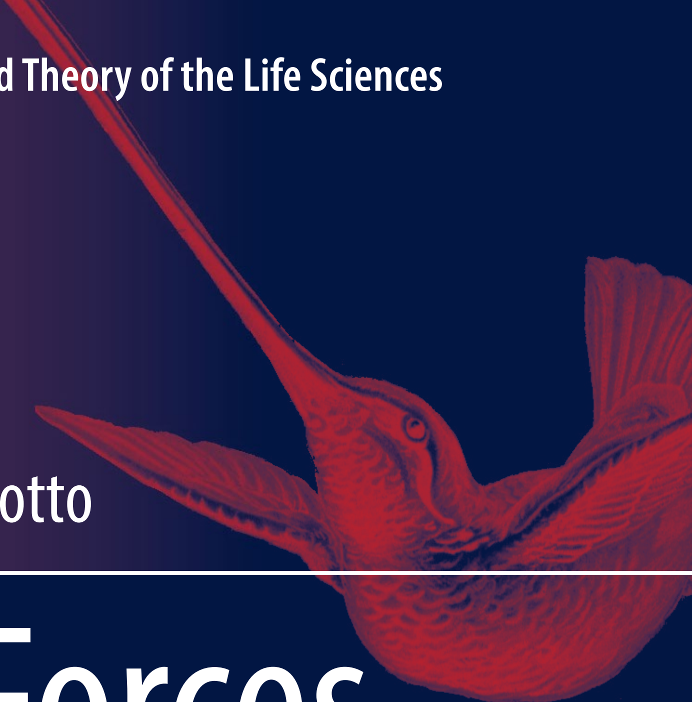
History, Philosophy and Theory of the Life Sciences



Andrea Gambarotto

Vital Forces, Teleology and Organization

Philosophy of Nature and the Rise of Biology in Germany

Springer

History, Philosophy and Theory of the Life Sciences

Volume 21

More information about this series at http://www.springer.com/series/8916

Andrea Gambarotto

Vital Forces, Teleology and Organization

Philosophy of Nature and the Rise of Biology in Germany

Springer

Andrea Gambarotto
Université catholique de Louvain
Louvain-la-Neuve, Belgium

ISSN 2211-1948 ISSN 2211-1956 (electronic)
History, Philosophy and Theory of the Life Sciences
ISBN 978-3-319-65414-0 ISBN 978-3-319-65415-7 (eBook)
DOI 10.1007/978-3-319-65415-7

Library of Congress Control Number: 2017949283

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Foreword

This book by Andrea Gambarotto which I have the honor of prefacing provides an important milestone for understanding how biology came about as an independent science at the turn of the nineteenth century. It is customary to view that outcome, generally identified with the work of Gottfried Reinhold Treviranus in Germany and that of Jean-Baptiste Monet de Lamarck in France, as a major conceptual shift affecting at once the notion of living beings as organisms and the rational and empirical methods applied to their study. Part of the story has been formerly told as a change from natural history as *Naturbeschreibung* to natural history as *Naturgeschichte*, when the temporal and trans-specific dimension of the metamorphosis of life forms first came to be accounted for. Another scheme that was traditionally developed for the sake of explaining the advent of biology has consisted in tracing back the new concepts, models, and statements of law involved in the theories of physiology, pathology, and comparative anatomy that, at the time, tended to dissociate themselves from the methodological patterns of the then-dominant physical sciences.

But these interpretations remained very general and seemed unable to account for an apparent historical paradox, the fact that biology, which would later declare its allegiance to the natural sciences, abide by positive and empirically based methods, and ground its theories on naturalistic concepts, did stem from various forms of late-eighteenth-century vitalism and, even worse in the judgment of some, from transcendental speculations professed by upholders of *Naturphilosophie*. In the 1980s, Timothy Lenoir, in various publications epitomized in his authoritative *The Strategy of Life: Teleology and Mechanics in Nineteenth-Century German Biology* (1982), seemed to offer a way out of that paradox. The core element in Lenoir's interpretation boiled down to the presumed constitution of an influential school of researchers and theorists stemming from Johann Friedrich Blumenbach and his followers at the University of Göttingen. Blumenbach's vitalist physiology and epigenetic embryology would have combined with Immanuel Kant's critical philosophy to offer a consistent methodological pattern for the new biological science.

Especially in the *Critique of the Power of Judgment* (1790), Kant had rendered the conception of organic beings and physiological processes dependent upon the subordination of causal-mechanist analyses to the judicative use of teleological concepts. And thus appeals to regulative teleology, as opposed to constitutive finality, would have patterned actual methodological and theoretical approaches to biological phenomena, along a research program that bypassed the distinct tradition represented by *Naturphilosophie* and the so-called Romantic science. This tradition, which Lenoir termed "teleomechanism," would have subsequently contributed to define the epistemic profile of the new biological science in early-nineteenth-century Germany and fostered significant advances in embryology, in particular with Carl Ernst von Baer and Johannes Peter Müller; in cell theory, with Matthias Schleiden and Theodor Schwann; and in experimental physiology, with Carl Ludwig, Emil du Bois-Reymond, and Carl Ernst von Brücke.

Following Robert Richards, Peter McLaughlin, and John Zammito, Gambarotto questions Lenoir's interpretive hypothesis and resumes some of the criticisms addressed to the hypothesis of an existing and prevalent teleomechanist trend. He nicely clarifies the distinction to be drawn between Kant's and Blumenbach's respective conceptions of teleology. He establishes with all the required evidence that Blumenbach, through his notions of "formative drive" (*Bildungstrieb*) and subordinate "vital forces" (*Lebensvermögen*), conceived of a determinative and constitutive, but by no means reflective and regulative, role for teleology, in representing the purposive and goal-directed sequences of effects that powers immanent and active in organic matter, conceptually symbolized, are capable of yielding. But what is especially original and deserving in Gambarotto's work is his attempt at tracing back the multiple variants and shifting principles in the doctrines of vital forces that marked the emergence of the German biological theories. In this important, complex, yet never before clearly analyzed transition phase, he has been able to demonstrate that *Naturphilosophie*, in Friedrich Wilhelm Joseph von Schelling's paradigmatic formulations, did not steer a course entirely independent of, not to say antagonistic to, the more scientifically oriented synthetic theories. Gambarotto has rightly focused his analysis on the key concepts that were concurrently proposed by physiologists and philosophers to account for the self-organization of the living and the laws that they presumed ruled over epigenetic processes. And he went through a systematic investigation of those concepts and their multiple applications within purview of a broad research program devoted to the principles of life as self-organization, a program spanning over the boundaries of philosophy and the natural sciences. The proposed analysis bears on the self-sufficient theories on generation, functions, classification, and above all the unity of organic and vital processes, which formed the subject matter of a single overarching science in the becoming.

In Gambarotto's analysis of the theories of generation, the originality consists in the weight given to Caspar Friedrich Wolff's arguments for restoring epigenesis against the latest forms of preformation according to Albrecht von Haller and Charles Bonnet. Beyond the empirical statements that underpinned Wolff's arguments, one needed to interpret and appreciate the exact epistemic significance of the so-called essential force (*vis essentialis*). In this case, the suggested interpretation is that Wolff in his *Theoria Generationis* (1759) and *Theorie der Generation* (1764) supported a position that could be rightly termed "vital materialism." As for the analysis of Blumenbach's theory of generation, it yields unfailing evidence that the *Bildungstrieb* as an organizing principle played a constitutive, rather than a merely regulative, role in generation, growth, and regeneration. And thus the Göttingen physiologist had a different epistemic meaning for his notion of formative drive from the one to be inferred from the critical arguments developed about the "formative force" (*Bildungskraft*) in Kant's *Critique of the Power of Judgment*. This should not make us underrate the fact that Kant and Blumenbach felt that they had a kind of joint agreement. Although the *Bildungstrieb* acts as a causal efficient force for the development of organic bodies according to their type, the teleological contents involved in the notion still have to be appraised through analogy with humanly framed purposes. But this did not prevent Blumenbach from trying to provide objective expressions for the laws of vital organization as general empirical effects dependent on specific teleological principles that acted as their true causes. Further on, the analysis of Johann Christian Reil's 1795 paper points to this author's tendency toward materializing the teleological aspects of the formative principle, which, for Blumenbach, were not to be conceived of as reducible to forms of chemical composition. But still, what makes the difference between laws of living organization and laws ruling over inorganic process is a complex relation that might be diversely characterized as one of supervenience, emergence, or failed reduction depending on the way the typology of the variant theories involved was drawn.

About functions, Gambarotto rightly considers Haller's physiology as offering an original template after which the variant doctrines of late-eighteenth-century physiology can appear to have been molded. But his central argument here is based on a presumed synthesis between Haller's concept of the vital forces and Wolff's epigenetic assumption of the *vis essentialis*. This explanatory scheme had to overcome two potential objections. (1) It is hard to give a vitalist interpretation of Haller's fiber properties: irritability and sensibility. He was a micro-mechanist theorist who felt physiology should be devised as an "animated anatomy." For him, the two "vital" properties had to be identified as effects that causally derived from the inner structure of the fibers involved. At the same time, he would empirically link these properties with their phenomenal effects: vital contraction on the one hand and sensation on the other. This strict delimitation was supposed to prevent analogical extensions that would have transformed irritability and sensibility into vital principles. (2) On the other hand, Blumenbach would never have admitted that his *Bildungstrieb* could be conceived as a derived form of *vis essentialis*. The 1789 memoirs on the *Nutritionskraft* are especially telling on the unsurmountable disparity in doctrine that was involved here between Blumenbach and Wolff. A genetic account was therefore needed on the conceptual shifts that took place and fostered the later typologies of vital forces within and outside the Göttingen School. Gambarotto does a nice job untangling the matter for the Blumenbachian and post-Blumenbachian eras. His analyses of Carl Friedrich Kielmeyer's and Heinrich Friedrich Link's theoretical views are especially convincing. He went a good way explaining the transition phases that resulted into the well-known and influential Blumenbachian typology of vital forces. Blumenbach shifted from his original Hallerian position to a dynamic interpretation of those force as begotten by, and derivative from, the *Bildungstrieb*, with correlative generalization of irritability beyond muscle fibers and of sensibility beyond the level of sense awareness and with the addition of specific *vitae propriae*. At the same time, Blumenbach retained several features of Haller's models which his followers will get rid of. He would not, for instance, develop a trans-specific scale of apportioned vital properties nor draw empirical laws about the deviant structural-functional processes affecting the various life forms.

The chapter on classification is by all means one of the most important contributions of this book to historical and philosophical scholarship. Gambarotto is right in stressing the strong imprint of Georges-Louis Leclerc de Buffon's notion of biological species in contrast to Carl von Linné's nominal taxonomical categories. Obviously, much of Kant's and Blumenbach's views on the scale of nature and the degenerative processes affecting life forms were quite in line with that former tradition. Rightly though, Gambarotto tends to relativize the universality of scheme that could have stemmed from the so-called Kantian principle for natural history. Alternative options were on the rise, elements of which were provided by Johann Wolfgang von Goethe's comparative morphology, as well as by Kielmeyer's comparative appraisal of the harmonic economy of life forces. Two principles bred various theories about the inner dynamics of the system of life forms: the unity of plan and the law of continuity underpinned several significant attempts at accounting for such a system. And this was precisely the stage at which *Naturphilosophie*, and especially that of Schelling, developed speculations that shared a common basis with contemporary interpretations of anatomical and physiological processes which seemed to require some a priori explanatory framework. What is indeed surprising, but proof-telling for Gambarotto's narrative, is that there appears to have been but very slight gaps between metaphysical presuppositions, such as those concerning a universal organism and the derivative speculative schemes they authorized, on the one hand, and hypothetical inferences drawn from contemporary empirical studies in comparative morphology or general physiology, on the other.

Among the principal outcomes of this exceptional research work, major issues are evoked and at least partially solved, concerning the conceptual contexts that favored the advent of biology at a time when a precise borderline between the metaphysics of life and the biological science had not yet been drawn. In particular, there is much to be learned from Gambarotto's extensive analysis of Treviranus's work as an epitome of the synthetic approaches that the Göttingen School had fostered and to which *Naturphilosophie* had grafted its theoretical inventions. What is especially telling in those pages devoted to the late outcomes of the Blumenbachian-styled life science is the idea that a true explanation of vital phenomena could not take place, if not within a framework of speculations about the unity and dynamic integration of the system of nature, whether these could be treated as verifiable hypotheses in experimental enquiries or as sorts of ontological axioms for a purely deductive venture of the mind. It is evidently in support of that view that Gambarotto concludes: "I hope to have shown that what was at stake in this proximity [of the Göttingen School to Romantic *Naturphilosophie*] was a shift from a regulative to a constitutive understanding of teleology, which, at least in the German-speaking world, can be regarded as the historical condition for the emergence of biology as a field." But, if this argument forms the core ingredient for the proposed interpretation of the main research program that transformed biology in the initial decades of the nineteenth century, it should be further stressed that we needed a solid demonstration of the way this new understanding of endogenous teleology fostered the unification of ontogenetic, physiological, embryological, and taxonomic hypotheses within a common theoretical framework, under the aegis of a generalized conception of organisms. And this is precisely what Gambarotto's book provides.

Université de Montréal
Montréal, Canada

François Duchesneau

Acknowledgments

This book was once a PhD dissertation. The project behind it was born at the University of Padua back in 2010 when, not long after graduation, I stumbled upon the idea of writing about the relation between the life sciences and philosophy of nature in German Romanticism. Completing this project has been a long journey, one punctuated by many mentors and friends who led me along parts of the way. Luca Illetterati helped me give shape to the very first draft of the project, turning a vague idea into a viable working hypothesis – to him I owe some of the fundamental arguments developed in this book. Ferdinando Abbri, who sat on the board that accepted this project, helped convince me that I could turn it into a valuable book on the rise of biology in Germany. I did my best to honor his confidence. Stefano Poggi directed my research on the history of science and enabled me to identify the philosophical potential of Romantic biology. The supervision of Philippe Huneman skyrocketed my learning curve and laid the foundations upon which this book was built. Hannah Ginsborg hosted me as a visiting student researcher at UC Berkeley, where I developed the first draft of this manuscript. Charles T. Wolfe took the time (and patience) to read subsequent versions of that manuscript, helping me turn a rough jumble of ideas into rigorous scholarship. Luca Corti, François Duchesneau, Jim Kreines, Stéphane Schmitt, and John Zammito provided important insights that helped me refine later versions of the manuscript. Amanda Swain contributed considerably to turning that manuscript into a good, readable book. Across the years, I have also benefited from the funding of several institutions: Istituto Italiano di Scienze Umane (SUM), Università degli Studi di Padova, Deutscher Akademischer Austauschdienst (DAAD), Université Bordeaux-Montaigne, and Fonds National de la Recherche Scientifique (FRS-FNRS). A final thanks go to Gianni and Teresa, who always supported my research and encouraged me to pursue my goals – even when my goal was to write a book about Romantic philosophy of nature.

Contents

Generation: The Debate Over the Formative Force and the Question of Ontogenesis 1
1 Introduction and Outline: Ontogenesis and the Legacy of the Haller-Wolff Debate 1
2 Diverging Views of Epigenesis: Wolff and Blumenbach on Teleology 6
2.1 Epigenesis Without Purpose: Wolff and the Nutritive Force 6
2.2 Goal-Directed Organization: Blumenbach and the *Bildungstrieb* 10
3 An Unstable Middle Position: Kant on Teleology and Organization 14
3.1 The Technique of Nature 14
3.2 Organized Beings and Machines 22
4 From Chemistry to Organization: Reil on the Vital Force 26
5 Concluding Remarks 31

Functions: The Göttingen School and the Physiology of Vital Forces 33
1 Introduction and Outline: The Göttingen School as a Historical Category 33
2 Building Blocks of the Göttingen School: Haller on Sensibility and Irritability 36
3 Foundations of the Göttingen School: Vital Forces in Blumenbach's Physiology 40
4 Core of the Göttingen School: Kielmeyer's Lecture as the Program for a General Biology 42
5 Explanatory Framework of the Göttingen School: Link and the Organic Forces as an Autonomous Research Program 47
6 Kielmeyer and Link on *Naturphilosophie* 50
7 Concluding Remarks 55

Classification: *Naturphilosophie* and the Reform of Natural History 57
1 Introduction and Outline: Natural History and *Naturphilosophie* 57
2 Blumenbach on Natural History 63
3 The "Kantian Principle" for Natural History 65
3.1 Kant on the Concept of Race: A New Principle for Natural History? 65
3.2 Ideas so Monstrous that Reason Recoils Before Them: Kant on Transformism 68
3.3 Original Stem-Species: Kant and Girtanner on Archetypes 70
4 The Unity of Type in Goethe's Morphology 72
4.1 Metamorphosis as Idealized Epigenesis 72
4.2 The Metamorphosis of Animals 74
5 Animal Classification in Schelling's *Naturphilosophie* 78
5.1 A New Era of Natural History 78
5.2 *Animal Classification in the* Erster Entwurf 81
6 Natural History and *Naturphilosophie* in Lorenz Oken 83
6.1 Naturphilosophie as a Foundation for Biology 83
6.2 The Animal Kingdom and Human Anatomy: Oken's Classification 86
7 Concluding Remarks 89

Biology: Treviranus and the Life Sciences as a Unified Field 91
1 Introduction and Outline: A New Scene of Inquiry 91
2 Life and Vital Force 94
3 Nature as an Organism 98
4 The Levels of the Organic 101
5 Ecology and Transformism 106
6 Teleology and Organization 110
7 Concluding Remarks 112

Conclusion: Hegel on Vital Forces, Teleology and Organization 115
1 Introduction and Outline: Hegel as a Philosophical Reporter 115
2 The Limits of Observing Reason: The Critique of *Naturphilosophie* in the *Phenomenology of Spirit* 118
3 Teleology and the Idea of Life: The Critique to Kant in the *Science of Logic* 123
4 General Conclusion 127

References 129

Introduction

Teleology Beyond Regrets

This book addresses the rise of biology as a unified science in Germany at the turn of the nineteenth century. It does so by reconstructing the history of the notion of "vital force" from its first formulation in Albrecht von Haller's lecture *De partibus corporis humani sensilibus et irritabilibus* (1752) through the publication of Gottfried Reinhold Treviranus' *Biologie, oder Philosophie der lebenden Natur für Naturforscher und Aerzte* (1802–1822), where the concept of biology was first used to define the life sciences as a unified field. I argue that Romantic *Naturphilosophie* played an important role in the rise of biology in Germany during this period and that this role especially concerned how post-Kantian philosophers and naturalists thought about teleological principles as they determined the object of biological research.

The title of this introduction refers to an old controversy in the history and philosophy of biology that originates from the scholarly work of Timothy Lenoir, which has influenced our understanding of the turn-of-the-nineteenth-century German life sciences for more than 30 years. In a paper entitled "Teleology Without Regrets" (1981), Lenoir discusses the main features of his account of the relation between teleology and mechanics in nineteenth-century Germany – an account that also serves as the backbone of his seminal monograph.[1] According to the "received view," Lenoir maintains, the origins of scientific biology can be traced to the efforts of the so-called 1847 group (Ludwig, du Bois-Reymond, Helmholtz, and Brücke). These scientists allegedly threw off the yoke of "vitalistic explanation" and swore allegiance to the cause of "mechanistic reductionism" (Lenoir does not provide a clear definition for either of these terms). With this move, they cast aside vitalism and teleology, paving the way for the new reign of mechanistic biology.[2] Lenoir's scholarly intervention is to show how this "received view" implied that the

[1] Lenoir 1978, 1980, 1981a, b, 1982.

[2] Lenoir 1982, 293–294.

foundations for biology lay solely in the development of mechanistic reductionism. Lenoir argues to the contrary that the rise of biology in Germany was the result of a non-reductionist research program, which he defined as "teleomechanism" and ascribed three different phases: "vital materialism" (Kant, Blumenbach, Reil, Kielmeyer), "developmental morphology" (Meckel, Döllinger, von Baer, Müller), and "functional morphology" (Schwann, Liebig, Bergmann, Leuckart).

In Lenoir's reconstruction of this history, the "vital materialism" phase in the development of biology was dominated by the theories elaborated by the physicians and naturalists of the so-called Göttingen School. He isolates the approach to vital organization developed at Göttingen by means of a research program based on Kant's *Critique of the Power of Judgment* (1790), and he identifies Johann Friedrich Blumenbach (1752–1840) as the first naturalist to embrace Kant's understanding of teleological principles and to apply those principles to empirical research. In this respect, Lenoir introduced the idea of a Kant-Blumenbach "vital materialist" research program based on a regulative understanding of teleology, which he believed constituted the foundations of the Göttingen School and was further developed by Blumenbach's most influential students: Johann Christian Reil (1759–1813), Carl Friedrich Kielmeyer (1765–1844), Heinrich Friedrich Link (1767–1851), and Gottfried Reinhold Treviranus (1776–1837).[3]

As William Bechtel has pointed out, Lenoir's aim was to identify a genealogy within nineteenth-century German biology separate from either "vitalistic *Naturphilosophie*" or "reductionist materialism."[4] By locating an intellectual tradition in which teleology was not entangled with vitalism, Lenoir believed teleology could finally be considered in naturalized terms (i.e., without regrets), as a specific characteristic of organic processes that marked biological phenomena's irreducibility to mere physics and chemistry. Accordingly, Lenoir saw his study of the Kantian teleomechanistic tradition as a response to those who wrongly believed that early–nineteenth-century German biology had been dominated by Romantic *Naturphilosophie* and its "vitalistic" conception of teleology.

