from nature or that existing species will be obliterated by natural influence. Every substance can vary only within the limits of its previously determined organizing form. Even birth and death are moments or stages of their metamorphoses. The death of an animal, for example, appears only as a temporary state of anaesthesia, not as the end of living at all. In this connection Leibniz refers to experiments of researchers of his time in order to support his theory (e.g., to the experiments on insects by Marcello Malpighi, 1628–1694).[53] The theory of biogenesis in Leibniz's philosophy of nature includes the hypothesis that every created animal is completely created right from the beginning of its existence (e.g., in embryo). Its evolution actually corresponds with the increase of extensive quantity or extension.

In opposition to Descartes and some Cartesians, Leibniz stresses the importance of the fundamental difference between technical and natural machines (organisms). Here, the concept of the machine stands for organization. In contrast to technical apparatuses, machines of nature are indestructible, because they consist of an infinite number of organs. Fundamentally, every change is an act of reproduction, by which the living being keeps itself alive. The guarantee of this self-preservation is the primary activity or entelechy. Turning to Descartes, who is regarded as the initiator of the "machine-theoretical view of nature",[54] his theory completely lacks a corresponding autonomous institution of self-or-

*scientific revolution* (Dordrecht–Boston–London: Kluwer Academic Publishers, 1991) (Chap. 15, "Leibniz' Aristotelian Philosophy of Nature"), esp. 437–441, 451–454.

[53] Marcello Malpighi, *Anatome plantarum. Cui subjungitur appendix, iteratas & auctas ejusdem authoris de ovo incubato observationes continens* (Londini: Johannes Martyn, 1675–1679).

[54] Cf. Eve-Marie Engels, *Die Teleologie des Lebendigen*, 86 f.

ganization and self-regulation, so that, e.g., animals are considered to function like mechanical bodies.[55] The objective reason for comparing an organism with a technical machine is the complexity (differentiation) of the organization and the cooperation of the parts (e.g., in a clockwork) for the functioning of the unity of the whole thereby constructed. The structure of this whole is arranged purposively and presupposes an external actor (the clock-maker) as the origin of teleological activity.[56] The fundamental problem that arises from the machine-theory of living creatures is that it supplies no sufficient model of explanation to wide areas of phenomena in living nature. In addition to Leibniz, other natural philosophers of his time doubted fundamentally whether mechanism could be adequate to living nature.[57]

Later on, Leibniz even understands the entelechy of substance as life-principle of organic bodies.[58] Such substances are considered to be spread in the whole nature. Nevertheless, the existence of inorganic, inanimate matter is maintained as well. Certainly, Leibniz was not able to explain sufficiently the difference between organic and inorganic matter by his theoretical means. This is and remains a metaphysical deficit in reasoning within his natural philosophy. Teleology as an approach to researching nature has its borderlines, even in the case of Leibniz. On the one hand, the substance, of course, is able to spontaneously develop the form that has been put inside of it; the individual form as such, however, is predetermined, and appears as the work of God. Thus, the form is not determined by the activity of substance. On the other hand, there is no real interaction between substances, so that their external coherence in the world may be constituted by pre-established harmony alone.

So, what is the benefit of Leibniz's claim for a teleological grounding of substance and organic nature? Two answers may be given: First, predetermination is accepted and stressed by his follower Christian Wolff and widespread as physical-theological naturalism. Afterwards, in the later 18th century, pre-determinism is rejected by natural history and epigenetic vitalism. Second, a process theory of natural things, above all, of organisms, including genesis, growth and decay, is accepted by life sciences and limits the general validity of mechanical principles in nature, although many problems arising from the "New System of Nature"

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[55] Cf. Alex Sutter, *Göttliche Maschinen*, 41 ff.

[56] Cf. Eve-Marie Engels, *Die Teleologie des Lebendigen*, 88.

[57] So, look to the physician Georg Ernst Stahl (1660–1734) in his *Theoria Medica Vera*: *physiologiam & pathologiam, tanquam doctrinae medicae partes vere contemplativas, e naturae & artis veris fundamentis, intaminata ratione, & inconcussa experientia sistens*, Halae: Literis Orphanotrophei, 1708.