Lenoir's historical reconstruction has been harshly criticized by Kenneth Caneva in a review entitled, ironically enough, "Teleology with Regrets." Caneva charges Lenoir with "many serious mistakes in historical analysis": "errors, misinterpretations, inconsistencies, unsupported claims and plain unclear writing."[5] A further criticism has recently been formulated by Robert Richards and John Zammito, who argue that Lenoir's account of an alleged agreement between Kant and Blumenbach is based on a "historical misunderstanding" and that the "Lenoir thesis" needs to be "revisited."[6] Building on these critiques, I will excavate the historical interrelation between the "vital materialism" of the Göttingen School and Romantic

[3] Lenoir 1981b, 115–119. As I argue in chapter "Generation: The Debate Over the Formative Force and the Question of Ontogenesis", Johann Christian Reil was never Blumenbach's student, as Lenoir has it, and should not be included in any "Göttingen School." Thanks to John Zammito for pointing this out.

[4] Bechtel 1983.

[5] Caneva 1990, 300.

[6] Richards 2000; Zammito 2012.

Naturphilosophie, in order to show that the distinct boundary between the two described by Lenoir is historically unattested. Indeed, I argue that *Naturphilosophie*, like the Göttingen School, played a pivotal conceptual role in the birth of biology as a unified science. The emergence of biology required a discursive break with Kant's understanding of teleology as a regulative principle, so that teleology could be considered a constitutive character of living organisms. This break occurred in the writings of the Göttingen tradition and is given a clear philosophical formulation in Schelling's *Naturphilosophie*.

Stressing teleological thinking in biology only inasmuch as it can be reduced to a mechanistic framework of explanation, Lenoir's work acknowledges a role for teleology but does so "with regrets." I argue that we instead need a historical account that moves beyond those regrets. In fact, I contend that the formalization of biology as an autonomous field at the beginning of the nineteenth century implied a shift from a *regulative* to a *constitutive* understanding of teleology – a shift most strongly endorsed by Romantic *Naturphilosophie*. In this sense, biology as a science became possible only once purposeful organization was considered a constitutive characteristic of living bodies and, as such, something that required scientific explanation.

It should be noted that the vast majority of scholarly work dedicated to this historical period continues to use the vocabulary first introduced in the late 1970s by Imre Lakatos to discuss the methodology of scientific research programs.[7] In fact, the idea of a Kant-Blumenbach "teleomechanical" research program for biology, which was first formulated by Lenoir in 1982, is still endorsed in recent studies.[8] However, this notion of a Kant-Blumenbach research program is inadequate to describe the transformations that led to the rise of biology at the beginning of the nineteenth century. As scholars like Philippe Huneman and Rachel Zuckert have shown, the idea that the *Critique of the Power of Judgment* provides a research program for biology can be criticized not only by emphasizing the divergence between Kant and Blumenbach but also by highlighting how Kant's attention to biological issues did not (at least not primarily) emerge from interest in scientific concerns. Rather, biological issues emerged in his work as a product of his interrogation of metaphysical questions concerning the concepts of necessity, contingency, and purposiveness.[9]

It is true that Kant dealt with at least three biological issues: (1) the relationship between the notion of *Naturzweck* and modern epigenesis, which interested him because the process of embryogenesis seems to presuppose its result (the adult organism) and to be directed toward its realization; (2) the problem of biological functions, which he believed could not be explained without reference to final causes; and (3) the difference between *Naturbeschreibung* and *Naturgeschichte*, which he considered an index of natural history's epistemological status as a descriptive cataloguing or causal explanation of varieties. Nevertheless, Kant did not consider biology a proper science that treats its objects wholly according to a

[7] Lakatos 1978.

[8] Bach 2001; Schmitt 2006; Dupont 2007.

[9] Zuckert 2007; Huneman 2008.

priori principles, because such consideration of living beings for him implied teleological principles and, in his view, teleological principles have a regulative (i.e., heuristic) character that makes them insufficient to ground a theory.

This denial of biology as a proper science is most explicit in the third *Critique*. Yet, despite Kant's denial, in the late eighteenth century, the term "biology" began to appear in the works of several naturalists. The most important instance is in the monumental *Biologie, oder Philosophie der lebenden Natur für Naturforscher und Aerzte* (1802–1822) by Gottfried Reinhold Treviranus. This historical fact leads us to the following question: what happened between 1790, the year Kant's third *Critique* was published, and 1802, when Treviranus used the term "biology" to title his scientific work about physical life as a natural phenomenon?

In attempt to account for this shift between Kant's disavowal of the very possibility of a life science and the rise of a general biology in Treviranus' work, I will trace the conceptual history of the notion of "vital force," which was a unifying element of most scientific and philosophical enterprises concerned with the explanation of organic nature in the second half of the eighteenth century. This might seem a counterintuitive strategy, since the prevailing view of the history of biology – already promulgated at the end of the nineteenth century by those who elaborated modern cell theory, Schwann and Schleiden, and by the physiologist du Bois-Reymond and the biochemist Liebig – considers vitalism and "vital forces" epistemological obstacles to the birth of biology as a science. This view, however, rests on a limited definition of the term "vitalism." Indeed, in challenging the idea that vitalism per se constituted an obstacle to the rise of biology at the turn of the nineteenth century, I aim to interrogate what the label "vitalism" has come to mean in the first place.

Georges Canguilhem has argued that "in general and as a consequence of the signification it acquired in the eighteenth century, the term *vitalism* is appropriate for any biology careful to maintain its independence from the annexionist ambitions of the sciences of matter."[10] In this respect, "a history of biology systematic enough not to privilege any bias or point of view would perhaps teach us that the fecundity of vitalism as such is far from null – and in particular that this fecundity is a function of historical and national circumstances."[11] This idea constitutes the fundamental

[10] Canguilhem 2008, 61.

[11] *Ivi*, 67. In his preface to *The Normal and the Pathological*, Michel Foucault makes an important point about the paradoxical fact that the "scientificization" of the life sciences occurred by bringing to light physical and chemical mechanisms – through the constitution of domains such as molecular chemistry or biophysics – that make use of mathematical models, but that this process was simultaneously "able to develop only insofar as the problem of the specificity of life and of the threshold it marks among all natural beings was continually thrown back as a challenge." This does not mean that vitalism (however we define it) is true, but simply "that it had and undoubtedly still has an essential role as an 'indicator' in the history of biology. And this in two respects: as a theoretical indicator of problems to be solved (i.e., what constitutes the originality of life without, in any way, constituting an independent empire in nature); as a critical indicator of reduction to be avoided (i.e., all those which tend to ignore the fact that the life sciences cannot do without a certain position of value indicating preservation, regulation, adaptation, reproduction, etc.)" (Foucault 1991, 18). In other words, the historical and conceptual significance of vitalism lies in its perpetual attempt to justify the autonomy of biological entities from the explanatory framework of physical sciences.

working hypothesis of this book and is applied in particular to Romantic *Naturphilosophie*.

Lenoir tried to rehabilitate eighteenth-century vitalism by showing that its research program could be considered in "naturalized" terms. His most important concern was marking the difference between the Göttingen program and *Naturphilosophie*, which he considered the metaphysical and anti-naturalist program *par excellence*. However, his analysis is one-sided. We could perhaps best describe its nature by adapting an expression used by Ron Amundson: "modern synthesis historiography."[12] What Lenoir presents seems to be a rather distinct form of "naturalist historiography," since the naturalist historiographer holds the belief that biology – which we as contemporary (more or less) naturalist readers consider to be a scientific framework – must necessarily have a "naturalized" origin. This assumption leads scholars like Lenoir to undertake a quest to "naturalize" the past, in order to purge the history of natural science from all traces of non-naturalist metaphysics. Unfortunately, from the standpoint of contemporary biology, the natural-historical concerns (and attendant metaphysical commitments) of Kant and Blumenbach are just as alien to us as those of Herder, Goethe, Schelling, and Oken.

As Nicholas Jardine has suggested, "this alienation does not arise from their having given what are, according to present-day biology, largely false answers to genuine questions, nor does it arise from their having addressed what are, from our scientific viewpoint, genuine but eccentric or uninteresting questions." Rather "the alienation is engendered by their having addressed what are for the most part, for us, unreal questions," because in fact "too few of the questions they addressed are, by our lights, real questions; too few of their beliefs are for us even candidates for truth."[13] Indeed, I maintain that Kant's arguments are at least equally alien to us, and just as "non-naturalistic," as the metaphysical arguments of the *Naturphilosophen*. In this sense, if we take up Lenoir's search for a non-metaphysical, naturalist-friendly, conceptual framework in Kant's work upon which to found biology, we come up empty-handed.

Rather, as far as biological organization is concerned, Kant lies at the crossroad of two metaphysical traditions: the rationalist metaphysics of Leibniz, Wolff, and Baumgarten, according to which teleology is construed as (God's) intention, and the metaphysics of *Naturphilosophie*, in which teleology is interpreted as self-organization. We find Kant at the border of these two conceptual spaces, a position conceptually expressed by his distinction between *external* and *internal* purposiveness. The former defines vital organization as the product of technical agency and the latter as the result of autonomous activity. Despite the significance of this distinction, Kant ended up conceiving teleology in technical terms, as the result of subjective intention, i.e., as *external* purposiveness, in a manner coherent with the former metaphysical tradition. Yet he was unwilling to appeal to God as an explanatory ground for natural science. He thus held an "unstable middle position"[14]

---

[12] Amundson 2005.

[13] Jardine 1991, 51.

[14] Weber and Varela 2002, 99.

by arguing, on the one hand, for the impossibility of a mechanical account of organisms, while, on the other hand, maintaining that the teleological features displayed by living systems should only be considered heuristic concepts, not ontologically essential characteristics of those systems.

My central argument is that the problem of intrinsic teleology is bound to the philosophical enterprise of the *Naturphilosophen* and belongs to the historical conditions from which something like a "biology" was able to emerge at the turn of the nineteenth century. The authors that fall under the category of the "Göttingen School" played a crucial role in facilitating a discursive shift from an *external*-technical conceptual paradigm to an *internal*-autonomous understanding of purposiveness. Of course, as physicians and naturalists engaged in empirical research, they were unable to provide (and uninterested in) a philosophical account of this shift. This account is instead provided by Schelling's *Naturphilosophie* at the very end of the eighteenth century. Using a method of a priori deduction, Schelling aimed to establish a metaphysical foundation for the theories found in the works of the Göttingen naturalists – an attempt not dissimilar in nature from the one we find of Newtonian mechanics in Kant's *Metaphysical Foundations of Natural Science* (1786). The theoretical framework elaborated by Schelling's *Naturphilosophie* played a significant role in laying the foundations for the emerging biological science and in fact became a fundamental reference for Treviranus' *Biologie*. In this way, both the Göttingen tradition and the *naturphilosophisch* movement interrogated the self-organizing features of organic nature and thereby played crucial roles in establishing conceptual space for biology as what Nicholas Jardine would define as a new "scene of inquiry."

Certainly, Romantic *Naturphilosophie* upheld an idea of science that differs quite strongly from our current naturalistic approach, but, strictly speaking, so did Kant and Blumenbach. If adherence to our current scientific beliefs is the yardstick for our evaluation of past scientific enterprises, none of the authors I take into account are likely to pass the test. Indeed, if our attention is focused on *answers*, all we can do is try to "translate" past scientific theories into our contemporary language in order to make them understandable or consider them "forerunners" of our current views. Yet if we instead focus on *questions*, we see a totally different picture. We are instead able to assess the meaning of a scientific enterprise not according to the degree to which it accords with "naturalization" but rather with regard to the scenes of inquiry that its questions open up.

This book will expand on this argument through four chapters and a conclusion:

1. Chapter "Generation: The Debate Over The Formative Force and the Question of Ontogenesis" is concerned with the problem of generation in the mid- to late eighteenth century and reconstructs the debate on the notion of *formative force* with reference to Caspar Friedrich Wolff (1734–1794), Johann Friedrich Blumenbach (1752–1840), Immanuel Kant (1724–1804), and Johann Christian Reil (1759–1813). This debate interrogated the origin of form and addressed the epistemological status of the *Bildungskraft* as the fundamental principle behind

organization. My analysis focuses especially on the different interpretations of the notion of "teleology" defended by the authors, with the objective of providing a sort of general typology of the different forms of vitalism characterizing the German debate of this period.

2. Chapter "Functions: The Göttingen School and the Physiology of Vital Forces" provides a reconstruction of the physiology of vital forces as it was elaborated in the mid- to late eighteenth century by the physicians and naturalists gathered under the category of the "Göttingen School," namely, Albrecht von Haller (1708–1777), Johann Friedrich Blumenbach (1752–1840), Carl Friedrich Kielmeyer (1765–1844), and Heinrich Friedrich Link (1767–1851). I argue that the theoretical framework of the Göttingen School implied two fundamental tenets: first, an interpretation of teleology as internal purposiveness (argued by Blumenbach) and, second, a proposal to reform natural history in terms of comparative physiology, i.e., as a taxonomy of vital functions and an analysis of their distribution in the animal and plant kingdoms (articulated by Kielmeyer and Link). The chapter concludes with a reconstruction of Kielmeyer's and Link's assessment of *Naturphilosophie*. Whereas the aim of Lenoir's reconstruction of the Göttingen School was to stress its distinction from *Naturphilosophie*, my aim in this chapter is to emphasize the continuities between these two traditions.
3. "Classification: *Naturphilosophie* and the Reform of Natural History" reconstructs the reform of natural history that *Naturphilosophie* advocated in opposition to Kant and Blumenbach, with references to Johann Wolfgang Goethe (1749–1832), Friedrich Wilhelm Joseph Schelling (1775–1854), and Lorenz Oken (1779–1851). This chapter is organized as a counterargument to Peter Hanns Reill's stark distinction between "Enlightenment vitalism" and "Romantic *Naturphilosophie*." I will demonstrate that, although a difference can be identified between the approach to animal classification upheld by Kant and Blumenbach, on the one hand, and the reform of natural history promoted by Goethe, Schelling, and Oken, on the other, this division is much less significant than Reill assumes it to be. Moreover, I will show why the difference between the two camps cannot be reduced to their alleged lack of "epistemological modesty" but is rather ascribable to their desire to bring to completion what Kant and Blumenbach left unfinished: a program for a scientific classification of living organisms. I also argue that Kielmeyer's program for a comparative physiology was considered, especially by Schelling, a stepping-stone for this philosophical mission.
4. Chapter "Biology: Treviranus and the Life Sciences as a Unified Field" is devoted to thorough analysis of the work of Gottfried Reinhold Treviranus (1776–1837), including his monumental six-volume *Biologie, oder Philosophie der lebenden Natur für Naturforscher und Aerzte* (1802–1822) and the two-volume *Erscheinungen und Gesetze der Organischen Leben* (1831–1833). I argue that Treviranus' work constitutes a compelling synthesis of the framework elaborated by the Göttingen naturalists and later developed by *Naturphilosophie*. I focus on textual evidence that the formalization of biology at the turn of the nineteenth century implied a shift from the Kantian understanding of teleology

as a regulative principle to the idea of purposiveness as a constitutive characteristic of living systems. I stress that Schelling's organicist views played a relevant role in this shift and inform several key passages of the *Biologie*. At the same time, through emphasis on the geographical distribution of organisms and their transformation over time, Treviranus moved beyond *Naturphilosophie* to establish the foundation of biology as a historical science.

5. I conclude with some considerations of Hegel's position on Romantic *Naturphilosophie*. Unlike Kant and Schelling, Hegel did not play an active role in the scientific debate culminating in the emergence of biology as a unified field. However, as an external observer, he was well-positioned to grasp its fundamental philosophical stakes. In particular, he criticized Kant for interpreting teleology solely in terms of intention and the *naturphilosophisch* movement for its speculative excesses. These critiques, however, establish that Hegel did not consider *Naturphilosophie* something to be thoroughly rejected, but corrected and integrated. His attempt to facilitate this integration resulted in a theory of biological individuality in which teleology is understood as *internal* purposiveness, i.e., autonomous self-organization.

Generation: The Debate Over the Formative Force and the Question of Ontogenesis

1 Introduction and Outline: Ontogenesis and the Legacy of the Haller-Wolff Debate

We have been accustomed, at least since Kant, to distinguishing between a mechanical and a teleological conception of living organisms. In this respect, the notion of mechanism has taken on two different meanings: a very general one, in which reference to efficient causes is the only legitimate basis for scientific explanation, and a second, more specific meaning, in which mechanism serves as an explanatory framework for the relationship between parts and whole, such that the behavior of parts provides an adequate and complete account for the different properties of the whole. In both approaches, mechanism is opposed to teleology. Following the conceptualization of teleology provided by Kant in the third *Critique*, the teleological approach instead offers a "technical" understanding of living organisms, according to which they are understood as machines, i.e. products of divine design. In this chapter, I will outline the complex relationship between these two accounts of living organisms by reconstructing the debate over generation that took place in the German lands in the second half of the eighteenth century – a debate that involved such philosophers and naturalists as Caspar Friedrich Wolff, Johann Friedrich Blumenbach, Immanuel Kant, and Johann Christian Reil. I will argue that this debate can be considered the origin of a new paradigm for understanding the source of living organization that overcomes both mechanical and technical-teleological explanations to posit teleology as self-organization. As we shall see in the rest of the book, this new paradigm played an essential role in the rise of biology in Germany as the science addressing the laws regulating the self-organization of organic nature – laws marked by an explicitly teleological character. I will further argue that Kant played a crucial role in conceptually defining this idea, by outlining a controversial middle-position between the *mechanical* and the *technical-teleological* approaches to living organisms: a position which both acknowledged the mechanical inexplicability of living organisms and their irreducibility to the early-modern

A. Gambarotto, *Vital Forces, Teleology and Organization*, History, Philosophy and Theory of the Life Sciences 21, DOI 10.1007/978-3-319-65415-7_1

machine-model, yet ultimately failed to recognize the implication of this irreducibility, namely that teleology is a constitutive feature of organized beings. This failure made it impossible for Kant to move beyond the conceptual and epistemological space of the two former approaches.

I begin my analysis with a reference to the well-known experiments conducted by Abraham Trembely (1710–1784) on the green hydra in the first half of the eighteenth century.[1] In fact, the remarkable regenerative features of the small hydra that Trembley discovered caused many to question the standard beliefs about generation. Uncertainty about how to classify the hydra – was it an animal or plant? – convinced Trembley to conduct a series of experiments concerning its response to being damaged and its ability to regenerate. In his first observations, Trembley noticed that the polyp moved in a step-by-step way, much like an inchworm, which suggested it had an animal nature. He was therefore surprised to see that, when he cut its body in two halves, each half of the polyp regenerated, plant-like, into a complete new body. After detailed examination, Trembley finally concluded that there was no difference between the newly regenerated polyp and one that had never been cut.

The publication of the results of this work had a revolutionary impact on the international scientific community. Trembley wrote his experiments first in a letter to René Antoine Ferchault de Réaumur (1683–1757), whom he had met through his cousin, Charles Bonnet (1720–1793). Réaumur was so excited by the results that he immediately announced them to the Paris Academy of Sciences. By the time Trembley's discoveries appeared in print, in volume 42 of the *Philosophical Transactions* of the Royal Society, most of the scientific community was already familiar with them. Some had already replicated his experiments and others had investigated the same phenomena in other organisms. Charles Bonnet, for instance, performed similar experiments on worms and published his discovery that some of them displayed the ability to regenerate alongside Trembley's paper. This support from the scientific community and wide confirmation of his results led to Trembley's election to the Royal Society in 1743. The following year, he published the *Mémoires, pour server à l'histoire d'un genre de polyp d'eau douce, à bras en forme de cornes* (1744), which presented his experiments and observations in their entirety.

These results drew a great deal of attention, because they raised fundamental questions about the inherent power of living matter, which had been found to exceed mere mechanical forces. The discovery had profound implications for the heterogeneity of life: what had previously been considered brute matter were actually living bodies made up of internal vital forces. At a time when most naturalists believed that generation was preordained and facilitated by encased preformed embryos, the polyp's capacity to create whole new organisms from small pieces of substance, which lacked prior design by God, was a most unexpected phenomenon.

The last important endorser of this view of preformation was Albrecht von Haller (1708–1777), who opposed the founding father of modern embryology, the young

[1] Baker (1954), Lenhoff (1986), Ratcliff (2004).

physiologist Caspar Friedrich Wolff (1734–1794), in a famous debate over animal generation.[2] In the preface he wrote to the second volume of the German translation of the *Histoire Naturelle*, the monumental work of French naturalist Georges-Louis Leclerc Buffon (1707–1788), Haller argued that particles of matter could not come together to form an organized structure without prior divine design. In nature, Haller argued, one cannot find a force able to bring together millions of vessels, nerves, fibers, and bones always according to the same plan: "M. Buffon has here the necessity of a force that seeks, that chooses, that has a purpose, that against all the laws of blind combination always and infallibly casts the same throw."[3] How could a simple physical force bring forth such a complex animal? Haller concluded that the structure of the adult animal must exist preformed in the male semen. Physical forces such as attraction and repulsion, Haller maintains, play a role in the formation of salt and crystals, snowflakes, and natural products such as the Diana's tree,[4] but the invariable reproduction of animals must necessarily lie beyond these simple forces. Haller found complex reproduction to necessitate some form of guidance and believed it was God who directed the operation of natural forces in the developing embryo. Therefore, in Haller's view, animal generation (i.e. organic development) could only be understood by referring to God's original design.

Wolff, on the other hand, was the first physiologist in Germany to attempt an account of animal generation that did not make reference to God's activity, but rather explained organic development as a result of purely natural forces. Wolff's most important work is his doctoral dissertation at the University of Halle, the *Theoria generationis* (1759), in which he discusses his conception of generation for the first time. A copy of that dissertation was sent to Haller, triggering a review in the *Göttingische Anzeigen von gelehrten Sachen* that sparked the famous debate between the two. The second edition of Wolff's work – *Theorie von der Generation* (1764) – includes a restatement of his theory and a detailed polemical attack on the preformationist views of both Haller and Bonnet; this work was followed by a lengthy response in Haller's *Elementa physiologiae corporis humani* (1766). In 1768, recognizing the uselessness of further theoretical argument with his opponents, Wolff found himself at an impasse in advancing his views about formative causes – though he would return to these later in discussion with Blumenbach – and instead produced a technical work intended to equal Haller's detailed treatise on the heart: *De formatione intestinorum* (1768). In this text, after summarizing his ideas about generation, Wolff meticulously analyzed the development of the digestive system. Although very technical, this treatise has been unanimously recognized as the first great text of modern embryology.[5] I will not summarize all of Wolff's observations concerning the envelopes of the embryo and the digestive system, which can

[2] Roe (1981).

[3] Haller (1752), xi.

[4] The Diana's Tree is a compound of crystallized silver with a branched form that resembles a tree. This peculiar form led early-modern naturalists to theorize the existence of life in the kingdom of minerals.

[5] Canguilhem (1962), Roe (1981), Dupont (2007).

be found elsewhere,[6] but will only stress the most important concept of this treatise, namely that of intermediate embryonic forms. This concept appears already in the German edition of the *Theoria generationis*, when Wolff rejects Haller's invisibility argument. Haller had advanced the thesis that all the phenomena indicated by Wolff could be interpreted as a progressive manifestation of parts of the embryo that were previously invisible. According to Haller, Wolff had mistaken invisible for nonexistent. In his analysis in *De formatione*, Wolff shows that organic development is characterized by the progressive substitution of element B for element A, from which it follows that element B could not possibly already be present at the beginning of the process, because A was occupying its spot.[7]

Finally, as a faculty member at the St. Petersburg Academy of Sciences, in 1789 Wolff composed a long paper entitled "Von der eigentümlichen und wesentlichen Kraft der vegetabilischen sowohl als auch der animalischen Substanz," which sheds light on how he conceived of the essential force both in his early and later works. This treatise was written as a response to and published alongside two essays on similar topics by Johann Friedrich Blumenbach and Carl Friedrich Born. The latter were selected for first-place honors in a competition held by the St. Petersburg Academy of Sciences for best essays on the nature of the "nutritive force." According to Wolff, plants and animals arise from an amorphous and undifferentiated substance. Vesicles (*vesicuale*), or corpuscles (*globuli*), and vessels (*vasae*) progressively appear within this substance as small spherical cavities filled with liquid – a nutritive fluid decisive in the developmental process. Flowing slowly, this fluid loses its volatility, becoming sticky and creating vesicles; flowing rapidly, it creates vessels that then become organs. In Wolff's view, the movement of liquids and their tendency to coagulate was sufficient to explain the structure of plants and animals without any need for preexisting structures.[8]

The "germ" (*Keim*) is an important concept in Wolff's framework. It is an unorganized, amorphous substance secreted by the genital organs of the parents, which gradually becomes organized only after conception. The tendency of fluids in plant and animal embryos to coagulate – the former in the seed, the latter in the yolk – for Wolff is caused by a specific "force," defined as the *vis essentialis*. Each part secretes another that replicates its own formation in a self-organizing process. With this model of secretion, solidification, and *vis essentialis*, Wolff claimed to have offered a complete explanation of generation: "with the capacity of nourishing fluid to solidify, the essential force establishes the sufficient principle of all vegetation [development], both for plants and for animals."[9] He therefore frames development as a modification of structures, a form of construction effectuated by natural forces. Wolff's postulation of a vital force specific to organic development might be interpreted as introducing a hyperphysical element into natural inquiry. Yet the Haller-Wolff debate instead shows the contrary to be true: Wolff in fact postulated the *vis*

[6] Dupont and Perrin (2003).

[7] Huneman (2007b).

[8] Dupont (2007), 39.

[9] Wolff (1759), § 242.

essentialis precisely to *avoid* any such a reference to the hyperphysical element upheld by preformationist theorists, i.e. God's original design, and to explain development solely on the basis of natural laws.

The precise epistemological status of this force however is problematic. In his review of the *Theoria generationis*, Haller had already accused Wolff of not providing a clear definition of his *vis essentialis*. In fact, the term seems to point to a particular force inherent to the process of organic development, but, as I will argue in this chapter, Wolff did not consider it a formative force, i.e. a force determining the specific direction of development that was responsible for species determination. Strictly speaking, Wolff did not even posit it as a force but as the organic substance's property of attracting similar and rejecting dissimilar matter, which allows for generative and nutritive processes. Wolff distinguishes the *vis essentialis* from the action of the soul, thus distancing himself from the animist theory of Stahl, and he considers the *vis essentialis* to be nothing more than a physical force.[10] His theory dispenses with any teleological principle, and by extension, with any intelligent, architectural, or directing principle – or any other supplementary force. In this regard, it does not fit the concept of organism that emerged in Germany in the following years, chiefly with Blumenbach, and which is described in Kant's third *Critique* as an entity in which the parts reciprocally produce and are produced by the form of the whole.[11]

In this chapter, I reconstruct the different positions taken on the nature of generation in the debate that took place in Germany in the second half of the eighteenth century. I first show that the epistemological status of this force is problematic in Wolff's writings, by focusing on a relatively unknown yet crucial document, Wolff's 1789 essay on the nutritive force. I will stress the difference between Wolff's *vis essentialis* and Blumenbach's *Bildungstrieb* by means of the latter's explicit association with a goal-directed drive that is responsible for the formation of organized beings. I will then situate this discussion in relation to the Kantian account of teleology, especially his distinction between external and internal purposiveness – the former implying a technical-teleological approach to organized beings, according to which they must be understood as the result of intelligent design, the latter pointing towards an understanding of teleology as self-organization. I will argue that, despite this distinction, Kant was ultimately unable to move beyond a "technical" understanding of organization. Finally, I will analyze the position of Johann Christian Reil, who maintained that the purposive features displayed by organized beings result from a particular arrangement of matter: organization is not the result of a particular teleological vital force but rather the result of a particular kind of organization. This survey of the debate over generation will help us to overcome a one-sided view of the German life sciences of the period as stemming from a unified Kant-Blumenbach research program and will lay the foundation for a more nuanced historical narrative, which I try to provide in the rest of the book.

---

[10] Roe (1981), 102–110.

[11] Witt (2008), 662.

2 Diverging Views of Epigenesis: Wolff and Blumenbach on Teleology

2.1 Epigenesis Without Purpose: Wolff and the Nutritive Force

In the introduction to the second edition of his doctoral thesis, the *Theorie von der Generation* (1764), Wolff argues that despite the many existing works on the problem of generation, no one had yet been able to explain this phenomenon – or to find its causes. Only Descartes genuinely tried to provide an explanatory framework for the development of organic bodies, albeit a wrong one.[12] This comment is paradigmatic of Wolff's position on eighteenth-century mechanical theories of generation (such as Descartes') and on later German embryology (such as Blumenbach's). In fact, on the one hand Wolff was the first to call for a non-mechanical treatment of organic development, while on the other hand he refused to appeal to teleological notions or vital agents.

Wolff maintains that the "essential force" (or "nutritive force") operates through the movement of fluids. The question was how it could thereby account for the developmental process of organization. Since a chick egg becomes a chick, while a peacock egg becomes a peacock, how could the force direct the developmental process toward these two different goals? Wolff's 1789 paper "Von der eigentümlichen und wesentlichen Kraft der vegetabilischen sowohl als auch der animalischen Substanz" helps shed light on how he conceived of the *vis essentialis* both in his early and later works. In this text, Wolff explicitly discusses the nature of the essential force, its properties, and its difference from the attractive force of bodies. In part a commentary on the essays of Blumenbach and Born, the work is above all a presentation of Wolff's answer to the question of how the developmental process was directed.

In this text Wolff upholds a simple model for how the essential force operates: in living bodies, he contends, similar substances attract one another, whereas different substances repel one another. On the basis of this phenomenon, Wolff claims, one can explain all vegetative activities: in nourishment, for example, liquids are brought to the different parts of the plant or animal, each part attracting material that is similar to it, which can be therefore used for growth and repair. Attraction is produced by the fact that two substances are similar in nature and is caused by the presence of the essential force in both the organism's nourishing liquid and its various parts. Through repulsion, a solidified part secretes material that is dissimilar to it, which solidifies to become a new structure and grows by attracting material similar to itself via the nourishing liquids. Wolff argues again, as he did in earlier works, that mechanical causes (for example the pumping of the heart after it is formed) influence vegetative activities but do not cause them. Their cause is the essential force, which "must be peculiar to this plant and animal substance, because no material other than plant and animal substance is nourished, vegetates, or reproduces its

[12] Wolff (1764), 5.

kind. Moreover, because the whole life of plants [and animals], their nutrition, growth, vegetation, and reproduction, rests upon it, one can call it a characteristic of the essential force. For where this force is absent, all vegetable process cease."[13] In other words, a body cannot be alive without the essential force.

Nevertheless, Wolff does not understand this as a form of animism and therefore underscores the difference between himself and Stahl: "this characteristic essential force appears to be that, if I do not err […], whose existence Stahl very certainly recognizes, but which he incorrectly attributed to the soul. It consists in nothing further than a particularly defined kind of attractive and repulsive force." The essence of life, Wolff contends, need not be attributed to a soul but to an attractive and repulsive force. The *vis essentialis* is thus not a "formative force," a force determining the specific direction of development in every species, but rather a simple agent: "the generation of different parts of the body cannot depend immediately upon the force. There is no reason for which this force should work differently in different bodies."[14] It only attracts similar substances and repels dissimilar ones. It thus "does not produce the different parts of the organic body only through itself and according to its nature, but rather with the help of countless other concurring causes; what it does through itself alone, becomes a completely simple effects, as attraction or repulsion, it is far from producing organic bodies by itself."[15] All of the vegetative processes are produced by the combination of this essential force and different circumstances – the most important of which is a certain similarity or dissimilarity of substances according to their "chemical" properties.

Wolff's understanding of the *vis essentialis* is clarified if we compare it to Blumenbach's notion of *nisus formativus*, also known as *Bildungstrieb*. In an unpublished note, Wolff objected to Blumenbach's comparison of the *vis essentialis* to his own formative drive: "does this most illustrious gentleman not see then that the motion of the humors through a plant is one thing, whereas the formation of a plant is something else? And that therefore the force that moves humors through a plant is different from the formative force? Does he not see that by supposing the motion of humors I do not suppose formation, and by supposing a moving force I do not suppose a formative force?"[16] Since it contains a direct discussion of this matter, Wolff's 1789 paper is particularly helpful for assessing the difference between Blumenbach's standpoint and his own.

The question motivating both Blumenbach and Wolff concerned the nature of the nutritive force that allows plants and animals to develop and grow: "what kind of force is it? In first place, is it the same as the attractive force that involves all physical bodies or rather a different force proper to living substance alone, like plants and animals? If the latter is true, it is further asked, what are the effects of this force and which properties distinguish it from the common attractive force?" The mentioned collection of essays, published in 1789 with the title *Zwo Abhandlungen über die*

---

[13] Wolff (1789), 66.

[14] *Ibidem*.

[15] *Ivi*, 67.

[16] Wolff (1793), 225.

Nutritionskraft, contains two essays that aim to provide an answer to these questions. The first was authored by Blumenbach, the second by Born, a professor of chemistry at the University of Kronstadt. In a third essay, Wolff expounds his own position on the issue at hand. He begins with the "determination of the different nutritive forces or, if it is just one, of its different effects," arguing that the first effects of the essential forces in organic bodies are for the most part mechanical. For example, the initial movements in the egg depend on repulsive forces, and they play a role in the development of the whole embryo. One can thus observe how strong the influence of mechanical causes is on the life of plants and animals. However, one must thereafter also recognize that life in general, and all of its expressions, are based on the essential force, which is the hallmark of both animal and vegetable substance. Without it, the organizational process would not produce any of the effects that we observe in plants and animals and that constitute their life.[17]

Wolff maintains that, at the beginning, the formation of parts in plants and animals occurs by means of the excretion of a fluid "juice" – this occurs before vessels, gaps, or anything else organic is formed. As these fluids continue to flow down the same paths, over time they solidify and form vessels. These nutritive juices penetrate all the different parts of the organism: skin, muscles, bones, any place without gaps or vessels. They spread through the substance of a part by means of an attractive force[18] The more juice an area has absorbed by means of attraction, the weaker the attraction will be and the more likely the fluids will begin to flow to other parts. On the contrary, the less juice an area has already attracted, the stronger the attraction will be. This process continues until the part contains the same amount of juice everywhere.[19] According to this framework, the nutritive force cannot be anything other than an attractive force, and certainly is not a propelling force or drive: "the attractive force is the only moving force, which not only causes the motion, but also determines its direction, its quantity, and its duration."[20] However, the nutritive force should not be confused with a mere mechanical force.

In fact, if organic bodies were acted upon only by mechanical forces, "they would not be anything other than machines, different from artificial machines only with regard to their construction or kind of organization, because the force would be exactly the same."[21] If this were the case, Wolff contends, one could build a model of a plant and it would grow like a natural plant; it would produce the same flowers and reproduce its species in the same way. It would have the same organization and the same force and would be exactly the same 'machine',

> but I think that the model would stay still, and that even the most zealous advocates of the mechanistic medicine would not believe it is possible to produce such a model. The nutritive force of plants and animals must thus be different from the attractive force that all bodies possess. Since only vegetable and animal substance is nourished, vegetates and

[17] Wolff (1789), § 21.

[18] *Ivi*, § 63.

[19] *Ivi*, § 64.

[20] *Ivi*, § 67.

[21] *Ivi*, § 72.

> reproduces its species, this force has to be proper only to this vegetable and animal substance. Since also the whole life of the plant, its nourishment, growth, vegetation and reproduction is based on it, it could be defined as the peculiar and essential force. Where this force lacks all vegetative processes (*Verrichtungen*) disappear.[22]

In this fundamental statement, Wolff emphasizes the difference between living organisms and machines, arguing that the "essential" or "nutritive" force is not a mere mechanical force: it is a force specific to living organisms. Vital phenomena all depend on this force, and since there is only one essential force in plants and animals, "all the differences that take place in the effects of nature, if they are not just mechanical modifications, depend on determinations of this very force."[23] This essential force expresses itself and operates in growth, it is present at the beginning of all absorbing vessels and veins, in the nutritive and vegetative points of all parts of the body, at the beginning of the embryo (both plant and animal). "All the vegetative phenomena are basically all the same: they are in fact caused in the same way [i.e. in the process of progressive secretion and solidification described by his theory of generation] from the same force."[24] It is important to note that despite the *vis essentialis* is considered as the fundamental cause of epigenetic development, the epistemological status of this essential force remains unclear.

On the one hand, the *vis essentialis* marks the difference between living and inert matter, between organisms and machines; on the other hand, it is considered a merely physical force, without any teleological agency. This opens up a relevant epistemological issue within Wolff's theory of generation, because in these terms the notion of *vis essentialis* can account for tissue growth but not for species determinacy. In fact, as Charles Bonnet did not fail to note,

> if there is nothing preformed in the matter that essential force organizes, how will this force determine the production of an animal, rather than a plant, and a certain animal in preference to another one? Why will the essential force produce a certain organ in a certain place and not in another? Why will this organ constantly have the same shape, the same proportions, and the same situation in a given genus? Why?[25]

In the next section, I take up Blumenbach's notion of *Bildungstrieb* to stress its difference from Wolff's *vis essentialis*. Blumenbach understands the *Bildungstrieb* as not only as the cause of organization but also the source of any *specific* organization: it is a goal-directed principle of vital organization that supervises the process of organic development.

---

[22] *Ivi*, § 74.

[23] *Ivi*, § 124.

[24] *Ivi*, § 133.

[25] Bonnet (1985), 467.

2.2 Goal-Directed Organization: Blumenbach and the **Bildungstrieb**

I now take up Blumenbach's notion of formative drive (*Bildungstrieb*, *nisus formativus*) to stress its difference from Wolff's *vis essentialis*. Blumenbach understands the *Bildungstrieb* as not only as the cause of organization but as the source of *specific* types of organization: it is a goal-directed principle of vital organization that supervises the process of organic development. I argue that Blumenbach conceived this goal-directed drive as inherent to all organic matter, which, as such, marks the boundary between living and non-living matter. This contrasts with Wolff, who understood his *vis essentialis* as a physical force responsible only for the movement of fluids in organic bodies.

Blumenbach's contribution to the 1789 publication on the nutritive force deals mainly with specific physiological issues concerning the vital properties of vessels. Blumenbach argues that "all these vessels, taken in the broad, as much as in the narrow sense of the term (veins), possess a vital force (*Lebenskraft*) through which they are, as it were, animated." This vital force ensures that each vessel absorbs only specific liquids (blood vessels, milk vessels, etc.), which are necessary for the nourishment the living body. This force implies a certain receptivity (*Empfänglichkeit*) on the part of vessels to absorb homogeneous substances, "an ability to attract (*Anziehungsvermögen*), a kind of affinity."[26] This description of this force converges with Wolff's definition of the essential force embodied in the vessels of nourishment: "I take these vital forces (or these modification of the vital force, as one prefers), as it were, as an expedient to investigate the essential force that was discussed in two different essays in 1759 and 1762 [the two editions of Wolff's theory of generation] and then used from the same hand in some academic treatises with regard to the functions of single parts of an organized body."[27] As we can see, the tone of this 1789 text is relatively accommodating to Wolff and there are no signs of a real controversy. There is of course a rhetorical motivation for this. Indeed, it is likely that the nature of the competition, and the fact that it was Wolff who proposed the topic, led Blumenbach to be rather generous in his judgments. However, there is also strong evidence of a change of view on Blumenbach's part, which becomes apparent once we take into account the various editions of his *Bildungstrieb* essay.

The essay was published for the first time in 1781 (before the competition) and again, in a slightly expanded version, in 1789 and 1791 (after the competition). Blumenbach started his career as an endorser of preformation, but the unexpected result of a small experiment – intended to prove the theory of evolution and, once again, involving a fresh-water hydra – brought him to epigenesis. As a matter of fact, the regenerative properties of the polyp, which allowed it to re-grow arms and a tail after they had been cut off, for Blumenbach were related to a more common

[26] Blumenbach (1789), § 3.

[27] *Ivi*, § 14.

phenomenon: they reminded him of a time he had visited a patient with a wounded knee and observed the wound heal as the hole filled with lymph and built new healthy flesh. *Mutatis mutandis* he realized the same occurred in the hydra. This realization led Blumenbach to dedicate his work to investigation of this phenomenon.

In the first edition of the essay, Blumenbach argues that this phenomenon testifies to the existence of a "drive (*Trieb*) (or tendency [*Tendenz*] or aim [*Bestreben*]) which is entirely different from the general properties of the bodies, as well as from the other peculiar forces of organized bodies in particular), which is the cause of all generation, nutrition, and reproduction, and which, to avoid all misunderstanding and distinguish it from the other natural forces, I define as *nisus formativus*."[28] This drive should not be confused "with the *vis essentialis*, or even with the chemical fermentation […] or else merely mechanical forces."[29] But what precisely is the difference?

The difference is made clear in the later editions of the essay, where Blumenbach defines the *nisus formativus* as "a peculiar lifelong drive" that "pushes it towards its determined shape" and maintains that shape over the course of its life and restores it in cases of mutilation. This drive "belongs to the vital forces, but it is also clearly different from all the other vital forces of living bodies (contractility, irritability, sensibility etc.) and from all the universal forces of bodies in general." It seems to be the first force important for generation, nutrition and reproduction, and Blumenbach defines it as the "formative drive" (*Bildungstrieb*, *nisus formativus*).[30] In these later essay editions, Blumenbach specifies that with this term he refers to something like "attraction" or "weight," as he intends to indicate "nothing less than a force, whose constant action can be empirically observed."[31] Its cause, as well as the cause of the other natural forces, is a *qualitas occulta* (unknown quality), for to all of these forces what Ovid said applies: *Causa latet, vis est notissima* (the cause is hidden, the force is well-known).

This last statement, which is absent in the first edition, is a reference to the famous phrase *Hypotheses non fingo* (I feign no hypotheses) used by Isaac Newton in the *General Scholium* appended to the second edition of his *Principia mathematica* (1713), where Newton argues: "I have not as yet been able to discover the reason for these properties of gravity from phenomena, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena, and afterwards rendered general by induction."[32] This Newtonian strategy of identifying the effects of a force (gravity) without speculating on its origin (the cause is hidden, the force is well-known) was

---

[28] Blumenbach (1781), 12–13.

[29] *Ivi*, 14.

[30] Blumenbach (1791), 32–33.

[31] *Ivi*, 33.

[32] Newton (1999), 943.

very frequent in the eighteenth-century life sciences.[33] After Haller defined irritability by comparison to Newton's gravitational force, it became customary to justify reference to an original force or property by referring to Netwon's *Hypotheses non fingo*. Blumenbach is no exception, defining the *Bildungstrieb* as a *qualitas occulta*, whose effect, however, can be empirically ascertained.

This clarification appears only in the later versions of the essay. Given the publication dates of the two subsequent editions, namely 1789 (the year of competition) and 1791, it makes sense to assume that the debate with Wolff played a role in the reformulation of Blumenbach's theory. Moreover, he may have used the Newtonian analogy to provide credibility to the *Bildungstrieb* as a natural force and break away from Stahlian forms of animism. On the other hand, Blumenbach continues to mark a difference between his formative drive and Wolff's essential force, most notably the fact that the *Bildungstrieb* is responsible not only for nutrition, i.e. the distribution of fluids in the organic body that causes tissue growth, but also for the origin of a specific living form, i.e. for species determination.