[58] See Gottfried Wilhelm Leibniz, "Considerations sur les Principes de Vie, et sur les Natures Plastiques, par l'auteur du Système de L'Harmonie preétablie" (1705), in: *Die Philosophischen Schriften*, Vol. VI, 539 ff.

concerning nature remain unsolved or even unsolvable, as there are the problem of interaction and unity of mind and body, the problem of defining inorganic matter, and so on.

The doctrine of nature based on Leibniz's new metaphysics of substance, on the one hand implies essentially teleological principles: genesis and decay of living beings are aimed at the self-preservation of their substantial unity; and they are produced by the spontaneous activity of this unity. From this point of view, the decisive stimulation to the elaboration of the theory of evolution (doctrine of preformation) of living beings and to the teleological thinking about nature has been given. On the other hand, this teleological view continues to be rooted in a mechanistic conception of nature as a whole. Teleology is installed in the mechanical world-machine, whose components and construction are created by God. Not only the external correlation of substances, but also and in particular the relation of corporeal parts to substances is based on mechanical causality, which has its final cause in God. Even the soul is performed by him. The theory of preformation, introduced by Leibniz, appears – as in particular paragraph 403 of the "Theodicée" elucidates – as a mechanistic theory of procreation, although, with regard to the soul, Leibniz explicitly declares: "L'operation des Automates spirituels, c'est à dire des Ames, n'est point mecanique, mais elle contient eminemment ce qu'il y a de beau dans la mecanique […]".[59] The "beauty of mechanics" undoubtedly is the technical organisation of machines, that is to say, the cooperation of the parts in order to constitute a whole with respect to the divine origin of organization.

## V. Post-Leibnizian Teleology within Philosophy and Science in the Eighteenth Century

The development of the problem of teleology not only achieved universal significance – outlined above – for philosophical reasoning in the theory of nature and for the grounding of natural science, but it seems to belong eminently to the theoretical foundations of those particular sciences whose topic is living nature. The progress of Biology mainly depended on the use of the principle of final causation in explaining special processes of nature, e.g. the doctrine of genesis, growth, and variation of organisms.

Thus, it is right to appreciate that organized nature with the view to teleological principles is a genuine part of Biology. Therefore, a systematically conceptualized, mature theory of the organism was a necessary

[59] Idem, "Theodicée", in: *Die Philosophischen Schriften*, Vol. VI, 356.

precondition for a response to special problems of this science. Such a theoretical approach to natural theory corresponded exactly with a real existing scientific need for clarification.

The concept of "Teleology" was first introduced into written German Philosophy by Christian Wolff, who in 1723 published a book under this title. A short time later he also discussed natural teleology in his "German Physiology" (1723). On the one hand metaphysics and natural philosophy in Wolff are combined with thoughts of Leibniz, on the other hand it emancipates itself from the ideas of his model teacher. But his doctrine of natural things is also a negative proof for the fact that by reducing everything purposive in nature to the intentions of God the teleological explanation of nature is given up for arbitrariness. This statement stands in opposition to the author's claim for rigorous evidence. In the so-called "German Physiology", one may find examples of this kind of explanation and demonstration that are sometimes amusing. Their formalism excludes really objective referential teleological explanation of natural phenomena, e.g., on the use of the feet. Wolff argues in the following way: Feet are given to man and animal for the purpose to keep steady and to walk from one place to another. A man has two feet in order to achieve more steadiness. The reason is taken from ordinary experience: A corpus with a wide foot has more steadiness than another with a small foot, e.g. a pot in comparison with a cup. Two soles are wider than one. Therefore it is useful to have two feet.[60]

The goal of the Wolffian teleology lies exactly in the detection and determination of properties by experience of individual things and events in nature. The degree of perfection of these properties shows then that the universe as a whole as well as every part of it, even a part of any size desired, reflects a perfect quality of God. Hence, the purpose of teleological explanation of nature is the knowledge of God through nature, e.g. Physical theology. In this respect teleology is a certain kind of Theology, called "Theologia experimentalis" (experimental Theology).[61] It is Theology through knowledge of nature, including scientific experiment. All insights into the concept of the living and into the organization and evolution of living beings as well follow in the end from that purpose, placed above nature. However, the exploration of the causes of alteration in nature is a subject attributed to physics.