In the later editions of the essay, Blumenbach mentions "a perspicacious physiologist, Caspar Wolff," who "assumed another force for the growth of animal and plants, that he calls *vis essentialis*." He goes on to claim that "if one knows it only by hearsay, one could confuse it with my *nisus formativus*." Nevertheless, Blumenbach claims, the difference between the two forces is clear if one reads the definition of the *vis essentialis* in the *Theoria generationis*. Wolff's *vis essentialis* was a chemical force: the process of the formation of organic life was driven by chemical attraction and repulsion and controlled by the mechanical properties of the parts of an organism, by means of a chain reaction in which each organ secreted another based on its mechanical-chemical nature. In this process, it is important to note that the direction of development is determined by the circumstances in which the essential force expresses itself and that the flow of nutritive substance is necessary for this development to take place.[34] Blumenbach, on the other hand, stresses the existence of a gap dividing "living from lifeless, organized from unorganized nature." He does not understand the *Bildungstrieb* as the *cause* of this gap, but rather as its *expression*.[35] This emphasis on the *Bildungstrieb* as an organic force distinguishable from all inorganic forces was not envisioned in the first edition of the essay. This is an addition appearing in the later versions not envisioned in the earlier document.[36]

For Blumenbach the fact that traces of formative forces (such as metallic crystallization) can be detected in the inorganic realm is no argument for extending the formative drive to inert matter. Reproduction in living nature has a unique character. For instance, in the first phases of its development, a water plant consists is a small, straight, light-green thread. At this stage, its growth is fast and its texture is transparent. As Wolff had already argued, this stage is followed by solidification, formation

[33] Wolfe (2014).

[34] McLaughlin (1982), 366.

[35] *Ivi*, 365.

[36] Thanks to an anonymous peer reviewer for pointing this out.

of vesicles and tissues, and growth. The same phenomenon can be observed in the formation of animals, especially those that, like the freshwater polyp, are characterized by fast growth and a transparent texture. In order to reproduce itself, the polyp swells a part of its matter, first forming the cylindrical body of the young polyp and afterward its arms.[37] No sign of preformed germs can be observed in this process.

Blumenbach considered these phenomena to be undeniable arguments for the existence of the formative drive. He used them to formulate several general laws: (I.) The strength of the formative drive is inverse to the increasing age of the organized body; for this reason early embryos are almost formless. (II.) The strength of the early formative drive is unequal in newly conceived mammals and newly conceived fowls. The first signs of the drive can be observed in the chicken after fecundation, while a human embryo needs 16 weeks. (III.) In the formation of single parts of the organized body, the formative drive is much stronger than during other stages of development. (IV.) The cases in which the formative drive takes a wrong direction in the course of development explain the phenomenon of teratism, or monstruosity. (V.) Another deviation of the formative drive takes place in the formation of sexual organs. (VI.) When the formative drive does not take just a strange turn, as in the previous cases, but a completely unnatural one, a so-called "monster" is formed.[38]

This reference to monsters is important. As Canguilhem has pointed out, the existence of "monsters" calls into question the specificity of life, its normativity in accordance with specific rules of order. We must reserve the qualification "monster" for organic beings: there are no mineral or mechanical monsters. Something with no rule of internal cohesion – something whose form and dimension cannot be seen to diverge from a measure, mold, or model – cannot be called monstrous. The monstrous is what lies outside the norm.[39] Blumenbach marks a difference, distinguishing between the normative (life) and the non-normative (the rest), whose variance is marked by the presence of the *Bildungstrieb*. Within the normative (i.e. things inhabited by the formative drive), he also distinguishes between normal and abnormal according to whether the *Bildungstrieb* achieves its goal or not.

In other words, for Blumenbach the formative drive is what characterizes the difference between what is living and what is not. Lenoir relied upon this definition of the formative drive as *qualitas occulta* to stress Blumenbach's proximity to Kant in terms of refusing to ascribe any constitutive character to forces other than attraction and repulsion. As we have seen, however, the argumentative pattern employed by Blumenbach, according to which "the cause is hidden, the force is well-known," is the exact equivalent of the Newtonian motto "I feign no hypotheses," which was frequently referenced by medical theory in the second half of the eighteenth century (after Haller). This argument suggests that, although its origin is unknown, the *Bildungstrieb* is what distinguishes organic from inorganic bodies. To read this argument as a confirmation of Blumenbach's "Kantianism" would be as bold as

[37] Blumenbach (1791), 89.

[38] *Ivi*, 101–111.

[39] Canguilhem (2008), 134–135.

claiming that Newton thinks gravity is a regulative principle of our power of judgment.

Indeed, Blumenbach might be considered Newtonian for his use of this argumentative analogy, but not Kantian. He believes that the phenomena of life, and above all of generation, can be explained by postulating a particular force, i.e. the formative drive, which is seen as the primary cause of all other phenomena. Although the inherent nature of this force cannot be known, it can be treated empirically in terms of its specific expressions by formulating the laws that regulate its functioning. From this point of view, it is difficult to imagine that there may have been something like a Kant-Blumenbach research program, especially if one looks at the famous passage on the "Newton of the grass-blade" in Kant's third *Critique*. For Kant, in fact, the formative force is by no means on the same level as fundamental (mechanical) forces like attraction and repulsion. More importantly, as I will extensively argue in the following section, in Kant's view there can be absolutely no "Newtonian" treatment of organized beings.

In this section I have considered Blumenbach's notion of *Bildungstrieb* in order to stress its specific difference from Wolff's *vis essentialis*. As we have seen in the previous section, Wolff understands the *vis essentialis* as a physical-chemical force responsible for the movement of fluids through organic bodies, which does not per se imply goal-directedness. On the contrary, the *Bildungstrieb* is a goal-directed drive responsible for the specific formation of the adult organism's course of development and for its conservation over the course of its life. As Richards and Zammito have pointed out, this theory should be distinguished from the Kantian treatment of "organized beings." In fact, despite a somewhat remarkable conceptual proximity, several key aspects of Kant's epistemology, such as the distinction between regulative and constitutive principles, are way beyond what we find in Blumenbach's writings.

In fact, the debate with Wolff played a key role in the development of Blumenbach's mature views on the nature of the formative force – much more than his alleged encounter with Kant did. In fact, it was Wolff who defined the *vis essentialis* as a special kind of attractive and repulsive force through which tissues attract homologous and replace heterogeneous substances. This force was by nature close, although not identical, to Newton's attractive force. Blumenbach introduced this Newtonian analogy in the later versions of his *Bildungstrieb* essay as a result of his debate with Wolff, though he maintained his position concerning the teleological nature of this formative drive.

3 An Unstable Middle Position: Kant on Teleology and Organization

3.1 The Technique of Nature

In this section I reconstruct Kant's arguments about the problem of whether living organisms should be considered to be organized according to specific purposes. In the opening paragraphs of the *Critique of Teleological Judgment*, the second section of his *Critique of the Power of Judgment* (1790), Kant famously uses the structure of a bird to illustrate this point. The form of a bird, especially its bone structure and the position of its wings, suggests a positive answer to this question: these features all seem intended for flight. Kant, however, finds this interpretation tantamount to conceiving nature in technical terms, i.e. as the product of a maker. This tension between mechanism and teleology is at the heart of Kant's so-called antinomy of teleological judgment: on the one hand, "all generation of material things is possible in accordance with merely mechanical laws," while on the other hand, "some generation of such things is not possible in accordance with merely mechanical laws".[40] The Kantian solution to this dilemma is introduction of the distinction between "determinant" and "reflective" judgment. The former refers to a constitutive property of the object in question, the latter to the way in which our cognitive faculty makes sense of things. According to Kant, we must consider living organisms *as if* they were the products of intentionally acting causes, while nonetheless dealing with them within a mechanistic explanatory framework. This method of resolving the antinomy of teleological judgement is of course controversial, and whether Kant's response is coherent is still open to debate.

Scholarship on the topic offers two main lines of interpretation: the first is roughly represented by Timothy Lenoir and Clark Zumbach and the second by Robert Richards and John Zammito. Lenoir has argued that German biology in the early nineteenth century was the result of a coherent research program developed at Göttingen by Blumenbach and his students, which received its first formulation in Kant's *Critique of the Power of Judgment* in 1790.[41] Along these lines, Zumbach has argued that Kant's remarks on teleology have a significance that has been almost totally overlooked, in that they advance a cohesive conceptual framework for understanding the functional and goal-directed features of living organisms. In this sense, he argues they provide sound conceptual foundations for biological methodology.[42] Richards was the first to contest these readings, arguing that the alleged agreement between Kant and Blumenbach upon which they are based is a "historical misunderstanding" of their respective conceptions of teleology. He contends that Blumenbach in fact ignored the Kantian distinction between constitutive and regulative principles and conceived of the *Bildungstrieb* as a goal-directed drive proper to all organized beings.[43] For this reason, Zammito has contended that the "Lenoir thesis" can no longer serve as our point of departure for reconstructions of this period.[44] The first camp thus maintains a 'foundationalist' (or 'quasi-foundationalist') reading of Kantian teleology: internal purposiveness determines the domain of biology, thereby establishing its autonomy as a special science. The second camp instead develops a more 'eliminativist' account: Kant took organisms to be mechanically inexplicable and denied that biology can ever be reconciled with his prescriptions for proper natural science.

[40] Kant (1968), Ak, 5: 387 (259).

[41] Lenoir (1982).

[42] Zumbach (1984), cf. also McLaughlin (1990).

[43] Richards (2000).

[44] Zammito (2012), cf. also Zammito (2003), (2006).

Behind this disagreement is an issue that has occupied Kantian interpreters throughout recent decades, an issue that Hannah Ginsborg has defined as "the problem of coherence."[45] This issue concerns the central concept of Kant's *Critique of Teleological Judgment*, namely the notion of a "natural purpose" (*Naturzweck*). For Kant, something qualifies as a purpose not only if it was brought about by intentional design but also if we can conceive of its possibility only by assuming that it was produced by intentional design: "an object or a state of mind or even an action, […] even if its possibility does not necessarily presuppose the representation of an end, is called purposive merely because its possibility can only be explained and conceived by us insofar as we assume as its ground a causality in accordance with ends, i.e., a will that has arranged it so in accordance with the representation of a certain rule."[46] Accordingly, "organized beings" must be considered purposes because, in Kant's view, we can conceive of their possibility only by assuming that they were produced as the result of an intentional design. At the same time, however, he argues they must be considered products of nature. These two aspects, however, seem to contradict each other.

In § 65, Kant sketches the two conditions that must be fulfilled for something to be called a natural purpose: (1) the first is "that its parts (as far as their existence and their form is concerned) are possible only through their relation to the whole."[47] This kind of purposiveness is often found in artifacts: every part of a machine is there only on account, or rather as a function, of the whole for which it serves as a part. (2) To be called a *natural* purpose it must also have parts "combined into a whole by being reciprocally the cause and effect of their form."[48] This requirement marks a radical difference between artifacts and organized beings, because the former are produced *by something else*, the latter *by themselves*, i.e. they self-produce. By formulating these two requirements, Kant emphasizes both an *analogy* and a *disanalogy* in the comparison between artifacts and organisms. Thus the problem of coherence: if we are not ascribing organisms the properties of artifacts, in what respect can we coherently regard them as similar to artifacts?[49] The issue arises from the fact that, according to Kant, on the one hand we cannot understand the possibility of organized beings unless we invoke the notion of design, while on the other hand, we cannot legitimately affirm that organisms are in fact the product of design. So how is it possible to reconcile these apparently opposed conditions? How can we regard an organism as a purpose while at the same time regarding it as a natural entity?

Hannah Ginsborg has attempted to resolve this problem by appealing to a conception of purposiveness as normativity, arguing that organized beings can be regarded as subject to normative standards without implying that they were in fact designed according to those standards: "to regard something as a purpose without

[45] Ginsborg (2001).
[46] Kant Ak, 5: 220.
[47] *Ivi*, 373.
[48] *Ibidem*.
[49] Ginsborg (2001).

regarding it as an artifact is to regard it as governed by normative rules without regarding those rules as concepts in the mind of a designer."[50] Considering something as subject to normative standards implies that we judge the way it is in relation to the way it ought to be. My question is: could Kant have accounted for this normativity without referring to the argument about design? Could he have spoken of organisms and their parts as subject to norms without any commitment to the idea that they have a supernatural origin? And if he did, then where do these norms come from? More importantly, can they provide the ground for a scientific account of vital organization?

Recent scholarship has dug deeper into the background of Kant's treatment of organized beings.[51] In this respect, Philippe Huneman has shown that eighteenth-century life scientists were dealing with empirical problems connected to generation, physiology, and classification, while Kant's treatment of organized beings is part of his wider philosophical agenda, namely his critique of the concepts of necessity, contingent order, and purposiveness and his open confrontation with rationalist metaphysics, most importantly Leibniz.[52] On this score, Hein van den Berg has emphasized the link between Kant's views on the concept of purpose to those of Christian Wolff and Alexander Gottlieb Baumgarten. This analysis is an especially valuable contribution to the field in that it shows how Kant adopted the definition offered by his predecessors of "purpose" as "intention." In fact, for Wolff and Baumgarten purposes are objects of intention, namely God's intention. Kant adopted this intentional definition of purpose but could not appeal to God as an explanatory ground, thus making it impossible for him to make teleology constitutive of organized beings.[53]

The roots of this understanding of teleology as intention are found in the philosophy of Leibniz. In his *Système nouveau de la nature et de la communication des substances aussi bien que de l'union de l'âme avec le corps* (1695), Leibniz formulates the concept of "machines de la nature." He thereby differentiates human machines from natural or divine ones, arguing that a machine made by the art of man is not a machine in each of its parts, "but the machines of nature, that is to say, living bodies, are still machines in their smallest parts, to infinity. This is what makes the difference between nature and art, that is to say between the Divine art and ours."[54] According to Leibniz, "the body of animals are machines of perpetual motion, or, to put it more clearly, arranged to maintain in the world a determined and singular kind of organic perpetual motion."[55] In this way, Leibniz understands the animal body as a *divine machine*, distinguished from the ordinary products of human artifice through its infinite complexity and consequent indestructibility. In this respect, both living bodies and artifacts are the product of intelligent design.

---

[50] Ginsborg (2001), 251.

[51] Huneman (2007a, b), Goy and Watkins (2014).

[52] Huneman (2008).

[53] Van den Berg (2014).

[54] Quoted in Fichant (2003), 2.

[55] *Ivi*, 6.

The difference between these artificial and natural machines ultimately lies in their designer, i.e. humans in the former case, God in the latter. It is thus not surprising that Leibniz endorsed preformation: for him organs were designed by an omniscient creator and brought into existence, all together, at creation: development was thus nothing more than the growth of an already preformed structure.

With regard to this background, the argument of the third *Critique* seems unstable: an instability notably expressed in the notion of a "technique of nature."[56] In fact, on the one hand Kant rejected the argument of design as an explanatory ground for the purposive nature of living organisms, but on the other hand, he held that purposiveness can be conceived only in relation to an intention, which per se implies reference to a designer.

Already in *The Only Possible Argument in Support for a Demonstration of the Existence of God* (1763), Kant had dedicated an entire section to physico-theological arguments for the existence of God. Here Kant criticizes physico-teleology, because it "regards all perfection, harmony and beauty of nature as contingent and as an arrangement instituted by wisdom, whereas many of these issue with necessary unity from the most essential rules of nature."[57] At the same time, however, he admits that the unique order organizing living organisms seems necessarily to imply reference to an Intelligent Author. In fact, "the great regularity and the harmoniousness of a complex harmony is perplexing, and even common sense itself finds it inconceivable in the absence of an Intelligent Author," because "extensive harmony is never adequately given in the absence of an intelligent ground."[58] Here Kant is fairly explicit that, when considering how well-connected the organs of an animal are, "one would have to be of an ill-natured disposition (for no-one could be so unreasonable) not to recognize the existence of a Wise Author, who had so excellently ordered the matter of which the animal was constituted."[59]

The internal constitution of plants and animals suggests "an artificial order of nature" that "cannot be explained by appeal to the universal and necessary laws of nature."[60] In fact, using an example that he would more famously employ again in the third *Critique*, Kant maintains that the specific ways in which a tree is able to reproduce itself are utterly unintelligible in light of human knowledge – nor could "arbitrary inventions," such as the theories of generation advocated by Buffon and Maupertuis, account for them. At the same time, he asks whether one is "obliged for that reason to develop an alternative reading oneself, which is just as arbitrary, the theory, namely, that, since their natural manner of coming to be is unintelligible to us, all these individuals must be of supernatural origin? Has anyone offered a mechanical explanation of yeast to generate its kind? And yet one does not appeal

[56] This instability was already stressed by Paul Guyer (2001, 275). See also Weber and Varela (2002).

[57] Kant Ak 2: 118.

[58] *Ivi*, 124.

[59] *Ivi*, 125.

[60] *Ivi*, 114.

for that reason to a supernatural ground."[61] This is the "problem of coherence" in its very first formulation: the insufficiency of mechanical explanations to account for organized beings and the illegitimacy of the technical explanations used by natural science. One cannot account for the organization of living organisms by means of mechanical laws; one instead has to make reference to teleological principles. Still, teleological principles seem necessarily to imply reference to intentional design, which Kant rejects because it involves reference to the supersensible.

What Kant means by this discussion of mechanical inexplicability is sketched in detail in the *Metaphysical Foundations of Natural Science* (1786). Here Kant maintains that "natural science can be either *properly* or *improperly* natural science, the first treating its objects wholly according to a priori principles and the second according to laws of experience."[62] Only a discourse with apodictic character – i.e. necessary connection between grounds and consequences – can be called a proper science (*Wissenschaft*), while if it contains mere empirical certainty, the argument should be considered just general *knowledge* (*Wissen*). A rational doctrine of nature thus deserves the title of a natural science only if the fundamental laws therein are known a priori and not the mere result of experience. If the grounds or principles are merely empirical, as in chemistry, they carry no consciousness of their necessity. In this case, the knowledge involved does not merit the title of natural science.

Accordingly, chemistry should be considered a systematic art rather than a science. Natural science instead derives its legitimacy from its 'pure' basis in the a priori principles of natural explanations. Indeed, explanation based on chemical principles always leave behind a certain dissatisfaction for Kant, because one can adduce no a priori grounds for these principles, which, as contingent laws, have been learned merely from experience.

In Kant's view, although a pure philosophy of nature (i.e. that which investigates only the concept of nature in general) may be possible without mathematics, a pure doctrine of nature is only possible by means of mathematics: "in any special doctrine of nature there can be – in fact – only as much *proper* science as there is *mathematics* therein."[63] Therefore, as long as there is no a priori law to explain chemical effects, chemistry can be nothing more than a systematic art or experimental doctrine – not a proper science.

The same argument applies to the life sciences. This claim is grounded in the definition Kant provides for the concept of matter. The first chapter of *Metaphysical Foundations* begins with a definition of matter as what is "movable in space."[64] With this notion, Kant claims that, since motion represents the primary category of our experience of nature, it has to be the first determination in our construction of the concept of matter. Since for Kant a science must be grounded upon necessary and universal concepts, and since such knowledge cannot be based upon experience alone but needs an a priori foundation, physics has to derive its universality and

[61] *Ivi*, 115.

[62] Kant Ak, 4: 468.

[63] *Ivi*, 470.

[64] *Ivi*, 480.

necessity from a priori grounds, which can be based in nothing other than the categories of the understanding.

By means of this analysis, Kant expected to be able to construct the complete metaphysics of nature through determination of matter. He argues that matter is characterized solely by attractive and repulsive forces, but if these are the only forces that exist in nature, matter must behave only *mechanically*: "matter as mere object of the external senses has no other determinations than those of external spatial relations, and hence undergoes no changes except by motion."[65] The cause of change in matter would not be internal, for matter has absolutely no internal grounds of determination. Hence, all change in matter would have to be based in an external cause, and the inertia of matter in this sense "signifies nothing but its *lifelessness*,"[66] as life for Kant means the capacity of a substance to determine itself, to act from an internal principle. To the extent that physics is concerned with motion in space, or mechanics, it excludes the possibility of any other cause of motion except external causes, because from the mechanical view, the only two forces that can be legitimately assumed are the attractive and the repulsive forces.

In the *Erste Einleitung* to the *Kritik der Urteilskraft*, Kant contrasts this mechanical view of nature with the kinds of statements he defines as "technical." A technical statement is a proposition that concerns "the art of bringing about that which one wishes to exist."[67] Accordingly, Kant uses the expression "technique" to describe the objects of nature when they are "*judged as if* their possibility were grounded in art."[68] These objects are organized beings, whose purposive structure must be considered "in accordance with the analogy of an art." In analogy, that is, because this judgment does not determine anything about the constitution of the object or "the way in which to produce it."[69]

Kant argues that such a definition of nature (as technical) necessarily implies "a formal purposiveness of nature, which we simply *assume* in it,"[70] but which we cannot use to ground a theoretical understanding of it. In other words, the definition of nature implies the impossibility of considering its purposiveness objective grounds for our cognition of organized beings, because this assumption of purposiveness would imply reference to an intentionally acting maker, which is untenable in natural science, since it goes beyond the realm of possible experience.

Kant thereby repudiates the legitimacy of technical-teleological arguments, which explain the organization of living bodies by reference to God's original design. He thus maintains that the concept of a technique of nature "does not ground any theory" and does not "contain cognition of objects and their constitution."[71] On the other hand, he argues that the only way we can make sense of the organized

[65] *Ivi*, 554.

[66] *Ibidem*.

[67] Kant Ak, 20: 200.

[68] *Ibidem*.

[69] *Ivi*, 201.

[70] *Ivi*, 204.