Wolff is perhaps the best example of the change in the function of teleological understanding of nature from an originally causal mode of explanation of the living world to Physical theology that is carried out in connection with and in partial renunciation of Leibniz. But he is,

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[60] Christian Wolff, *Deutsche Physiologie*, § 202 (Gesammelte Werke I.8, 561–563).

[61] Idem, *Ausführliche Nachricht von seinen eigenen Schrifften* (1733), § 187 (*Gesammelte Werke* I.9).

of course, also an example of an exaggerated application of the principle of teleology to the explanation of natural things. The purposes within natural entities are nothing else but God's intentions, put in these things and combined with effective causes, when the world was created. In this way the essences (substances) of natural beings and the qualities resulting from them are predetermined. In relation to the unity of the "main aim" ("Hauptabsicht"), they construct a closed connection of purposes and means. All special aims are parts of this "main aim", and they are at the same time the means for its realization. Their continuous causal connection means the coming into existence of the divine "main aim" within the total construction of the universe. The world is rationally constructed like a machine that is composed of the functions of its parts. In this respect, the purposes of nature are nothing else than alternative interpretations or rational over-determinations of mechanical causes, that is to say, in a way, that each cause gets its legitimation by reduction to an intention of God. Consequently, natural things are regarded in a way that everything in nature arises because of a special aim, and also that its effect is an intentional causation.

The purpose- and goal-directedness of natural evolution in classical Aristotle differs distinctively from modern metaphysical conceptions of teleology according to the model of Wolff. Whereas with Aristotle there are particular processes of nature that require teleological exegesis and mode of explanation, the teleology of nature appears as clothed in Christian thought: originally the divine creator put purposes into nature and installed the means by which the forces of nature were capable of unfolding purposively.[62] Nature and the universe, taken not only individually but also as a whole, are thought to be organized in accordance with purposiveness by God's wise foresight. As opposed to Aristotle the purposes originally do not arise from nature itself. The specific determinations of all particular purposes in nature are derived from the aims of God. The supreme purpose, that traverses all these individual purposes, i.e. the self-contemplation (-intuition) of God as his own "main aim", reflecting his reason, comes into reality through the individual purposes.

In fact, it was this kind of extramundane purposiveness given by God and interweaving the whole of nature, which brought teleology into discredit in the view of natural scientists who were strongly directed to a standard mathematically-empirical way of thinking.[63] The rejection

[62] Of course, there is already in the 6th century A.C. an approach to a doctrine of establishing ends by God in Johannes Philoponos (cf. Fritz Krafft, "Zielgerichtetheit und Zielsetzungin Wissenschaft und Natur", 60–61) and subsequently to him, in the Middle Ages.

[63] Look for that, Fritz Krafft, "Zielgerichtetheit und Zielsetzung in Wissenschaft und Natur", 58.

of purposiveness for its futility as a principle of scientific explanation had been intensified up to contempt. Although in some aspects, especially, concerning Biology, the critique of a physic-teleological character of teleological determination of nature regarding the obvious explanatory deficiency was justified, this sort of critique entailed new deficiencies, because of the resulting fundamental exclusion of teleological ways of reasoning.

Especially among its followers the after-effects of Wolffian philosophy show different tendencies of development concerning the teleological explanation of nature. On the one hand, Leibniz is accepted (and respected) as a reformer of mechanism, but whose critiques on Descartes are not sufficiently conclusive; his scientific conception of life still remained in the position of mechanism and therefore failed to give an adequate explanation of vital functions. Taking recourse in an ultimate divine reason made teleological explanation altogether at pleasure. On the other hand the philosophical results of Aristotelian natural philosophy had become discredited.

Hermann Samuel Reimarus, a scholar of Wolffianism (1694–1768), in his book "On the desires of animals" (first published in 1760, and again in 1762), rejects the Cartesian idea of the animal-machine, which was understood to be merely mechanistic. He constructs a series of arguments against this conception. One of them says that the theory of machine disqualifies numerous species of the living from scientific examination. Even it was killing the best part of nature. His last argument is aimed at the lack of explanation of mechanism:

> But really, Cartesian mechanism does not make us understand anything of the well-known rules of mechanical forces, rather, it refers only to God's, the master workman's, infinite perfections.[64]

By taking recourse to God, however, all explanation becomes arbitrary.

Reimarus fundamentally attacks not only the relevance of Aristotle's philosophy of nature (citing e.g. *Historia Aanimalium* VIII)[65] to biological

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[64] (My own translation: "Ueberhaupt aber macht uns der Cartesianische Mechanismus nichts aus den bekannten Regeln mechanischer Kräfte verständlich, sondern er bezieht sich blos auf Gottes, als des Werkmeisters, unendliche Vollkommenheit […]") (Hermann Samuel Reimarus, *Allgemeine Betrachtungen über die Triebe der Tiere, hauptsächlich über ihre Kunsttriebe* (Hamburg, 1760), 219 ([2]1762). Neuausgabe: Mit einem Geleitwort von Ernst Mayr und einem einleitenden Essay des Herausgebers unter Mitarbeit von Stefan Lorenz und Winfried Schröder, ed. Jürgen Kemski, 2 Vols. (Göttingen: Vandenhoeck & Ruprecht, 1982)).

[65] Hermann Samuel Reimarus, *Allgemeine Betrachtungen über die Triebe der Tiere* (1760), § 104.

research, but even the attempt of Leibniz to overcome Cartesian mechanism. Although Leibniz is granted to have the advantage over Descartes, that pre-established harmony restores soul, life, sensation and similar qualities to animals, the analysis of Reimarus entails that the theory of Leibniz gives no convincing alternative to the mechanical way of explaining vitality. According to the results of Leibniz, animal body remained for itself "a mere Cartesian Machine, that neither is animated by the soul nor really influenced by it; hence, in community with the soul it doesn't constitute a living animal, but it realizes in general exclusively for itself such movements as the soul is imagining, and therefore [the Cartesian Machine] would do the same as now even without soul".[66] In Leibniz, just as in Descartes, the incomprehensiveness of the perfection of God remains the final ground for a regularly working world-machine. This conclusion could be accepted from the point of view of dualism which also is a constitutive doctrine in the philosophy of Leibniz.

Another unsolved difficulty, in the view of Reimarus, concerned the contradiction between the difference in individual character of corporeal machines adapted to every individual soul, and natural procreation, because the last demonstrates just the similarity between the machines of the parents and their descendants. In fact, quite conversely to the aim of Leibniz, it ought to be assumed, that God directly interferes in procreation in order to guarantee the persistence of individual differences opposed to natural evolution.[67]

Reimarus concludes critically that the pre-established harmony of the world in fact did not cause natural coherence, but keeps the monads in isolation from each other:

> combination only is in the thoughts of the creator, who has made them unanimous and who conceives them in this way: thus, it is only a logical and metaphysical, not a physical combination.[68]

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[66] (My own translation: "[…] eine bloße Cartesianische Maschine, die nicht von der Seele belebt wird, noch von derselben einen wirklichen Einfluß bekommt; folglich mit der Seele kein lebendig Thier ausmacht, sondern schlechterdings nur für sich eben solche räumliche Bewegungen macht, als sich die Seele vorstellt, und daher auch ohne Seele eben dasselbe thun würde, was sie jetzt thut") (Hermann Samuel Reimarus, *Allgemeine Betrachtungen über die Triebe der Tiere* (1760), 220)).

[67] Hermann Samuel Reimarus, *Allgemeine Betrachtungen über die Triebe der Tiere* (1760), 221 (§ 110).

[68] (My own translation: "[...] die Verbindung ist nur in den Gedanken des Schoepfers, der sie einstimmig gemacht hat und sie sich so vorstellet: folglich ist es blos eine logische und metaphysische, nicht aber physische, Verbindung") (Hermann Samuel Reimarus, *Allgemeine Betrachtungen über die Triebe der Tiere* (1760), 223–224 (§ 111)).

Reimarus' critique of Leibniz leads him to the necessary assumption of a physical combination of soul and body in animals (Reimarus relates affirmatively and extensively to the results of English researchers on nature in the 18th century (Whytt)). But he too actually adheres to the theological superstructure of nature by reinstating the divine creator for the creation of the forces of nature;[69] because he knows no other reason for explaining their causation. The generation and the way of causality by forces, therefore, remain really inconceivable.