[71] *Ivi*, 204.

products of nature is to conceive of them as the products of a purposeful intention. But since we cannot legitimately refer to a designer as the origin of purpose within the context of natural science, Kant argues that purposiveness is not present in the object but inheres strictly in the subject, or more precisely, in the principles of a priori reflection inherent to its power of judgment.

Purposiveness is defined as the "lawfulness of the contingent as such."[72] The organization of living organisms is contingent, since it cannot be reduced to mechanical laws, but it is nonetheless lawful, since it indeed seems to function according to a rule – a rule which, however, is not graspable using the tools of proper natural science, i.e. mechanism. In fact, considering its "products as aggregates, nature proceeds *mechanically, as mere nature*, but with regard to its products as systems, e.g. crystal formations, various shapes of flowers, or the inner structure of animals and plants, it proceeds *technically*, i.e. at the same time as an *art*."[73]

Kant sees the technical argument as the *only possible explanation* for organized beings, because, in his view, organization can be explained only in relation to an intention. In fact, he argues explicitly that his consideration of purposiveness "by no means extends so far as to imply the generation of *natural forms that are purposive in themselves*."[74] Therefore, the only thing that we can legitimately do when experience shows us natural beings with purposive forms is to ascribe them a supreme ground, "even though this ground itself may lie in the supersensible and beyond the sphere of the insights into nature that are possible for us."[75] On the other hand, as we have seen, according to Kant the only legitimate explanation for nature is mechanical, while this form of technical causality lies beyond the scope of proper natural science. This, of course, seems to imply a contradiction, and in fact Kant argues that reference to a conscious maker is not sufficient to explain the possibility of living forms but makes it possible for us to apply the concept of purposiveness to nature and its lawfulness. This is a deflationist version of Leibniz's argument, as it were, and shows that, from a conceptual point of view, Kant's argument remains ultimately coherent with Leibniz's fundamental assumption that teleology is connected to intention.

In fact, for Kant purposes "must in general be given from someone," and if they are natural purposes, they "must be able to be considered as if they were products of a cause whose causality could only be determined through *representation* of the object."[76] Therefore, the concept of a real *purpose of nature* "lies entirely outside the field of the power of judgment."[77] Mechanical laws cannot explain vital organization, and technical-teleological explanations represent the only possible alternative for Kant.

[72] *Ivi*, 217.

[73] *Ibidem*.

[74] *Ivi*, 218.

[75] *Ibidem*.

[76] *Ivi*, 232.

[77] *Ivi*, 233.

At the same time, Kant's major preoccupation is to distance himself from the argument about design with claims such as: "no *intentionally* acting cause is thereby ascribed to nature, which would be a determining teleological judgment and as such transcendent, since it would suggest a causality that lies beyond the bounds of nature."[78] It is precisely this preoccupation that testifies to the fact that, at least in this case, Kant is moving in the same conceptual space as his predecessors – a space in which *purposiveness* can be grasped solely in terms of *intention*. In the following section, I will provide further evidence for this claim by analyzing Kant's stance on teleology and organization in the *Kritik der Urteilskraft*.

3.2 Organized Beings and Machines

In the opening paragraphs of the *Critique of the Teleological Power of Judgment*, Kant introduces his crucial distinction between *external* and *internal* purposiveness. External purposiveness might be defined as "utility"; it is constitutive of artifacts (which are in fact produced by a conscious maker for a specific purpose) but cannot be applied to natural products such as organisms (because we cannot legitimately refer to a conscious maker without exceeding the limits of a proper natural science based on experience). The internal purposiveness defines the most peculiar phenomena of living beings: growth, reproduction, and functional integration. So a watch, as an artifact, would be a case of external purposiveness. It has a determined purpose, i.e. to mark the hours, which was posited by an external designer (the watchmaker) in order to make the object useful to someone wanting to know what time it is. Conversely, a living body displays a different form of purposiveness, internal purposiveness, because it is not produced by someone else but rather by itself, and its purposive features are not related to another's utility but only to itself.

As an example of internal purposiveness, Kant famously takes the case of a tree. A tree generates another tree in accordance with a known natural law. It also generates itself as an individual: it prepares the matter that it adds to itself in a manner particular to its species, something "which could not be provided by the mechanism of nature outside of it, and develops itself further by means of material which, as far as its composition is concerned, is its own product."[79] Moreover, this being also "generates itself in such a way that the preservation of the one [part] is reciprocally dependent on the preservation of the other."[80] The leaves, for instance, are at once products of the tree and also what helps preserve it, such that its growth depends upon their effect. As Blumenbach also stressed, other such unique properties characterize organized beings, such their ability to heal in cases of injury, miscarriage, or growth malformation. In these phenomena, certain parts form themselves in

[78] *Ivi*, 236.

[79] Kant Ak, 5: 371.

[80] *Ibidem*.

entirely new ways because of chance defects or obstacles – and they seem to take place according to a determined purpose.

Kant defines a purpose (*Zweck*) as something that is possible only in relation to a concept, i.e. an entity that owes its form to a previous design. This is the case for artifacts: the structure of a watch, for example, and the way its parts are arranged is accordant with the idea that the device works in a certain way for a specific purpose. In order to achieve this purpose, it is necessary to have some previous representation of the whole, i.e. a project, based upon which the single parts can be orderly arranged. A *natural* purpose is characterized by the same feature (a concept involving the representation of a whole) but, because it is found in nature, and *cannot* imply this previous representation of the whole.

What's at stake in § 65 of the *Critique of the Power of Judgment* thus is the attempt to show that the only entities in nature displaying this internal purposiveness are what Kant calls "organized beings": "for a thing to be a natural purpose it is requisite, *first*, that its parts (as far as their existence and their form are concerned) are possible only through their relation to the whole. For the thing itself is a purpose, and is thus comprehended under a concept or an idea that must determine *a priori* everything that is to be contained in it" and "*second*, that its parts be combined into a whole by being reciprocally the effect of their form."[81] In such a product of nature, each part is conceived as if it existed only through the others, "thus as if existing *for the sake of the others* and *on account of* the whole." This must be thought of as an organ that *produces* the other parts: "only then and on that account can such a product, as an *organized* and *self-organizing* being, be called a *natural purpose*."[82]

In this section of his third *Critique*, Kant rejects the possibility of accounting for the structure of organized beings in mechanical terms, but at the same time, he argues against the legitimacy of a technical-teleological account: (1) Mechanism is insufficient to explain the structure of organized beings since each part of an organized body is conceived as if it existed for the sake of the others and on account of the whole, i.e. as an instrument (organ). In other words, every part of an organized being seems to have a specific purpose, as if it were the result of prior design. This was the main argument of preexistence theorists, for whom the role of efficient cause was played by God. (2) However, this kind of organization is the one we find in a work of art, which is the product of a rational cause distinct from the matter itself and is what sets the final goal in first place.

Moreover, organized beings display self-organizing features that are absent in machines. In a watch, in fact, every part is organically arranged in relation to the others, but the watch does not *produce* them. It "is certainly present for the sake of the other but not because of it." Hence the producing cause of the watch is the watchmaker, not the watch itself:

> one wheel in the watch does not produce the other, and even less does one watch produce another, using for that purpose other matter (organizing it); hence it also cannot by itself replace parts that have been taken from it, or make good defects in its original construction

[81] *Ivi*, 373.

[82] *Ivi*, 374.

> by the addition of other parts, or somehow repair itself when it has fallen into disorder: all of which, by contrast, we can expect from organized nature.[83]

Based on these considerations, Kant claims that "an organized being is thus not a mere machine, for that has only a *motive* force, while the organized being possesses in itself a *formative* force (*Bildungskraft*), and indeed one that it communicates to the matter, which does not have it (it organizes the latter): thus it has a self-propagating formative power, which cannot be explained through the capacity for movement alone (that is, mechanism)."[84]

In other words, Kant argues on the one hand that mechanism, as a reference to efficient causes, cannot account for the structure of organized beings, which seems to invoke a form of technical causation. However, a technical account is also inadequate to explain organized beings for two reasons: first, because the reference to intelligent design lies beyond the scope of proper natural science, and second, because organized beings display a peculiar form of self-organization that sets them apart from machines. As the scholarship on Kant attests, his solution to this predicament is to argue that the purposive features displayed by organized beings should not be considered ontologically defining properties, i.e. as having their own *constitutive* character, but should rather be ascribed to the way we make sense of them based on our own particular cognitive faculties, i.e. as reflective of the *regulative* principle of our power of judgment.

This regulative principle, according to Kant, should then guide our research into objects of this kind, such that we consider their teleological features only heuristically, as a way of "reducing" them to mechanical forces: "organized beings are thus the only ones in nature which, even if considered in themselves and without a relation to other things, must nevertheless be thought of as possible only as its ends, and which thus first provides objective reality for the concept of an end that is not a practical end but an end of nature, and thereby provide natural science with the basis for teleology."[85] The problem here, however, is that despite the distinction Kant made between internal and external purposiveness, teleology is still conceived in terms of intention.

In this respect, Kant opened up grounds for overcoming a technical understanding of teleology but did not consistently separate the concept of purposiveness from the concept of intention. In fact, in Kant's view, "teleology cannot find a complete answer for its inquires except in a theology."[86] This unstable middle position between the mechanical and technical accounts leads to the antinomy between mechanical inexplicability, on the one hand, and the illegitimacy of the technical-teleological argument, on the other.

Understanding this element of Kant's argument allows us to better situate his famous passage concerning the "Newton of the grass-blade." Since Kant is quite certain that we can never adequately come to know organized beings merely according to the mechanical principles of nature, "we can boldly say that it would be

[83] *Ivi*, 374

[84] *Ibidem*.

[85] *Ivi*, 376.

[86] *Ivi*, 399.

absurd for humans even to make such an attempt or to hope there may yet arise a Newton who could make comprehensible even the generation of a blade of grass according to natural laws that no intention (*Absicht*) has ordered; rather, we must deny this insight to human beings."[87] Since reference to intention is illegitimate for proper natural science, this quote represents Kant's denial of the possibility something like a scientific biology could exist.

Indeed, according to Kant, Blumenbach had already demonstrated the impossibility that raw matter could originally form itself in accordance with merely mechanical laws – and thus the impossibility that life could arise from the lifeless, assembling "into the form of the self-preserving purposiveness by itself." At the same time, however, Kant argues that Blumenbach gives "natural mechanism an indeterminable but at the same time also unmistakable role under this *inscrutable principle of an original organization*, on account of which he calls the faculty in the matter in an organized body (in distinction from a merely mechanical formative power that is present in all matter) a *formative drive* (standing, as it were, under the guidance and direction of that former principle)."[88]

How we interpret this quote is an extremely delicate issue. Lenoir has read it as the most decisive confirmation of the "teleo-mechanical" program upheld by both Kant and Blumenbach, and indeed this passage seems to provide textual evidence for his account. Yet, as my previous analysis suggests, for Blumenbach the *Bildungstrieb* played a *constitutive* role as an organizing principle, rather than a merely regulative role in generation, growth, and regeneration. This gives a different epistemic meaning to the notion of vital force than the one inferred from Kant's arguments in *Kritik der Urteilskraft*. Bearing this in mind gives us reason to support Richards' claim that Kant and Blumenbach were involved in a "creative misunderstanding," though the above-cited Kant quote shows that Kant felt he was in agreement with Blumenbach.

I would like to suggest that another, slightly different reading is also possible – one which better accounts for the above passage. Since Blumenbach aimed to build a theory of the formation of organized bodies that responded to the criteria of eighteenth-century experimental philosophy, he found it impossible to make sense of the formation of organized bodies by means of mere mechanical forces. Accordingly, he felt it necessary to presume matter was already endowed with the power of producing vital organization through generation and development. Hence his postulation of the *Bildungstrieb*. It was of course essentially unimportant to him whether the causality implied by this sort of vital principle depended upon the reflexive power of judgment. Kant's perspective is different, since it essentially questions the metaphysical and epistemological implications of Blumenbach's representation of this particular form of causality. Hence Kant argues that the representation of such teleological causality is merely a regulative principle.[89]

[87] *Ivi*, 400.

[88] *Ibidem*.

[89] This reading was suggested to me by François Duchesneau in his *rapport de soutenance* on my doctoral dissertation. A more detailed version of this argument will be available in his forthcoming book (Duchesneau 2017).

In conclusion, with his distinction between internal and external purposiveness, Kant cleared ground for a teleological approach to living organisms, but he was ultimately unable to conceive of purposiveness outside the model of practical-technical agency. As a result, he ended up confusing the conceptual distinction between internal and external purposiveness, interpreting the former as the latter, i.e. understanding teleology as solely the result of subjective intention.

Of course, this position is rather controversial throughout the third *Critique*. There we find passages, chiefly in § 65, in which Kant insists on the need to distinguish organized beings from machines, but these passages ultimately fail to take teleology – understood as internal purposiveness – seriously enough to admit self-organization as a legitimate object of scientific inquiry. Consequently, Kant argues that, since mechanical laws cannot explain organic processes, the only possible alternative is the argument for design, which he nonetheless finds untenable within the framework of proper natural science. In this respect, Kant's main concern is to distance himself from Intelligent Design, insisting that purposiveness is not a constitutive feature of organized beings but only a regulative principle inherent to our power of judgment. As a result, he categorically denies the possibility of scientifically explaining the purposive characteristics displayed by organized beings.

In this sense, Kant lays the foundations for overcoming both mechanical and technical-teleological understandings of vital organization but ultimately fails to move beyond this conceptual space. Indeed, Kant's account of purposiveness is extremely interesting precisely because it lies at the crossroad of a conceptual revolution from the concept of teleology as intention endorsed by Leibniz and Haller to the concept of teleology as self-organization upheld by Kielmeyer and Schelling. In fact, as I will argue in the rest of the book, this shift from a regulative to a constitutive understanding of teleology was *the* most important factor enabling the emergence of biology at the beginning of the nineteenth century (at least in Germany). This shift – which took place in the writings of Blumenbach, Kielmeyer, and Treviranus, as well as in Schelling's and Hegel's *Naturphilosophie* – occurred in firm opposition to, rather than in continuity with, Kant, since Kant ultimately understood purposiveness only in terms of conscious intention, not as autonomous self-organization.

4 From Chemistry to Organization: Reil on the Vital Force

This chapter has been concerned with different models of a vital agent in living beings, variously defined as "essential force" (*vis essentialis*) or "nutritive force" (*Nutritionskraft*) by Wolff, "formative drive" (*Bildungstrieb*) by Blumenbach, or "formative force" (*Bildungskraft*) by Kant. As we have seen, these authors had different views about how this vital agent should be understood: Wolff conceived it as a physical-chemical force responsible for nourishment and tissue growth, which acts by attracting similar substances and repelling dissimilar ones; Blumenbach considered the formative drive to imply a specific goal-directed tendency toward organization, which marks a powerful gap between the living and the lifeless, organic and inorganic nature; Kant understood the formative force to be based on the model of Blumenbach's *Bildungstrieb* but ultimately did not consider it a natural force, because its goal-directed action conflicted with his own epistemological prescriptions for a proper natural science.

In this last section, I analyze the theory of the vital force presented by Johann Christian Reil (1759–1813) in a paper entitled *Von der Lebenskraft* (1795), which presents us with a mostly overlooked theoretical alternative. In fact, this document testifies to the existence of an approach to teleology and organization different from the well-known accounts of Kant and Blumenbach. On this score, it is worth mentioning that Reil was never Blumenbach's student and should not be included in any "Göttingen school." He did attend Göttingen University, but very briefly and with no pleasure, retreating swiftly to Halle, which was the real center of his intellectual development.

His theory of the "vital force" (*Lebenskraft*) has been the object of different interpretative misunderstandings: it has been read both as endorsing a "teleomechanist" argument, in accordance with Kant and Blumenbach,[90] and as defending a plain mechanistic position.[91] I will propose an alternative reading, arguing that Reil upheld an account of teleology based on interpretation of the vital force as something emerging from chemical properties of matter. Accordingly, he argued that the teleological features of living bodies should not be understood as the result of a particular vital agent; instead, teleology should be understood as the result of a particular kind of chemical organization. We might perhaps define this position as "chemical" vitalism: a position which, in Reil's view, provided a solution to the issues Kant noted about assuming a teleological principle in accounts of vital organization.

Reil's essay is presented as an inquiry onto the phenomena of organized bodies, specifically the form and composition of animal matter.[92] According to Reil, physicians and philosophers have been inclined to ascribe the phenomena of life to spirits that inhabit matter: the ancients assumed there were nymphs living in trees, Van Helmont presumed the existence of an archeus, and Stahl posited the soul as the principle of life. The existence of such spirits is not supported by any experience, he argues, since experience reveals only that plants and animals display particular vital movements: if one separates parts of the body, for instance the heart and the muscles from the head, they live on for a while.[93] Yet in those separated parts, the soul can have no direct influence. Thus life must depend on a specific composition and arrangement of matter, not such spirits. Reil maintains that we must thereby admit the possibility that matter is organized to produce vital phenomena. Analyzing all the manifold phenomena of living bodies, we always circle back to what Reil deems the cause of all vital phenomena: the *form* and *composition* of matter (*Form und*

[90] Lenoir (1982), 35–37.

[91] Richards (2002), 225–261.

[92] Reil (1795), 11.

[93] *Ivi*, 12.

Mischung der Materie). Reil contends that if we examine the form and composition of matter, it is possible to determine its most basic elements, which we must accept as the ultimate foundation (*Grund*) of all phenomena.[94] Through such investigation, we obtain information on: (1) the fundamental substances (*Grundstoffe*) of different elements of nature, composed of different compounds; and (2) the form and composition (*Beschaffenheit*) of matter, which are products of the aggregation of its fundamental parts.

These materials form the components of living bodies, which are endowed with more or less purposive (*zweckmässige*) structures. All natural elements have an essential common property, "elective attraction" (*Wahlanziehung*), by virtue of which they connect to each other.[95] The form of matter is thus grounded in "the elective attraction of fundamental substances and their products."[96] Matter's ability to engender particular phenomena is inseparable from the connections among specific fundamental substances that cause all vital phenomena: "form, structure, formation, organization of matter is already a consequence of its properties."[97] Every single natural body has a specific form and composition that cannot be found in other bodies. The cause of bodily phenomena in general and of living bodies in particular thus for Reil lies in the specific form and composition of their matter: "the substance of living nature differs noticeably from the substance of dead nature. Plant and animal matter are characterized by a specific uniformity and by components that are communal to both."[98] Hence we unite, and rightly, animals and plants under the communal name of organic beings and we separate them from dead nature.

In Reil's terms, "vital force indicates the relationship of more individualized phenomena to a particular kind of matter that we encounter in living nature, in plants and animals. The most general attribute of this peculiar kind of matter is a special kind of crystallization. Incidentally, we cannot give a genetic definition of this force so long as chemistry has not acquainted us more precisely with the basic principles of organic matter and its unique properties."[99] On this score, he calls into question Blumenbach, for whom the specific character of living matter is caused by its being endowed with a teleological agent. For Reil the relation works the other way around: it is the specific arrangement of matter that causes living substances to display particular vital and teleological characteristics. Vital properties rely on physical properties but are at the same time different and independent from them. Life is not the result of a specific force; rather, the vital force (the faculty of displaying vital phenomena) results from a specific arrangement of matter. For instance, if the only thing proper to life is a soul or a vital spirit embodied in matter, why are stones not endowed with life? The composition of animal matter is unique, from its most simple elements to its most complex organs. We thus must "identify a means through which organic matter is *put together in a purposive* (*zweckmässig*) *order*,

[94] *Ivi*, 15.
[95] *Ivi*, 16.
[96] *Ivi*, 17.
[97] *Ivi*, 19.
[98] *Ivi*, 23.
[99] *Ivi*, 48.

namely a core or stock of an organic being, to which the raw substances can attach."[100] This purposive order, i.e. the particular organization inherent to "organized beings," was precisely what Kant had defined as highly problematic in his third *Critique*. Reil's solution to the Kantian dilemma was simply to take into account how that purposive order emerged from the chemical reactions inherent to matter: "the vital force shows the relation of particular phenomena, by which living nature differs from inert nature, to a particularly formed and composed matter. This force we shall be able to distinguish precisely from the rest of the natural forces when we have come to know, by chemical examination, the composition of living animal matter."[101] In other words, to Reil the "Newton of the grass blade" was not a chimera, he was an organic chemist.

Living organisms display an admirable organization, "which surpasses by far the structure of dead nature." The body and all of its parts, even up to its smallest fibers, "resolves itself in nothing but a pure purposively (*zweckmässig*) formed body."[102] The body consists of several big members and each member of muscles, vessels, and nerves; these muscles of skins, fibers and vessels: "what an artificial and unified mechanics! How many its levels of order! Here is only the whole of a machine and the parts of the whole are raw natural bodies natural without purposive formation."[103] Reil refers to the *Critique of the Power of Judgment*, maintaining that, when Kant defined organized beings as entities characterized by internal purposiveness, "he wanted to determine the nature of living beings but not the meaning of the word organization."[104] For Reil the fundamental question was the *origin* of natural organization. He believed Kant and Blumenbach had addressed this question backwards, by framing organization as the result of a purposive agent (the formative force), rather than framing purposiveness as a consequence of vital organization. Instead, scientific inquiry into vitality should be carried out by analyzing the different degrees of organization and how they contribute to the formation of purposive structures.

In his view, this analysis could provide a solution to the epistemological problems raised by Kant: "Organic beings, says Kant, are not mere natural products, but natural purposes: each part relates as a means and at the same time an end to all the rest, each is there through all the rest and for all the rest. In the whole, everything is necessarily determined: the whole through its parts, and the parts through the whole. The nerves cannot be without a heart, and the heart cannot be without nerves; The blood requires a stomach and the stomach blood."[105] Most importantly, this arrangement of parts is not externally designed but is rather the result of a distinct faculty of self-formation: "the most general feature, by which organic nature is characterized, seems to me to be the ability of it to obtain a peculiar formation. In this unique

[100] *Ivi*, 26.