In the second half of the 18th century vitalism was represented by embryology and physiology. It opposed explicitly the conventional mechanistic modes of explaining vivid nature. In terms of the traditionally mechanistic view, life in general is a mechanical product of the form of organization and organic matter is moved by a special kind of causality, which means an "organic power" ("organische Kraft") being inherent in matter (so-called "animism"). But it had always assumed the existence of a vegetable and an animal soul. The representatives of biotheory, in the 18th century, actually transmitted the Newtonian gravitation to their concept of organic vital powers. The form of organization is not a presupposition but a product of vital power. Because of this assumption the theorists in this concern stayed on the same ground of mechanism. They merely added a new variant to the concept of mechanic force.[70]

Johann Friedrich Blumenbach (1752–1840), Professor of Medicine in Göttingen, who influenced three generations of natural scientists, is said to be the victor over mechanism in life sciences and the founder of vitalism. At the same time, he empirically perceived the problems, which conditioned the turn from mechanism to vitalism. With that he advanced the development of Biology from natural history to systematic science.[71]

In his writing *On the forming drive* ("Über den Bildungstrieb", Göttingen 1789),[72] Blumenbach tried to show that the theory of evolution which

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[69] Hermann Samuel Reimarus, *Allgemeine Betrachtungen über die Triebe der Tiere* (1760), § 102.

[70] Cf. Peter McLaughlin, "Blumenbach und der Bildungstrieb. Zum Verhältnis von epigenetischer Embryologie und typologischem Artbegriff", in: *Medizinhistorisches Journal* 17 (1982): 357–372, here: 360.

[71] Peter McLaughlin, "Blumenbach und der Bildungstrieb" (1982), 357. Analogous forms of this development can be recognized in France and in England; cf. Joseph Schiller, "Queries, Answers and Unsolved Problems in Eighteenth Century Biology", in: *History of Science* 12 (1974): 184–199; Theodore M. Brown, "From Mechanism to Vitalism in Eighteenth Century English Physiology", *Journal of the History of Biology* 7 (1974): 179–216.

[72] Preliminary studies to this work we find in Johann Friedrich Blumenbach, *Handbuch der Naturgeschichte*, 1st edition, 2 Parts (Göttingen: Johann Christian

was based on the supposition of pre-existing germs – that is the doctrine of "envelopment" and "development" created by Leibniz with the help of Aristotelian concepts and accepted by Wolff[73] – was unnecessary, and to replace it by a theory of "epigenesis".

Blumenbach opposed the theory according to which the "spermatozoa", discovered by Ludwig (Ludovicus) von Hammen (1652–1689) in 1677, were spiritless germs of future human beings. In the same way, Nikolaus Hartsoeker (1656–1725), a correspondent of Leibniz between 1706 and 1712,[74] in his "Essai de Dioptrique",[75] had portrayed a germinal animal ("Samentierchen"), which, staying in wait for his deliverance was fully developed and enveloped in a pod. He described this picture using the claim that each human seed existed already as a completely preformed embryo in miniature.[76] Other theorists of evolution (Swammerdam, Haller, Bonnet), who were criticized by Blumenbach because of their observations and claims on which the theory of evolution was grounded, agreed in that understanding. However, they differed from the conception of Hartsoeker in so far as they held the opinion that the preformed seed was in reserve in the ovary of the mother ("ovalists" in difference to "animalculists").[77] They imagined the "drowsy germ" ("schlaftrunkene Keim") being wakened by the stimulation of the male seed. The interpretations of the microscopic observations by the researchers in nature of the 17th century were fitting the picture of an organism as a machine, although it could explain only the movement but not the generation (or the self-organization) of living beings.

Blumenbach concludes that the assumption of pre-existence of a preformed germ must be given up and had to be replaced by a new theory. He refers essentially to empirical experience, in particular to the

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Dieterich 1779–1780); Johann Friedrich Blumenbach, *Über den Bildungstrieb und das Zeugungsgeschäfte*, 1st edition (Göttingen: Johann Christian Dieterich, 1781).