[101] *Ivi*, 50.

[102] *Ivi*, 41.

[103] *Ibidem*.

[104] *Ivi*, 42.

[105] *Ivi*, 54–55.

property of organic matter lies the foundation of generation, growth, nutrition, and reproduction, each being modified phenomena of a property of organic nature."[106]

This faculty allows precisely for the phenomena which Kant found particularly puzzling in the third *Critique*, something to which Reil refers directly by quoting § 65, which we have analyzed and commented in Sect. 3: an organic being "generates itself according to the species; it produces another one of the same genus and thereby preserve eternally its species." It also "generates itself as individual, develops and preserves itself and processes the matter that it adds to itself into a specific quality", and finally "it generates itself also according to the parts, and precisely in a way that the preservation of one part depends reciprocally on the preservation of the others."[107] This threefold kind of generation is precisely what Kant found so hard to fit into the mechanistic framework of explanation that, in his view, pertained to proper natural science, and that he ultimately declared inexplicable. Reil instead believed that analysis of "chemical affinity"[108] could provide a satisfactory solution to this scientific puzzle: "the animal body absorbs substances from outside itself, that are either similar to its parts, or which it make similar to them. These substances are attracted to its parts, and at the same time a purposive formation and form is given to them."[109]

He insisted that the faculty of self-formation inherent to organized beings had been defined as formative force (*Bildungskraft*) and formative drive (*Bildungstrieb*). Yet he found these names are incorrect, since that faculty is not the result of a teleological drive but rather of "blind necessity":[110] "we can therefore regard growth, nutrition, reproduction, and the formation of animal bodies as modified phenomena of a unique property, namely, the property of animal matter by virtue of which it crystallizes in a peculiar manner."[111] The formation of animal matter, generation, growth and nourishment occur by means of a chemical process based on the laws of affinity and elective attraction, which should be uncovered by organic chemistry.

Despite this emphasis on blind necessity, the use of "vitalist" vocabulary (above all the reference to the vital force that appears in nothing less than the title of Reil's paper), the repeated stress on the difference between organic and inorganic matter, and finally, the belief that chemistry is able to account for the specific compounds making up living beings all suggest that Reil cannot be categorized as a mechanist. He defines the vital force not as the cause of organization but rather as a *property* resulting from an organization's specific arrangement that relies on the unique chemical properties of organic matter:

> This faculty of animal bodies to add foreign matter from the outside, and to form it in an appropriate manner, lies in the nature of animal matter and is a unique property of it. We can call 'force' the relation of this property of animal matter to its effects. It has elsewhere been

[106] *Ivi*, 56.
[107] *Ivi*, 56.
[108] *Ivi*, 68.
[109] *Ivi*, 64–65.
[110] *Ivi*, 66–67.
[111] *Ivi*, 55–56.

> called formative force and formative drive. But the word is too narrow for the concept, because the animal, by virtue of this property of its matter, not only forms matter, but also adds foreign matter to its own mass. Instinct, which is not conceived in the actual understanding without feelings or ideas, does not take place in this operation, but is entirely based on blind necessity. Moreover, this force belongs in kind to the vital force, in that it belongs to all living beings, and to them alone."[112]

Since he distinguishes between vital and mere physical properties, Reil's position can thus be defined as a form of vitalism – but one different in kind from Blumenbach's. Indeed, for Reil, organization is not a result of teleology; teleology is a result of chemical organization "the addition of foreign matter to an animal body and the purposive formation of the added matter is a peculiar (animal) crystallization of animal matter. The animal matter shoots into vessels, nerves, membranes, muscle fibers, etc., like cooking salt into a diced crystal."[113] In conclusion, the core of Reil's argument is that "the whole activity, the addition of mass, and the proper formation of the supplement, are thus effected through attraction by means of a chemical affinity of matter."[114] He thereby supports the idea that there are several distinct "levels" or "orders" of nature, with the higher ones displaying properties absent in the lower ones, on account of their more complex organization.

5 Concluding Remarks

The debate over the notion of formative force in the late eighteenth century demonstrates the existence of several different forms of vitalism:

1. Wolff considers the *vis essentialis* not a formative force capable of fashioning new bodies on its own but a simple agent that acts by attracting similar substances and repelling dissimilar ones. Even though he considers the *vis essentialis* different from physical attractive and repulsive forces, Wolff maintains that it is not teleological. Rather, according to Wolff the *vis essentialis* is a physical force responsible for nourishment and tissue growth. This theoretical intervention was necessary to eliminate the notion of soul present in earlier theories of epigenesis (think of Stahl or Maupertuis). However, I agree with Jean-Claude Dupont that "the theoretical consequences of the *vis essentialis* were not totally assumed," and Wolff thus "found himself at a loss when faced with a tricky, perhaps unsolvable problem,"[115] namely species determination.
2. Blumenbach instead postulated a vital agent which implied a specific goal-directed action. In his view, each species was characterized by a specific *Bildungstreib* that transformed the embryo from undifferentiated substance into

[112] *Ivi*, 66–67.

[113] *Ivi*, 67.

[114] *Ivi*, 68.

[115] Dupont (2007), 46.

an adult organism; this accounted for species determination. Blumenbach argues that an active drive unique to the matter of living bodies directs their organization during development. This formative drive is different from the essential force: the *vis essentialis* is merely the force by which nutritive material is driven through the plant or young animal, while the *Bildungstrieb* is instead responsible for the entire process of development. It is characterized as a goal-directed tendency toward organization, which marks a powerful gap between the living and the lifeless, organic and inorganic nature.
3. Kant argues that organized beings are different from machines, insofar they possess a specific *formative force* (*Bildungskraft*). Kant deems the machine-model – what he defines as a "technical" understanding of organized beings – insufficient to describe the specific generative power of organized beings, and he invokes a particular formative force as the cause of organic formation. In so doing, he marks a key distinction between external and internal purposiveness, i.e. between teleology as intention and teleology as self-organization, but he does not elaborate this distinction enough to move beyond an understanding of teleology based on the model of technical agency. Since teleology cannot be explained without the reference to an intention, or to an artifact model, Kant considers the purposiveness displayed by organized beings a mere regulative principle of reason. In this sense, from a philosophical perspective, he holds an unstable position: on the one hand, he argued that organized beings are mechanically inexplicable and that they should be the object of teleological consideration, but on the other hand, since he still conceived of purposiveness in terms of subjective intention, he considered the argument for design the only possible, albeit untenable, explanation for life. This contradiction explains several controversial passages of the third *Critique* – first and foremost the one concerning the Newton of the grass-blade – and it represents Kant's rejection of the possibility of such a thing as a proper science of life.
4. Reil provides an account of teleology by defining the vital force as the result of specific chemical properties. In his view, life is not the result of any force; the vital force is rather a result of a specific arrangement of matter that allows for the emergence of living organization. Unlike both Blumenbach and Kant, Reil maintains that organization is not a result of purposiveness but that purposiveness instead is a consequence of organization. In this sense, teleology can be understood as a property emerging from a specific organization of matter.

All these positions attest to the relevance of the formative force to period's discussion of the *origin of form*. The formative force was importantly employed as an operative concept to define the *principle of organization* in the developmental process. In what follows, I will extend the scope of this analysis by accounting for the role played by the notion of vital force in a physiological context. The next chapter will reconstruct how the physiology of vital forces was elaborated by the so-called "Göttingen School" in the second half of the eighteenth century.

Functions: The Göttingen School and the Physiology of Vital Forces

1 Introduction and Outline: The Göttingen School as a Historical Category

Physiological vitalism in the eighteenth century is generally associated with the Faculty of Medicine at the Université de Montpellier. Studies on the subject have focused on either the physiological theories that Bordeu and Barthez formulated after Haller's *Elementa physiologiae,*[1] or completely overlooked the distinctions between this French vitalism and what was happening in Germany.[2] Only in some cases has attention been granted to the different national traditions represented by Bordeu and Barthez in France, Blumenbach in Germany, and Hunter in Scotland.[3] In his study of the German context, Lenoir famously formulated the label "Göttingen School"[4] to stress the existence of a unitary center of study characterized by intense institutional and intellectual relations among nearly three generations of physicians and naturalists. From a historical perspective, this center can be considered to have a "paradigmatic" character similar in importance to that of the *ecole médicale* of Montpellier. Although the most important stages of the Göttingen School tradition took place in the late 1780s and early 1790s, those developments were partially made possible by institutional arrangements established in Göttingen several years earlier. Not the least of these was the organizational planning of the university itself. From the beginning, Göttingen was organized around its science faculty, and in the early days, more specifically around its medical faculty.

The university was founded in 1737 by Gerlach Adolph von Münchhausen (1698–1770), a minister during the Hannoverian regime of George II. His plan for the university contained two important aspects: the first was a new role for the

[1] Rey 2000; Williams 2003; Boury 2004, 2008; Wolfe and Terada 2008.

[2] Reill 2005.

[3] Duchesneau 1982, 1985.

[4] Lenoir 1981b.

A. Gambarotto, *Vital Forces, Teleology and Organization*, History, Philosophy and Theory of the Life Sciences 21, DOI 10.1007/978-3-319-65415-7_2

professor as researcher-teacher, the second concerned the importance of empirical science in the university curriculum. Perhaps the most important consequence of this emphasis on empiricism was the establishment of the medical curriculum. Von Münchhausen's decision to exclude all medical theory that was based on uncertain speculation in favor of doctrines supported by careful observation and experimentation led to the formation of a curriculum based on the medical theories of Hermann Boerhaave, who had served as supervisor for Haller's doctoral dissertation at the University of Leiden in 1727. Albrecht von Haller (1708–1777) consequently joined the Göttingen faculty the year the university was founded. In 1747 he began directing the *Göttingische Anzeigen für gehlerten Sachen*, a journal founded in 1739 that would later host part of his debate with Wolff. It was through Von Münchhausen's and Haller's organizational efforts that Göttingen's new approach to natural philosophy was provided the institutional structure that it needed to develop.[5]

Although Haller left Göttingen in 1753, he continued to exert a strong influence on the development of science at its newborn University, not only through his many personal contacts but also through the publication of numerous editions of his work by former colleagues and students, which became part of the university's core curriculum. Johann Friedrich Blumenbach (1752–1840) graduated from Göttingen in 1776 and was appointed Extraordinary Professor of Medicine and Inspector of the Museum of Natural History the same year. He became a full professor in 1778. Blumenbach's reputation was greatly enhanced by the publication of his *Institutiones Physiologicae* – a condensed treatment of animal functions, which was comprehensive but did not over-discuss minute anatomical details. This work appeared in 1787, and between its first publication and 1821 the text went through many editions in Germany, where it was used as a general text book. Blumenbach's physiological theories were developed in various directions by his most distinguished students: Alexander von Humboldt (1769–1859), Carl Friedrich Kiemeyer (1765–1844), Heinrich Friedrich Link (1767–1851), and Gottfried Reinhold Treviranus (1779–1864).

As a historical category, the Göttingen School opens up fruitful possibilities for exploring the specific characteristics of German physiological vitalism in the late eighteenth century, but the central tenet of Lenoir's thesis about the tradition is debatable. Indeed, according to Lenoir the distinctive approach practiced at Göttingen derived from ideas fashioned by Blumenbach, who synthesized some of the best elements of the Enlightenment life sciences – especially the work of Buffon, Linnaeus and Haller – with a view of biological organization he found in the writings of Kant. This thesis is controversial chiefly because, as I have shown in the previous chapter, Blumenbach ignores the intricacies of Kant's transcendental arguments, especially his distinction between a regulative and a constitutive interpretation of teleology. In this respect, John Zammito is right in arguing that the "Lenoir thesis" needs revision.[6]

[5] Lenoir 1981a, b, 115–119.

[6] Zammito 2012.

This chapter contributes to this revision by outlining a history of the notion of *vital force* as it was understood at Göttingen. I first focus on the building blocks: the notions of *sensibility* and *irritability* as they were defined in Haller's lecture on the sensible and irritable parts of animals. I then move on to the fundamental framework of the Göttingen School which was laid down in Blumenbach's *Institutiones physiologicae*: Here Blumenbach extends the original Hallerian framework through the addition of *nisus formativus*, *vitae propriae*, and *contractility*. I then consider Kielmeyer's lecture on organic forces to be the keystone of the Göttingen School, which in my view constitutes the core development of the physiological framework elaborated at Göttingen. The text's fundamental structure is based on two main tenets: the idea that the distribution of vital forces in the animal kingdom is regulated by specific teleological laws and the idea of increasing complexity in the series of living organisms. Finally, I analyze Link's interpretation of the Kielmeyer approach to show how it constituted a common and highly debated explanatory framework accounting for the variety of living forms and functions in the animal kingdom. I conclude by discussing Kielmeyer's and Link's stances towards *Naturphilosophie*.

The point of this reconstruction of the theoretical underpinnings of the Göttingen School will become clear in the next chapter, where I undertake a detailed analysis of the reform of natural history promoted by *Naturphilosophie*. Whereas Lenoir's categorization of the Göttingen School emphasizes the difference between the authors belonging to that category and the *naturphilosophisch* movement, my reconstruction highlights the points of proximity and conceptual continuity. In the current chapter, I take into account the Göttingen tradition's transition from Haller's theory on the vital properties of nerves and fibers (centered upon the notions of sensibility and irritability) to the program of natural history reform formulated by Kielmeyer and Link (centered upon a more generalized notion of organic force). This latter program was based on two main tenets: (1) interpretation of teleology in terms of internal purposiveness, i.e. self-organization, which was explicitly advanced by Blumenbach; and (2) reform of natural history according to the premises of comparative physiology, i.e. the taxonomizing of different vital forces and analysis of their distribution within the animal kingdom, which was advanced by Kielmeyer and Link. A similar reform was strongly advocated by Friedrich Schelling, who made explicit reference to Kielmeyer, and it was later elaborated by Lorenz Oken as an empirical program for animal classification. In its attempt to formulate laws encompassing organic nature in its entirety, Kielmeyer's approach to physiology and natural history can be interpreted as the first outline of a general biology, which would later be developed by Treviranus.

2 Building Blocks of the Göttingen School: Haller on Sensibility and Irritability

Haller's physiology is a tribute to Newton's natural philosophy. It takes up Newton's notion of irreducible properties of matter, whose laws of expression had to be formulated without speculating on their cause or origin.[7] Haller applied this approach to his research on the properties of fibers, which had already been addressed in Francis Glisson's (1599–1677) work on the contraction of muscles. Glisson's *De natura substantiae energetica* (1672) was the first work to connect the notion of fiber to the specific property of irritability. Glisson argued that the living fiber is flexible, extendible, resistant, elastic, and irritable, meaning it has a distinctive force that can be activated by external or internal stimuli and which causes its changes of shape and other vital phenomena. In the decades following the publication of Glisson's work, the notion of irritability became increasingly popular, though Glisson's name gradually disappeared.[8]

As a student of Herman Boerhaave (1668–1738), Haller paid specific attention to fibers. The first appearance of irritability in Haller's work is located in a note on his own edition of Boerhaave's *Praeselectiones academica*, in which he remarks that the heart continues beating even after it has been extracted from the animal's body. It is, however, Haller's lecture on the sensible and irritable parts of the body that actually develops this notion. Delivered in 1752 and published in 1753, Haller's *De Partibus Corposis Humani Sensilibus et Irritabilibus* claims to have proven by means of animal experiments that only muscular fiber possesses the ability to contract. Haller calls this irritability and finds it responsible for movement. Haller clearly distinguishes this property from sensibility, which is responsible for sensual impressions and inherent only to nerves. He thereby challenges the traditional mechanical – mainly Boerhaavian – framework for animal physiology on three main points. First, by postulating a force inherent to the muscular fiber that is independent of the nerves and the soul. Secondly, by separating, both conceptually and physically, the properties of movement and sense perception. Third, by establishing a strict correlation between structure and function, not at the level of elementary particles but at the level of compounding structures, i.e. the muscular and nervous fibers.[9]

This famous essay is the result of the experiments on irritability Haller conducted between 1750 and 1751 in the Göttingen laboratory in collaboration with one of his students, Johann Georg Zimmermann (1728–1795).[10] In this experimental context, irritability was defined as the capacity of contraction. Although Zimmermann never clearly distinguished between irritability and sensibility, Haller associated the latter with the transmission of sensation through the nerves and the

[7] Wolfe 2014.

[8] Giglioni 2008, 466.

[9] Monti 1990, 45–77.

[10] Steinke 2005, 49–92.

brain's conscious reception of this stimuli. Once he noted that the muscular part of the diaphragm would contract upon irritation but the tendinous part did not, Haller started testing other parts of the body for sensibility too, paying close attention to movement and sensation. He found it crucial to recognize that nerves themselves are not irritable. This was fundamental for Haller, since he found irritability to be a property restricted merely to a specific structure and specific action: he rejected the concept of irritability as a governing vital force.

Well-known among Haller's contemporaries, the lecture of 1752 is still today considered a classic statement of his physiological doctrine and seen as the main (if not sole) source of Haller's achievements. In this text, Haller writes that his experiments suggested a new division of the parts of the human body based on distinction between those susceptible to irritability and sensibility and those that are not. He also states that his theory will not meddle with the question of *why* some parts are endowed with these properties, for he is persuaded that the source of both lies beyond the reach of the knife and microscope, where one should not hazard any conjectures. Accordingly, Haller provides a detailed description of the experiments he used to discover the sensibility and irritability of parts, which consisted in taking living animals of different kinds and ages and irritating a specific body part by blowing on it or applying heat, wine, the scalpel, oil, or vitriol to it. He then attentively examined the result, sometimes touching, cutting, burning, or lacerating the part and observing whether the animal responded, made a noise, struggled, or pulled back the wounded limb – or if the part itself convulsed or nothing happened at all.

The first discovery Haller made is that the skin is sensible, indeed more so than any other part of the body, for in whatever manner it was irritated, the animal would make a noise, struggle, and indicate in every way that it was in pain. Fat and cellular membrane, to the contrary, are not sensitive to pain; muscular flesh is, but that owes more to the presence of nerves than to the flesh itself.[11] On the other hand, tendons are capable of neither sensation nor pain. Haller had laid bare the tendons of the *extensores recti* of the tibia and the *tendo achillis*, pricking them and cutting off up to half of their fibers. These experiments, repeated several times after 1746 – on dogs, goats, rats, cats, rabbits, and various other animals – proved that while muscular fiber contracts once irritated, the same is not true of the tendon, which can be pricked and lacerated without causing the least muscular motion. Animals whose tendons had been lacerated, burnt, or pricked remained quiet, without showing any sign of pain; when released, so long as even a small part of the tendon remained whole, the animal could walk easily and without complaint. It was only after Haller was fully satisfied with the certainty of this phenomenon that he began to address its cause: that there are *nerves* in the muscles but not in the tendons. Seeing that only nerves in the human body are capable of sensation, "it is neither unnatural nor improbable, that the tendons being destitute of nerves should have no sensation."[12]

Haller then moved on to discuss irritability, which is so different from sensibility that "the most irritable parts are not at all sensible, and *vice versa*, the most sensible

[11] Haller 1981, 660–661.

[12] *Ivi*, 663.

are not irritable." Moreover, "irritability does not depend upon the nerves, but on the original fabric of the parts which are susceptible of it."[13] Indeed, once a nerve is irritated, the muscle to which it is connected immediately convulses. Irritability is not proportionate to sensibility; the stomach is extremely sensible and the intestines less so, considering that they are not liable to such violent pain, and yet the intestines are far more irritable. The heart, which is very irritable, has but small share of sensation; touching it in a living person causes fainting rather than pain. We thus cannot conclude "that a part is sensible because it is irritable; for the tying or cutting of a nerve, which destroys the sensibility of that part to which it is sent, does by no means destroy its irritability."[14] Rather, in Haller's view, these experiments proved that muscular contraction does not depend upon nerves, because after these have been tied or cut, the muscular fibers are still capable of irritability and contraction.

As a result, Haller claimed to have identified the irritable parts of the human body and to what degree they were irritable. He concluded that the skin, cellular membrane, and fat are not irritable parts nor are the lungs, kidney, liver, or spleen, since they are composed of cellular substance. Irritability seemed to Haller "to be that which distinguishes the cellular fibers from the muscular," since the cellular membrane's capacity for irritability is precisely the same as that of the fibers of dead flesh: yielding to the touch, dimpling if pressed, and recovering once the pressure is removed. On the other hand, when irritated with a knife or corrosives in a living body, muscular fibers become shorter, and their extremities approach each other; then they are relaxed again, and these contractions and relaxations alternatively repeat for some time. On the other hand, the tendons are as devoid of irritability as they are of sensation; no irritation by knife or gentle corrosive can excite convulsion in them or produce any motion in the muscle to which the irritated tendon belongs. The ligaments, periosteum, meninges of the brain, and all the membranes composed of cellular membrane also lack irritability.