[73] Cf. Christian Wolff, *Deutsche Physik*, §§ 407, 454 (*Gesammelte Werke* I.6, 641–645, 732–735).

[74] See Gottfried Wilhelm Leibniz, *Die philosophischen Schriften*, Vol. III, 483–535.

[75] Nikolaus Hartsoeker, *Essai de Dioptrique* (Paris 1694), 230.

[76] Usually, Anton van Leeuwenhoek (1632–1723) is held to be the explorer of the spermatozoa. He outlined a theory of preformation of the evolution of living beings. Cf. Eve-Marie Engels, *Die Teleologie des Lebendigen* (Berlin: Duncker & Humblot, 1982 (Reihe: Erfahrung und Denken Bd. 63)), 89.

[77] Descartes did not believe in a preformation in germ, neither in ovum nor in sperm. He made the human being getting procreated from the seminal fluids of each of the parents (for the history of the theory of preformation cf. among others: Jacques Roger, *Les sciences de la vie dans la pensée francaise du XVIIIe siècle* (Poitiers 1962; 2nd ed. Paris 1971); Emil Ungerer, *Handbuch der Biologie* (Konstanz: Athenaion 1965); Eve-Marie Engels, *Die Teleologie des Lebendigen*, 81 ff.; Ilse Jahn, "Biologische Fragestellungen in der Epoche der Aufklärung (18. Jh.)", in: *Geschichte der Biologie*, ed. Ilse Jahn (Hamburg: Nicol $^{3}$2004), 231–273).

observation of some experiments on hydras that had shaken the theory of evolution. According to the theory of "epigenesis" the unformed "procreative stuff" ("Zeugungsstoff") was formed to become a living being by a special natural force. This theory implies that a drive incorporated in the "procreative stuff" of an organized corpus and acting for life will awake immediately after the insemination. It causes the corpus to take its shape, to keep it for life and to reproduce his form when mutilation has happened. This drive, belonging to the "forces of life",[78] is the first for procreation, nutrition and reproduction and it is called "forming drive" ("Bildungstrieb"). The living force no longer has the same significance and function as the Leibnizian "entelechy"; because for Blumenbach it doesn't imply unity of purpose and substantial form. It underlies, in other words, the abstraction to the opposite direction: the reduction of rational forms to empirical facts. By this solution Blumenbach rejects actually the Leibnizian attempt of teleological explanation. The concept of "forming drive" is intended to serve the denotation of a force "whose constant effect is admitted by experience, but whose cause as well as the cause of the noted and widely accepted natural forces are for us qualitas occulta".[79] The merit in studying these forces was only to determine their effects more precisely and to reduce them to more general laws.

Blumenbach denied continuity and transition, in place of which he thought of a "cleft" between inorganic and organic natures. The criterion for this demarcation is the "forming drive", which cannot be given in the inorganic realm of nature because it is classified as one of the "forces of life".[80] But the install of such power does not resolve the problem. It presupposes already a definition of living things. The "forming drive" produces a new creature through the "unformed stuff of procreation" ("ungeformten Zeugungsstoff") (or, in case of defects, through

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[78] For the history of generation and classification of the concept of "force of life", cf. Eve-Marie Engels, *Die Teleologie des Lebendigen* (1982), 93 ff. Francis (Francisco) Glisson (1599–1677) is held to be the creator of this concept, which had been accepted in the following period of natural philosophy (see his *Tractatus de natura substantiae energetica, seu, De vita naturae ejúsque tribus primis facultatibus, I. perceptivae, II. Appetitive, III. Motiva, & naturalibus, &c.* (Londoni 1672)). In the middle of the 18th century, Albrecht von Haller (1708–1777) gave rise to a proper debate on the meaning of this concept, which opposed to the machine-theory about the organic (cf. e.g. Friedrich Casimir Medicus, *Von der Lebenskraft. Eine Vorlesung bei Gelegenheit des höchsten Namensfestes Sr. Kurfürstlichen Durchlaucht von der Pfalz […] abgelesen* (Mannheim 1774); and also Christoph Wilhelm Hufeland, "Mein Begriff von der Lebenskraft", *Journal der practischen Arzneykunde und Wundarzneykunst* 6, 4 (1798) 788–789).

[79] (My own translation: "[…] deren constante Wirkung aus der Erfahrung anerkannt worden, deren *Ursache* aber so gut wie die Ursache der genannten, noch so allgemein anerkannten Naturkraefte, fuer uns *qualitas occulta* ist") (Johann Friedrich Blumenbach, *Ueber den Bildungstrieb* (Göttingen ²1789), 261 (1. Aufl. Göttingen 1781)).

[80] Johann Friedrich Blumenbach, *Ueber den Bildungstrieb* (Göttingen ²1789), 71–72.

the "stuff of nutrition" ("Nahrungsstoff")). Generation (procreation) and reproduction (restitution) are held to be modifications of one and the same force.[81] The move from reproduction to an originally active (spontaneous) "forming drive", which has been opposed to the thesis of the preexistence of the doctrine of incapsulation ("Einschachtelungslehre"), followed from the observation of nature (especially of the birth of a young polyp) as well as from experiments (the observation of the regeneration of amputated limbs). In this way, empiricism advanced to the decisive power of argumentation for the refutation of the theory of evolution. However, the explanation of the regeneration of the limbs of the polyp given by the theorists of preformation was comparatively difficult and laborious. Accordingly, in every limb of the body germs preexisted which contained the enveloped embryonic polyp conserving him in a state of freezing sleep until he would be roused, released and stimulated for development.[82]

Although Leibniz grounded his theory of organized nature in general and of living beings in particular on the individual unity of the substance or the monad and so made the preformation of living beings in the last consequence dependent on the divine creation (which left no space for him to introduce the concept of species in the meaning of separated unities)[83], it was forgotten in the late 18th century that the invention of living forces ("Lebenskräfte") and their instrumentation in the research of nature had been prepared by the Leibnizian concept of "vis activa" originated from the Aristotelian "entelechy". Along with the neglect of the Leibnizian foundation of nature and the rejection of the organizing form, mechanism was just modified and strengthened. The teleological aspect, on the contrary, was superseded. That was even the destiny of Blumenbach's doctrine of formative power ("Bildungskraft"). Of course, his consideration of the organization of nature as a whole is teleological or more precisely, physic-theological. For, as in Christian Wolff, nature is deliberated as a perfect product of creation of which no part is aimless, but on the contrary, is determined according to the original device of the world-creator as a member of the whole and as the means to other ends.[84] On the basis just of these functions and of their causality Blumenbach classifies the individuals into species, although the species and genus, whose character is a physical process evoked by

[81] Ibidem, 83.

[82] Johann Friedrich Blumenbach, *Ueber den Bildungstrieb* (Goettingen ²1789), 85.

[83] For the controversy between philosophy of nature and biology on the meaning of *classification* in the eighteenth century, look Wolfgang Lefèvre, "Natural or artificial systems? The Eighteenth-Century Controversy on Classification of Animals and Plants and its Philosophical Contexts", in: *Between Leibniz, Newton, and Kant*, ed. Wolfgang Lefèvre (Dordrecht: Kluwer Academic Publishers, 2001), 191–209, here: 194.

[84] Johann Friedrich Blumenbach, *Ueber den Bildungstrieb* (Goettingen ²1789), § 7.

procreation, also represent a series of origins of congenial individuals, but in a sense that it is constituted neither through fertility (Buffon) nor by the merely comparing comprehension of individuals according to certain qualities of similarity (Linné). Without realizing the true meaning of his result, Blumenbach rethought lastingly Aristotelian cognitions in natural teleology and biology. One of his most important results was the thought that the genesis of an individual implies the preformation of the genus.[85]

In the later 18th century, philosophy of nature lost its reference to Aristotle and to Leibniz to a large extent or even consciously retired from them as being antiquated (outdated), although this reference had been a necessary condition of its formation. The disadvantages following from this philosophical turn consisted in the fact that, first, by the sacrifice of that reference to Aristotelian-Leibnizian principles conceptual patterns were thereby lost that belonged essentially to the understanding of the causes of genesis and development of living natures; and second, that the relation between mechanism and teleology is not comprehended. Near the end of the 18th Century these problems appeared intensively in the "Critique of Judgment" (1790) of Immanuel Kant (1724–1804), who criticized the machine-theory of organism[86] and praised Blumenbach's theory of the forming drive.[87] Kant recognized and examined the problematic nature of the relation between mechanism and teleology and their consistent union within divine intellect as a problem of antinomies, seemingly without giving a satisfactory solution by means of transcendental principles from the point of his critical philosophy. Friedrich W. J. Schelling (1775–1854), who rejects the concept of living force, afterwards accepted the concept of forming drive, but he modified it in a direction where it could function as a general principle within the framework of organism-conception, excluding the thought about a wise world-creator.[88]