Lacteal vessels contract and empty themselves upon being touched with oil of vitriol; what proves that they are considerably irritable is that, even if they are full at the time of the animal's death, they empty themselves and contract.[15] Pricking the bladder of a dog that was almost dead with a knife or needle frequently caused considerable spontaneous contraction. Muscles are irritable, since they all have at least one natural palpitation after death; they tremble and are alternatively contracted and relaxed. The esophagus contracts itself if irritated above the diaphragm. The stomach is highly irritable: when touched with a corrosive, the resulting impression immediately produces a long superficial furrow. The intestines, both large and small, are extremely irritable. By degrees, Haller proceeds to the most irritable organ of all, the heart, the cause of all motion in the human body. The heart is the most constructed for contraction and therefore, Haller believed, ought to be endowed with the greatest irritability. His experiments confirmed this to be so, especially in

[13] *Ivi*, 675.
[14] *Ivi*, 676.
[15] *Ivi*, 680–681.

cold-blooded animals, where the heart is constantly irritable – much more than even the intestines.[16]

Collecting all of Haller's experiments together, it appears that "there is nothing irritable in the animal body but the muscular fiber and that the faculty of endeavoring to shorten itself when we touch it is proper to the fiber. From the same experiments it likewise follows, that the vital parts are the most irritable." The diaphragm frequently moves after all the other muscles have ceased, the intestines and stomach move still longer, and the heart continues its motion after all the other parts are quiet. "This furnishes us with a distinct character between vital organs and the others, *viz*. the first, being extremely irritable, require only a weak stimulus to put them in motion, whereas the others, which are endowed with very little Irritability, are not to be moved but by determinations of the will, or by very strong irritations."[17]

Haller found it easy to prove that this power (*potestatem*) of producing motion was different from all other properties of bodies. Moreover, irritability continues after death in entirely insensible parts that are separate from the body once the heart is taken out, the head is cut off, and the spinal marrow removed. What should therefore hinder us "from granting Irritability to be a property of the animal *gluten*, the same as we acknowledge attraction to gravity to be properties of matter in general, without being able to determine the cause of them? Experiments have taught us the existence of this property, and doubtless it is owing to a physical cause which depends upon the arrangement of the ultimate particles, though the experiments that we can make are too gross to investigate them."[18]

In other words, Haller's experiments on irritability carried out at the Göttingen laboratory led him to define the property as a force inherent to muscular fiber. In doing so, he relied on a Newtonian analogy that was common in the eighteenth-century life sciences: Newton had posited an unknown entity, gravity, in order to provide a mathematical treatment of the movement of physical bodies. This allowed him to remain neutral about the ontological status of this entity while using it as a key concept in his account of celestial mechanics. Similarly, Haller posited an unknown force, irritability, and used it as the key concept of his experimental physiology in order to account for the phenomenon of contraction. As we saw in chapter "Generation: The Debate Over the Formative Force and the Question of Ontogenesis," the very same Newtonian argument was used by Blumenbach to justify the *Bildungstrieb*. This rhetorical strategy was widely used in eighteenth-century physiology to define "vital forces" such as sensibility and irritability as objects of scientific inquiry. In the following section, I analyze the way in which Blumenbach extended the Hallerian concepts of sensibility and irritability into a general physiological framework characterized by several "vital forces."

[16] *Ivi*, 687.

[17] *Ivi*, 690.

[18] *Ivi*, 692.

3 Foundations of the Göttingen School: Vital Forces in Blumenbach's Physiology

In this section I consider Blumenbach's physiology – in particular his extension of the Hallerian framework into a physiological system that integrated the concepts of sensibility and irritability with his epigenesist view of development. In subsequent sections, I will go on to outline how two of Blumenbach's students, Kielmeyer and Link, further extended the scope of this physiological framework to include the domain of natural history and thereby advanced a reform of natural history based on the comparative physiology of vital forces.

In the preface to his *Institutiones physiologicae* (first edition 1787), Blumenbach states that his objective was "to deliver, in a faithful, concise and intelligible manner, the principles of a science inferior in beauty, importance and utility, to no part of medicine."[19] Physiological study for Blumenbach consisted in observing the different parts of a being "endowed with *vitality*, capable of receiving the agency of stimuli and performing motions." He maintained that although vitality was a subject perhaps more easily known than defined, and therefore usually rendered obscure rather than illustrated or clarified, its effects were sufficiently manifest and "ascribable to peculiar *forces*."[20] Vital was an epithet given those forces only because the actions of the body depended on them in life; they moreover remained in some parts for a short time after death and therefore could not refer to merely physical, chemical, or mechanical properties.

For Blumenbach, the difference between *dead* and *vital* forces was evident with even the slightest comparison of an organized system with any inorganic body. Indeed, he found the energy and strength of *vital forces* most conspicuously manifested by their resistance and superiority to other forces. For example, in a living body the vital forces oppose chemical affinities like putrefaction; they also sometimes oppose physical forces, such as gravity. Referring to an experiment performed by Borelli, Blumenbach argues that a dead muscle would be easily broken apart by the very same weight it could lift if alive. He maintains that vital forces (*vires vitals*) constitute the very basis of physiology and have been bestowed different names by different authors: *impetum faciens*, innate heat, archeus, vital spirit, brute life, head of the nervous system, active thinking principle, vital tonic attraction. Nor has there been less variety in the *notions* and definitions to which it has given rise, though on one point all have agreed: that its nature and causes are obscure. Blumenbach thought it best to establish *distinct orders of the vital forces*, according to the variety of phenomena by which they are manifested. These phenomena are threefold: organic *formation* and growth, *motion* in the formed parts, *sensation* from the motion of certain similar parts.[21] In other words, Blumenbach postulated several

[19] *Ivi*, xiv.

[20] *Ivi*, 27.

[21] *Ivi*, 29.

vital forces as responsible for these three orders of phenomena: (1) generation, i.e. formation and development, (2) motion and contraction, (3) sensation.

(1) The vital force that in general produces the genital and nutritive fluids is the *nisus formativus*, the source of all generation, nutrition, and reproduction in each organized kingdom. (2) The vital properties manifested by *motion* in formed parts are the contractility of the mucous web and the irritability of the muscular fiber. Other kinds of organic movement include the motions of the iris, the erection of the nipple, the motions of the fimbriae of the Fallopian tubes, the action of the placenta, the womb during labor, and the greater part of the secretory functions. (3) *Sensibility* is particular to the nervous medulla's communication with the sense organs.

To explain how these various functions are performed in the living body, Blumenbach postulated five different vital forces, thus adding three new forces to the standard Hallerian framework (which included only *sensibility* and *irritability*), namely: *contractility*, *vitae propriae*, and most importantly, the *Bildungstrieb* (*nisus formativus*), which I analyzed in chapter "Generation: The Debate Over the Formative Force and the Question of Ontogenesis" as the principle of vital organization during development. The order Blumenbach gave to the vital forces – i.e. *Bildungstrieb*, contractility, irritability, *vitae propriae*, sensibility – was due to their *successive* appearance both during our formation after birth.[22] As Blumenbach had already argued in the *Bildungstrieb* paper, the formative drive appears before we can ascertain the fact of conception; it is followed by contractility, which is exerted by the gelatinous substance of the embryo. When muscular fibers are produced, they are endowed with irritability. Next, in those few organs whose motions cannot be explained by either contractility irritability, there exists a *vita propria*. After birth, sensibility is finally manifested. A similar order organizes the manner by which these vital forces are distributed in the *organized bodies* of each kingdom.

This schema sheds light on the crucial role Blumenbach's epigenetic framework played in extending Haller's conceptual model, formulated under the assumption of pre-existence. As we have seen in chapter "Generation: The Debate Over the Formative Force and the Question of Ontogenesis," Blumenbach intended the *Bildungstrieb*, or formative drive, as the guiding principle of organic development, responsible for the progressive organization of the amorphous substance from which the embryo became an adult organism. For Haller, the function specific to each body part (such as muscular fiber) was ultimately the result of divine design. On the other hand, for Blumenbach it was the developmental process itself, regulated by the *Bildungstrieb* as its principle of self-organization, that was the origin of functional integration. Early in his career, Blumenbach himself had endorsed pre-existence, but as he argues in the *Bildungstrieb* paper, the experience of the hydra turned him into an epigenesist. Accordingly, he considers the formative drive (*nisus formativus*) the most universal of the vital forces, since without it there would be no organization at all.

According to Blumenbach, every structure of the living body is characterized by a particular vital force that allows it to carry out its specific function. The *nisus formativus* oversees generation, irritability allows muscular movement, sensibility is the hallmark of the nervous system, the *vitae propriae* enables the contraction of

[22] *Ivi*, 30.

specific structures, and *contractility* is present in all mucous tissue. As mentioned above, Blumenbach conceives of the *nisus formativus* as the principle of vital organization, whereas he frames the *vitae propriae* and *contractility* as extensions of Hallerian irritability to other structures. Consequently, Blumenbach's schema envisions five vital forces: (1) the *formative drive* (*nisus formativus*), responsible for developmental organization and active throughout the life of the organized body; (2) *contractility* (*vis cellularis*), responsible for the contraction of mucosa; (3) *irritability* (*vis muscularis*), responsible for the contraction of muscles; (4) *vitae propriae,* responsible for the contraction of specific organs, such as the iris or the fallopian tubes; and (5) *sensibility* (*vis nervea*), which facilitates the perceptive functions.

By adding three new vital forces – namely, the *Bildungstrieb*, contractility, and *vitae propriae* – Blumenbach's physiology extends Haller's framework for conceiving the action of muscular fibers and nerves. The most remarkable of these additions is the *Bildungstrieb*, understood as a principle of self-organization in organic matter. This idea of self-organization plays a crucial role in the further elaboration of this physiological model that was offered by Blumenbach's students. In the following section, I consider the work of one of these students, Carl Friedrich Kielmeyer, who implements Blumenbach's framework and its lexicon but, instead of applying it to the individual organic body, applies it to all organic nature. In this sense, he uses the notion of vital forces not to analyze the functions of a single organized body but to analyze how these forces are distributed in the entire animal kingdom. As I will subsequently argue, this theoretical framework that stems from Haller through Blumenbach to Kielmeyer can be interpreted as the core of the Göttingen School.

4 Core of the Göttingen School: Kielmeyer's Lecture as the Program for a General Biology

In this section I analyze the extension of Bluemenbach's physiological framework by one of his most distinguished students, Carl Friedrich Kielmeyer (1765–1844) – an extension that aimed to apply Blumenbach's taxonomy of vital forces to the full scope of natural history. Kielmeyer began his studies at the *Karlsschule* in Stuttgart and furthered his education at the University of Göttingen between 1786 and 1788, under Blumenbach's supervision. He afterward returned to Stuttgart where, in 1792, he was appointed a professor of chemistry and zoology. Kielmeyer published little in his lifetime, but on February 11th 1793 he delivered a famous plenary lecture entitled *Über die Verhältnisse der organischen Kräfte untereinander in der Reihe der verschiedenen Organisationen* in honour of the 65th birthday of Duke Carl Eugen of Württemberg. In this lecture, Kielmeyer attempted to demonstrate, on the basis of inductive evidence, that particular teleological laws regulate the distribution of vital functions throughout the animal kingdom. Despite its limited length, this document is extremely relevant to my narrative for two reason: (1) because of the extraordinary impact it had on the scientific and philosophical cultures of the late-eighteenth and early-nineteenth centuries; (2) because it outlines, for the first time, a general theory of animal organization, which has been considered the earliest *Systemprogramm* for biology as a unified science in Germany.[23]

In his lectures on comparative zoology, held in Stuttgart between 1790 and 1793, Kielmeyer defined this research program as *Physik der Tierreichs* (physics of the animal kingdom). He argued that this discipline had to account for: (a) the number of existing animal forms and the laws according to which they are divided into different groups – as well as the causes, consequences, or purposes of those classifications (*Zwecke*); (b) the division of the animal kingdom into groups distributed across the Earth (geography) according to different characteristics and laws and the causes and effects of the differences among those different groups; (c) the laws, causes, and effects of this classification; (d) the developmental history of the animal kingdom in relation to the epochs of the Earth; and (e) the changes the animal kingdom and its groups continue to undergo across epochs.[24]

This research program never resulted in an extensive text, but the *Rede* held in 1793 constitutes an incisive outline of its fundamental features. Like Blumenbach, Kielmeyer considered natural purposiveness to be a feature proper to living bodies, which he refers to as *organizations*, i.e. organisms: "let us grant that nature had no intention in establishing this artful juxtaposition of appearances in time, that effects and their consequences were to form no goals that she had wished to achieve," nonetheless "we still must confess that the chain of effects and causes in most cases seems like a chain of means and ends to us and that we would find it advantageous for our reason to assume such a chain."[25] Richards has stressed that Kielmeyer's remarks here are grammatically cast as counterfactual subjunctives. They grant that nature may not have intrinsic purposes and that the search for higher goals may appear to be mere fantasy. It is important to note, however, that these concessions are a direct reference to a Kantian argument: in the third *Critique,* Kant maintains that any inductions focused on organic processes would lead to poetic fantasizing (*dichterisch zu schwärmen*), or the conjuring up of teleological principles supposedly governing these processes. Despite his qualifications, Kielmeyer's point is that such inductions nonetheless convince us, and rightly so, that organic nature is teleologically structured.[26]

Organic (i.e. vital) forces must therefore be regarded as teleological principles that make organisms different from nonliving matter. Based on these premises, the questions Kielmeyer addresses are: which forces are present in most individuals? What are the reciprocal relationships between these forces in different kinds of organizations? And according to which laws are these relationships modified in different organizations? On the basis of Blumenbach's schema, Kielmeyer distinguishes five forces: (1) *sensibility*, or the ability of the nerves to retain representation;

---

[23] Kanz 1994; Bach 2001a.

[24] Kielmeyer 1938, 28–29.

[25] Kielmeyer 1993, 6.

[26] Richards 2002, 242.

(2) *irritability*, or the ability of muscles and other organs to respond to stimulation through contraction; (3) *reproductive force*, or the ability of an organization to restore injured parts and produce a new ones of like kind; (4) *secretive force*, or the ability to deliver different fluids to the right places; and (5) *propulsive force*, or the ability to move fluids through vessels. Like Blumenbach, Kielmeyer lists five different vital forces, but he substitutes two of Blumenbach's with forces of his own definition. Another relevant change, as we shall see, is the fact that these concepts are not applied to the analysis of human physiology but to a totally different field, i.e. natural history.

In this framework, the original Hallerian forces – sensibility and irritability – remain unaltered, while Blumenbach's *Bildungstrieb* is renamed as the reproductive force. On the other hand, Blumenbach's *vis cellularis* and the *vitae propriae* are replaced by the secretive and propulsive forces. This difference is substantially irrelevant, as it involves the least important forces of both schemas. The latter force is in fact mentioned but barely taken into account in Kielmeyer's lecture, while several examples are provided for each of the others. Sensibility is the first organic force Kielmeyer considers. Empirical evidence, he contends, shows that the ability to receive different sensations decreases across organisms, moving from higher mammals to lower classes.[27] Among quadrupeds, birds, snakes and fishes, all the sense organs are perfect; among insects, however, the auditory and olfactory organs are largely missing. The brain and most of the nervous system found in other animals is not present in worms, for which a single organ collects all sensory stimuli. In plants, this receptivity to external impression is only obscurely present. Kielmeyer also finds it evident that, when a sense organ is lost, effectively decreasing an organism's susceptibility to sensation, the remaining senses are stronger and more elaborate. Insects and worms, without eyes and ears, have a significantly more developed sense of touch than monkeys and humans. The malfunctioning eyes of moles seem to be compensated for by the development of more sensitive paws and noses. Ocular insensitivity in other animals similarly results in the sharpening of the auditory and olfactory organs. From these observations, Kielmeyer establishes a law: "*the multiplicity of possible sensations decreases in the series of organizations* [organisms] *as much as the ease and finesse of remaining sensation increases*."[28] The lack of multiple kinds of sensations among lower animals is thus balanced by the sophistication of those that remain.

After his discussion of sensibility, Kielmeyer provides empirical observations of irritability. Nature features major differences in terms of the duration and frequency of irritability under similar conditions. Among warm-blooded quadrupeds and birds, for instance, there is no trace of irritability, since this phenomenon results from the separation of a body from the sensory apparatus or the division of individual limbs from their trunk. By contrast, manifestations of irritability are very remarkable in cold-blooded animals: frogs continue hopping after decapitation, and turtles continue moving for days after experiencing fatal heart trauma and/or head

[27] Kielmeyer 1993, 12–13.

[28] *Ivi*, 19.

amputation. Similar phenomena are observed among fish and insects: the feet of some spiders, for example, have been observed to move for more than 7 days after being removed from the body. On the other hand, most animals displaying this endurance of irritability tend to be slower in at least some of their movements. The movements of most amphibians are weak, and their hearts beat more slowly than those of warm-blooded animals. Finally, Kielmeyer points out that most animals with long-lasting irritability are precisely those with a limited range of sensations. The opposite is the case for warm-blooded animals, whose irritability is temporary but whose muscles are far more elaborate. Based on these observations, Kielmeyer formulated a second law: "*irritability, estimated according to the permanence of its manifestations, increases as much as speed, frequency and variety of these same manifestations, and the variety of sensations decreases*."[29] The lack of duration of irritability is compensated for by its variety, speed and by a greater sensibility.

The reproductive force, claims Kielmeyer, is the most universal and dispersed force among organisms and could be defined as the force that distinguishes them from other products of nature. Since it is the most universal force, it is manifested by the greatest variety of manifestations. This amazing variety nonetheless falls under a few simple laws. First, the number of offspring produced at any one time by warm-blooded quadrupeds is between one and fifteen. This number increases among birds and even more so among amphibians and fishes. Insects, worms, and plants generate with greater frequency. This pattern suggests a general decrease of reproductive faculties in the movement from complex mammals to simpler organizations. Higher-level organisms generate a smaller number of large offspring, and in a longer amount of time, than lower-level ones. After formulating laws concerning sensibility and irritability, Kielmeyer formulates a third law: "*the reproductive force, the number of new individuals that will be created in a given place, increases as much as the magnitude of what is to be produced; or more generally, the dimension of individual product, as it appears after birth, decreases*."[30] Animals with lower fertility are also those with a larger size and are more highly developed at birth. They are also those for which generation takes more time. To form an elephant, for example, takes 2 years, while it takes only a few weeks to generate a rat. Kielmeyer thus hones in on a more specific and universal version of the law: the more the reproductive force manifests a high number of new individuals, the smaller the body size of such individuals; the simpler the constitution of their bodies, the less time it takes to form them in the body of the parents.[31]

These are, for Kielmeyer, the laws regulating the distribution of vital forces in the animal kingdom, which he generalizes as

> the faculty of sensation is gradually replaced in the series of organizations from irritability and reproductive force and finally decreases the irritability of the latter [organizations]; the more the first increases the less is the other. Furthermore, there is little accord between

[29] *Ivi*, 23.

[30] *Ivi*, 28.

[31] *Ivi*, 30.

sensitivity and reproductive force; the greater one of these forces is at the time of initial development, the more the other is neglected.[32]

In general, then, the faculties of sensation, widely developed in higher animals, gradually decrease in lower classes and are endowed with great irritability. In the lowest classes (insects, worms), irritability is gradually replaced with reproductive force. For Kielmeyer, the simplicity of these laws becomes clearer after the realization that "the forces divided among the various organizations are also those under which the division of forces took place among the different individuals of the same species, even in the same individual at different phases of development."[33] At the beginning of their development, humans and birds are both similar to plants: they are mainly endowed with the reproductive force; only in subsequent developmental phases does their irritability increase. Then the faculty of irritability is replaced by the faculty of sensation.

These far-reaching conclusions have been interpreted as the first formulation of the so-called principle of recapitulation, which was to have extraordinary implications for the theory of species evolution.[34] Indeed, this formulation became one of the most appealing and long-lived doctrines of *Naturphilosophie* and transcendental morphology. The core of Kielmeyer's principle stresses the fact that many animals, as they develop embryologically, temporarily manifest structures that closely resemble those exhibited by the adult forms of species lower down in the scale of animal organization. A detailed elaboration and explication of this law was later offered by Johan Friedrich Meckel (1781–1833) in Germany and by Étienne Serres (1786–1868) in France, and it is often referred to as the Meckel-Serres Law of parallelism, in order to distinguish it from the later biogenetic version formulated by Ernst Haeckel (1835–1919).

In my view, however, this principle is not the most important component or contribution of Kielmeyer's lecture, which can be properly understood only when situated within the conceptual genealogy of vital forces in the second half of the eighteenth century. If Blumenbach's contribution to this genealogy was the integration of Haller's physiological notions of sensibility and irritability into a physiological framework that included epigenesis and self-organization via the notion of *Bildungstrieb*, Kielmeyer used a similar framework to explain self-organization not in the individual body but for organic nature in its entirety. In this sense, though not as explicitly as Treviranus a few years later, Kielmeyer's *Rede* addresses for the first time the possibility of biology as a general, unified field – one concerned with the laws that regulate the organization of all living nature.

---

[32] *Ivi*, 35.

[33] *Ivi*, 36.

[34] Coleman 1973, 1977, Richards 1992.

5 Explanatory Framework of the Göttingen School: Link and the Organic Forces as an Autonomous Research Program

In the previous section I reconstructed Kielmeyer's program for a "physics of the animal kingdom." This program consisted in taxonomizing the different organic forces, which are more or less the same ones outlined in Blumenbach's physiology, and it focused on analysis of their distribution across the animal kingdom. The main tenets of this theory are: (1) the idea that when one force decreases, the remaining ones increase, and vice versa (i.e. the idea of a compensatory relation that regulates the distribution of vital forces); and (2) the idea of the animal kingdom as a graded series of organisms characterized by increasing functional complexity. This whole program is grounded in an idea of teleology conceived in terms of internal purposiveness and self-organization, which serves as the constitutive character of organic nature. Organic nature is thereby understood as a system able to self-regulate according to the law of compensation. In this sense, organic forces cannot be reduced to physicochemical mechanisms, because they have an intrinsic teleological character. Although Kielmeyer is not explicit about it, we can locate in this research agenda the outlines of a radical reform of natural history, which will later be reframed in terms of comparative physiology, i.e. as an analysis of the different vital forces at play in each animal class.