The outlined reflections and remarks on the use and the development of teleological principles of explanation in natural philosophy and science are rather abstract and undetermined. It will be necessary,

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[85] Cf. Peter McLaughlin, "Blumenbach und der Bildungstrieb. Zum Verhältnis von epigenetischer Embryologie und typologischem Artbegriff", in: *Medizinhistorisches Journal* 17 (1982), 357–372, here 369.

[86] Immanuel Kant, *Kritik der Urteilskraft* (1790), § 65 (AA V, 374).

[87] Ibidem, § 81 (AA V, 424).

[88] Friedrich Wilhelm Joseph Schelling, "Von der Weltseele, eine Hypothese der höheren Physik zur Erklärung des allgemeinen Organismus" (1798) (Chapter: "Ueber den Ursprung des allgemeinen Organismus"), in: *Friedrich Wilhelm Joseph Schelling. Werke* (Historisch-kritische Ausgabe. Im Auftrag der Schelling-Kommission der Bayerischen Akademie der Wissenschaften, hrsg. von W. G. Jacobs, J. Jantzen, H. Krings. Reihe I: Werke), Vol. 6 (Stuttgart: Frommann-Holzboog, 2000), 183 ff.

furthermore, to study in more detail a wide range of textbooks and articles on this topic in order to demonstrate the rejection of mechanism on the one hand and the acceptance of Aristotle's physics and biology on the other. But this must be the task of research in future.

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## Summary

The aim of the present article is to consider some aspects of and reasons for the renaissance of the teleological mode of explaining nature in Western European philosophy and science at the time when strong mechanistic thought in combination with mathematical (geometrical) prove was still predominant since the birth of early modern thought in 16th century.

This development was dependent on the reformation of metaphysics that was centred on the new concept of substance created by Leibniz around 1685. Taking argument with Descartes, Leibniz reverts to the original meaning of concepts as adopted from Aristotelian natural philosophy. Consequently Leibniz prefers a dynamical, purposive interpretation of substance and natural beings, consisting of spontaneous activity, living force and final cause. This teleologi-

cal project struggles with the predominance of mechanistic principles in metaphysics and natural philosophy and, moreover, with the widespread elimination of Aristotelian physics. Leibniz, however, conceived the Aristotelian concept of "entelechy", which he translated into "substantial form", to be productive.

I would like to show that from the viewpoint of the history of philosophy and scientific theory there were irrefutable factual reasons, which made the search for teleological principles a matter of concern in the study of nature in the 17th century. Such factual reasons are given not only by experiments and discoveries through biological research, but also by the renovation of adequate concepts of explanation. At the same time, that should not be taken to mean that those same factual reasons would still be scientifically relevant today and would be suitable as justifiable grounds for the use of teleological principles in natural science. Nevertheless, I will proceed by analysing concepts of causation and their preconditions sketching in a first step the origin of teleological thinking in the natural philosophy of Aristotle (II); in a second step, I will cite references from modern philosophical thought, from which it should follow that the upswing of mechanism pushed aside the achievement of Aristotle on the one hand, but on the other hand aroused the need for a conception of purposive causality in order to explain nature completely (III); in a further step, I will show that this development, which took place in the conflict between scientific-philosophical self-understanding and objective deficits of explanation within mechanism, led to a revival of the Aristotelian understanding of teleology in Leibniz (IV). Finally, I try to describe the ambitious step of natural research to the origins of life sciences through the post-Leibnizian and post-Wolffian periods of metaphysics in 18th century and the ambiguous references to ancient approaches to teleological explanatory conceptions of nature involved in that advancement (V).

**Keywords**: teleology, Leibniz, Aristotle, science, metaphysics