Kielmeyer was not unique in this respect. This is attested by a text by Heinrich Friedrich Link (1767–1851), *Über die Lebenskräfte in naturhistorischer Rücksicht und die Classification der Säugthiere* (1795), which is substantially less important than Kielmeyer's lecture but nonetheless interestingly points to the widespread nature of this discussion on the vital forces and their distribution in the animal kingdom. Link was also a student of Blumenbach's in Göttingen, where he defended his dissertation in 1789. He was a supporter of Lavoisier, and his work entitled *Grundwahrheiten der neuen Chemie* (1806) contributed to the spread of Lavoisierian theories in the German context.

Because of his expertise in chemistry, Link is more explicit than Kielmeyer in arguing for the irreducibility of organic matter to physicochemical forces. In fact, he begins *Über die Lebenskräfte* by outlining the specificity of the vital forces characterizing living beings (development, sensibility, irritability, and secretion), most of which cannot be accounted for by physics and chemistry.

He begins by observing that in animal bodies we find phenomena that differ completely from those found in lifeless nature and argues that they thus require a special kind of explanation. Animals display signs of pain when their bare nerves are touched; muscles move in peculiar ways when irritated, and other parts contract in still different ways. To this list of unique phenomena, Link adds the secretion of juices, which he finds inexplicable through chemistry and the formation of the animal itself, "organized according to purposes in the most ingenious and perfect way." He argues that all these phenomena deserve careful consideration, since "it seems that we will not accomplish anything using the habitual method of explanation used for other phenomena of nature." Indeed "if we call vital forces (*Lebenskräfte*) those which in the organic body are the cause of a phenomenon that we cannot explain otherwise, then we must assume several vital forces since sensibility and irritability are not sufficient."[35]

Like Kielmeyer, Link lists five vital forces: (1) *Sensibility*; (2) *Irritability* and *Contractility*; (3) *Secretory force* (4) *Propulsive force*; (5) *Formative drives* (*Bildungstriebe*). His framework is essentially the same as Kilemeyer's, since it makes reference to the same five vital forces. However, Link proposes a more nuanced interpretation of their epistemological significance. For instance, (1) one cannot explain *sensibility* by physical forces: it is possible to reduce the transmission of sensation to a function of the nerves but not to say what ultimately makes the phenomenon of sensation possible. (2) *Irritability* and *contractility* describe the simple movement of parts upon stimulation, which should not be considered physically inexplicable, and the failure of many explanations to account for this phenomenon should not stop our inquiry of them. (3) The *secretory force* can be explained in physical or chemical terms. (4) The movement of fluids by means of *propulsive force* had not yet been explained, but for Link that does not mean that a physical explanation of this phenomenon is impossible per se. (5) Most importantly, Link deems it especially difficult to understand how a purposeful (*zweckmässige*) formation, or organized being, can be realized according to the simple forces of attraction and repulsion.[36] In this way, Link argues more explicitly than Kielmeyer for the physicochemical inexplicability of some of these vital functions – and this is especially true for the *Bildungstrieb*.

The *Bildungstreb* works (or at least it seems to) in such a way that "the formation of each part takes into account all the other parts, which is a consistent difference with regard to physical forces."[37] The latter function by means of nothing other than the approach and parting of particles, yet Link argues that we cannot thereby explain the formation of a living body – even with the boldest hypotheses. Link frames the formative drive as similar to the tendency of matter to adopt a crystalline form, but the great difference between a crystal and an organic being leads him to believe that these two drives must be essentially different. A crystal is a body that can be divided into two similar halves; its parts do not function for the sake of the others. On the other hand, an organic being is composed of parts, each of which exists for the sake of the others. According to Link, many naturalists could not accommodate the idea of a formative drive because they were looking for a force resembling physical forces.

From Link's argument, it follows that we must admit the existence of two completely different classes of vital forces, which differ considerably from one another. To the first class belong phenomena that cannot be explained in physical or chemical terms. To the other class belong those vital forces, or rather, phenomena, displayed only by organic bodies that lack explanation but are in theory explainable in

[35] Link 1795, 2.

[36] *Ivi*, 9–10.

[37] *Ivi*, 13.

physical or chemical terms. As for Kielmeyer, natural history's most important objective consequently becomes investigating the distribution of the various vital forces in the organic kingdom and their reciprocal relationship.

In Link's view, this was an enterprise for which there was still a total lack of empirical evidence, but he nevertheless formulated some general guidelines for it, which are analogous to Kielmeyer's laws of compensation. With regard to the *formative faculty*, he argued that it is possible to establish the rule that "the quantity or repetition of the same organs and parts increases as much as the perfection of the structure decreases in the whole." The number of fins in fish, the legs, muscles, and eyes of many insects, and the movement of tentacles and other organs in worms confirm this general rule: "nature replaces as much as it removes the other hand."[38] Similarly, the *reproductive faculty* manifests itself as replacement for lost or mutilated parts. Parts whose interiors are composed of different organs are not reproduced as easily as those with simple interiors: Link thus points out that the reproductive faculty is rare in large animals with a more perfect structure. This faculty is expressed less often by mammals and birds and occurs more frequently among amphibians: "also here, nature wanted to replace a faculty with another."[39] Likewise, the different ways that *sensibility* manifests itself in the animal kingdom are opposed to one another: as one sense decreases and becomes weaker, another increases and becomes stronger, so that one replaces the other. In mammals, the senses have more or less the same intensity; one sense does not display a particular advantage over another. In lower classes, on the other hand, one sense is prominent while the others are significantly weaker. In general, the total sum of the sensory faculties progressively decreases in the movement from humans toward lower classes. Manifestations of sensibility are also connected to the faculty of reproduction: mammals and birds with high sensibility are characterized by weaker reproductive faculties, which however are strong among amphibians, where sensibility is less intense.[40]

The strong conceptual and theoretical proximity of Link's treatment of the vital forces in relation to natural history demonstrates that, much like Kielmeyer, Link provides a detailed analysis of the vital forces in the plant and animal kingdoms that emphasizes their difference from mere physical forces – yet he is more explicit than Kielmeyer in marking this distinction. Most importantly, as for Kielmeyer, Link's program is based on the taxonomy of vital forces and their distribution in organic nature and implies a reform of natural history in terms of comparative physiology, so that animal classification is not addressed in terms of the description of external characteristics but rather in terms of the particular vital forces at play in different animal classes. As such, Link's analysis did not imply a simple *description* of organic nature but rather an attempt to *explain* it via the formulation of specific laws, namely the laws of compensation. The program formulated by Kielmeyer and Link makes creative use of the notion of vital forces first formulated by Haller and

[38] *Ivi*, 22.

[39] *Ivi*, 24.

[40] *Ivi*, 28.

implemented by Blumenbach, shifting its domain of application from physiology to natural history, i.e. from the study of the organization of the individual living body to the organization of the plant and animal kingdoms as a whole. As such, this theoretical framework can be interpreted as the first systematic program for a general biology in the German-speaking lands and must be understood as the most fundamental contribution the Göttingen School made to the development of a unified science of life.

6 Kielmeyer and Link on *Naturphilosophie*

In the previous sections I have argued that Kielmeyer and Link put forth a research program concerned with the distribution of the vital forces in the plant and animal kingdoms, which can be understood to have laid the foundation for the idea of a general biology. Their approach displays a relationship to the philosophy of organic nature (*Naturphilosophie des Organischen*) developed during the same period, especially after Schelling. Both Kielmeyer and Link expressed criticism of *Naturphilosophie*, and especially of its methodology of a priori deduction, though they at the same time acknowledged the importance of its overall contribution to the scientific culture of the time. As I will argue in the following chapter, a careful historical analysis shows that at least some of the *Naturphilosophen* elaborated a research program for the reform of natural history that, despite Kielmeyer's and Link's disagreements, shows an overall theoretical convergence with theirs.

Kielmeyer expressed his thoughts on Kant and *Naturphilosophie* in a letter to Georges Cuvier in 1807. Cuvier had been Kielmeyer's student in Stuttgart and kept epistolary contact with him throughout his Parisian career. In 1807 he wrote his former teacher his opinion on recent philosophical developments in Germany. Cuvier posed two questions: he asked Kilemeyer's thoughts on other German philosophers' claims about the relation between subject and object, specifically the possibility of deducing nature from a priori principles, and also inquired after Kielmeyer's evaluation of the ideas advocated by Kant and *Naturphilosophie*.

Kielmeyer's answer is long and detailed. In response to the first question, he displays remarkable acquaintance with and understanding of the philosophical literature of his time. He reports that these authors "assume the objects first of all as produced in us and by us, and at the same time they want to explain the way of their production from the nature of our spirit (*Geistes*), the original activity of our own I and the laws that explain this activity."[41] He divides these "Idealists" into three categories:

> 1. *either* they postulate a check (*Anstoß*) through which our spirit, our original *acting I*, is determined and induced to posit an opposite, a not-I, i.e., an external world of objects; 2. Or, in order to explain, as it were, the impregnation (*Befruchtung*) of our spirit and its stir (*Aufregung*) to action, and the rise thereby of a that opposition within the I, between I and

[41] Kielmeyer 1938, 236.

> not-I, subject and object, they *fantasize* about it as the excitement (*Erregung*) of both poles of perceivable electricity from the non-perceivable, latent, quiescent electricity; 3. *Or* they leave unexplained the rise of that opposition between I and not-I, subject and object, spirit and nature, and they posit it as an original fact that cannot be explained.[42]

The first case is clearly a reference to Johann Gottlieb Fichte's *Grundlage der gesammten Wissenschaftslehre* (1794), the second is probably a reference to Johann Wilhelm Ritter's works on electricity, and the third is likely a reference to Schelling's *System der transzendentalen Idealismus* (1800). In all of these cases, however, Kielmeyer argues that the statements concerning "the production of an objective world in us through the simple self-activity of our own I remains completely unproven."[43]

This letter has been used as a proof of Kielmeyer's utter rejection of *Naturphilosophie* and his endorsement of Kantianism,[44] but this interpretation results from a partial reading. Considered in its entirety, the document is in fact much less unilateral. Indeed, after articulating his criticism of the method of a priori deduction, Kielmeyer argues that

> it cannot be denied that these attempts remain worthy of attention with regard to the truly great purpose of bringing the entire human knowledge to unity, to derive it from a principle or bring it back to one, providing a complete genealogy of our knowledge and a genealogical table (*Stammtafel*) of nature itself. To attempt something great is already great for itself, and *Plato* or *Leibniz*, and with regard to some aspects even *Kepler*, would not have been ashamed of these attempts.[45]

On the other hand, in Kielmeyer's view, Kant's philosophy of nature exhibits "significant weaknesses."[46] In fact, in the *Metaphysische Anfangsgründe*, he argues, Kant provides a definition of matter as what is movable in space and assumes that the diversity of matter depends solely on different quantitative relationships between attractive and repulsive force. Yet since such relations can be determined a priori, the entire variety of matter on Earth could be derived a priori from the general concept of matter.

Consequently, "Kant, who apparently had avoided the cliff of the idealists, that of explaining the multiplicity of nature through the division of subject and object in our consciousness, suddenly comes across the same cliff, and one might expect him to explain the variety of nature according to his principles and, as it were, to construct it a priori."[47] Accordingly, Kielmeyer deems the Kantian distinction between the subjective-formal and the objective-material components of knowledge "unreliable and unproven" and argues that "a fully determined division between subjective and objective in our knowledge of nature belongs to the impossible tasks."[48] Given

[42] *Ivi*, 238.

[43] *Ibidem*.

[44] Reill 2005, 199–203

[45] Kielmeyer 1938, 239–240.

[46] *Ivi*, 244.

[47] *Ivi*, 244–245.

[48] *Ivi*, 246.

this weakness of the Kantian framework, it is no wonder that, after Kant, the Idealists tried to explain as subjective

> not only the formal side of our knowledge of nature, but also the material, not only the mathematical, but also the physical, and considered nature *either* as a *mere product* of our spirit that acts according to laws, *or*, since they were unable to explain its multiplicity, they simultaneously assumed an objective nature next to this nature produced by us, harmonically corresponding to it – a residual or a spark of the world-soul in us.[49]

Between the lines of this schema, it is fairly easy to identify references to Fichte and Schelling respectively.

With regard to Curvier's second question, concerning the results of these philosophical systems, Kielmeyer argues that, despite their failure to deduce facts from a priori principles, they nonetheless produce some remarkable outcomes. In particular, he maintains that Kant's philosophy inaugurated a "dynamical view of nature" that has overshadowed the "the mechanical and atomistic way of explanation."[50] Despite its shortcomings, this "dynamical view of matter certainly has crucial merits in the explanation of chemical phenomena" and with regard to "the transformation of matter in organic bodies."[51] More importantly, "through the recent philosophical systems it has become customary to consider nature in its entirety as an organism and as living in all its aspects, and the single organizations as individualized representations of the great nature, an idea that lied already in the ancient opposition between macrocosm and microcosm, the organism and the universe."[52] Finally, Kielmeyer admitted that some contemporary philosophers had expressed important "general observations" and "great bold views"[53] on specific aspects of nature. On the other hand, this should be ascribed to their "rich mind, fruitful fantasy and wit" and did not necessarily bolster the claims of their philosophical systems, which, he concluded, "have done more harm than good to our knowledge of nature, especially with regard to younger people."[54]

These passages show quite unmistakably that the prevailing portrait of Kielmeyer as an Enlightenment thinker in solid opposition to Romantic *Naturphilosophie* is untenable. Firstly, because he criticizes Kant just as much he does Fichte and Schelling, and secondly because his account of *Naturphilosophie* is nuanced, balancing criticism with appreciation. In this respect, Kielmeyer is especially controversial. More than 20 years after receiving this letter, Cuvier expressed his own position on the matter during a lecture held at the *Muséum* in 1832 in which he defined Kielmeyer as "the father of *Naturphilosophie* who did not want to recognize his daughter."[55] This statement is in fact an effective definition of Kielmeyer's role

[49] *Ivi*, 248.

[50] *Ivi*, 249–250.

[51] *Ivi*, 250.

[52] *Ivi*, 251.

[53] *Ibidem*.

[54] *Ivi*, 252.

[55] Quoted in Bach 1994, 234.

in this story. Indeed, as I will extensively argue in the next chapter, Schelling saw himself to be working solidly within the framework laid down by Kielmeyer, whose influence is also attested by other important *Naturphilosophie* works, e.g., Goethe's morphology.

In a work entitled *Über Naturphilosophie* (1806), Link undertakes a similar criticism of the Idealists' speculative philosophy of nature. The title of Link's work does not refer to Schelling in particular, but rather concerns the very idea of a philosophy of nature, in terms of its scope and method. The goal of Link's text was to criticize those naturalists who built systems without empirical foundations. These "speculative heads" have the tendency to "deduce everything from one, or to reduce everything to one, and precisely in this attempt lies the essence of speculation. Once this eagerness is excited, the heads approach this unity gradually, and so rises a speculative epoch, until they become aware how hard it is to reach that unity, and how little is gained by all those efforts."[56]

Link thus provides a long history of the philosophy of nature from pre-Socratic philosophers through Schelling that includes Plato, Aristoteles, Newton, Linnaeus, and Kant. In Link's view, no one had carried speculation further and applied it to the philosophy of nature in a more complete and accurate way than Schelling, but he found Schelling's natural philosophy completely lacking in any empirical evidence. This form of philosophy "has found approval and supporters in Germany, but less among philosophers than among naturalists, and especially physicians."[57] Through this approach, "one enters easily into the absolute, but does not easily come out."[58] According to Link, naturalists speaking the language of Schelling's philosophy of nature try to prove its truth through excellent observations. For example, "Mr. Ritter has made very precise and extremely important experiments on galvanism, and has shown step by step its accordance with phenomena of electricity," but his master, Schelling, "dismissed him because he had considered the tribunal of experience as higher than the enunciations of Idealism."[59]

In opposition to Schelling, Link proposes his own idea of a philosophy of nature. He argues that we should aim at a system, a unity "which in itself empty and sterile, embraces the multiplicity known to us, namely in a harmonious order that the human spirit can easily follow. It will thus be possible to express such a system in a teleological way, and thus to unify natural history with teleology through experience." In fact, "if speculation wants to bring unity into the whole of natural history, it will be possible only in this way, without being one-sided and without providing deduced characters instead of the objects themselves."[60] For example, when we consider organic bodies we realize that they are composed of different parts. If we consider the similarities of these parts through the whole realm of organisms and order them in a series, a law could probably be found "concerning the way in which

---

[56] Link 1806, 1.

[57] *Ivi*, 117.

[58] *Ivi*, 118.

[59] *Ivi*, 122.

[60] *Ivi*, 200.

these series tend to be connected in individuals and kinds. We would notice that some connections occur frequently, certain only rarely, some only in this or in that zone, and in this way it would be possible to give at least an easy overview of the whole."[61] New series can always be added, new parts distinguished, new features discovered, but if the series is properly connected, the structure remains reliable. In Link's view, these are "the rules that must be followed by the naturalist who considers experience as the source of all our knowledge in natural history."[62]

It is interesting that here Link mentions the relationship between speculation and experience, one of the main topics in the scholarly debate among members of the Schellingian circle in Würzburg in the early years of the nineteenth century. Recent studies have shown that Schelling and his circle did not reject empirical methodology at all, but to the contrary saw experience as an essential component of their theories. In fact, Schelling's philosophy of nature was not primarily intended to compete with the positive sciences, discredit them, or question the validity of empirical knowledge, but rather was conceived as a theoretical foundation for empiricism.[63] One of the most prominent proponents of the Schelling circle in Würzburg, Lorenz Oken, claimed on several occasions that empiricism and speculation should work together. He went on to argue that "I have therefore attempted to blend experience and science so intimately that it might be impossible to know if the whole thing is the result of empirical sources, or if these have been deduced only after their position [in the system] was found by measurement."[64] Reference to experience was just as important to the *Naturphilosophen* as their method of a priori deduction. Most importantly, the fundamental idea of *Naturphilosophie* – namely that organic nature is a graded series, moving from most simple to overly complex organisms – is explicitly drawn from the doctrines of the Göttingen school, notably Kielmeyer's work.

In the next chapter I provide a detailed account of the proximities between the core research programme of the Göttingen school and the reform of natural history advocated by Romantic *Naturphilosophie*. This reform was of course part of a wider philosophical agenda, chiefly based on the idea of a priori deduction, which was absent from the works of the authors analyzed in this chapter. However, I will argue that this does not justify an overly strong distinction between the Göttingen school and *Naturphilosophie*.

[61] *Ivi*, 201.

[62] *Ivi*, 202.

[63] Gerabek, 55.

[64] Oken 1805b, viii–ix.

7 Concluding Remarks

In this chapter I have considered the characteristics of the physiology of vital forces elaborated by the physicians and naturalists who studied at the Göttingen medical school. I began by analyzing the work of Albrecht von Haller. For Haller, the two "vital" properties were effects causally derived from the inner structure of given fibers. At the same time, Haller empirically linked these properties with their phenomenal effects: vital contraction, on one hand, and sensation on the other. This strict delimitation was supposed to prevent analogical extensions that might transform these properties into vital principles. I then analyzed the reform of the Hallerian framework advanced by Johann Friedrich Blumenbach, who integrated the Hallerian vital properties of sensibility and irritability with a vital principle of self-organization, the *Bildungstrieb*. Accordingly, the specific properties inherent to nerves and fibers, which Haller had explained as the result of God's original design, were understood by Blumenbach to be the result of a principle purposively directing the process of organic development. This idea of self-organization played a crucial role in the further extension of this framework by Carl Friedrich Kielmeyer, who considered all organic nature as a self-organizing and self-regulating organism. This self-organization for Kielmeyer was based on a uniform distribution of vital forces throughout the animal and plant kingdoms, which allowed for a certain balance among different classes and species. Heinrich Friedrich Link made similar use of the notion of vital forces formulated by Haller and implemented by Blumenbach, shifting, as Kielmeyer did, its domain of application from physiology to natural history. He emphasized the physical and chemical inexplicability of the vital forces and called for a separate treatment of the phenomena of organic nature. In this respect, both Kielmeyer and Link advanced a reform of natural history based on the taxonomy of vital forces and their distribution in organic nature. In doing so, they demanded that scientific treatment of organic phenomena be granted its own proper, autonomous domain. On this score, they were both in tension with and proximity to contemporary advocates of *Naturphilosophie*, whose philosophical and scientific project is considered in the following chapter.

Classification: *Naturphilosophie* and the Reform of Natural History

1 Introduction and Outline: Natural History and *Naturphilosophie*

In the introduction to *The Scenes of Inquiry*, his remarkable book on the role of questions in the sciences, Nicholas Jardine states that the text was occasioned by his reading of a "seemingly grotesque work."[1] The work in question is the *Lehrbuch der Naturphilosophie* by Lorenz Oken (1779–1851), which attempts to demonstrate how the entire universe was derived from the primordial zero, identified with God, and formed into the three kingdoms of nature, i.e. mineral, plant, and animal, in order to produce the noblest product of nature, humans. The text includes 3652 numbered sections, full of wondrous pronouncements such as "the nose is the thorax repeated in the head," "the animal is a detached blossom moving freely in the air," and "the fish is a mussel from between whose shells a monstrous abdomen has grown."[2] While this language is puzzling and almost incomprehensible for the contemporary reader, it swept the German universities by storm in the early nineteenth century. In fact, in many universities in the German lands – Jena, Heidelberg, Munich, Erlangen, Giessen, Leipzig, Breslau, Bonn, Berlin – the study of natural history was dominated by forms of *Naturphilosophie* attempting to comprehend nature in its totality and to outline its general theoretical structure, thus laying the foundations for the natural sciences. In the first decades of the nineteenth century, a substantial body of natural historical writings outside Germany also displayed significant convergence with Oken's work. Notable examples include the work of Étienne Geoffroy Saint-Hilaire, André-Marie-Constant Dumeril, and Étienne Serres in France; Robert Knox, Peter Mark Roget, Martin Barry, William Carpenter, John Goodsir and Richard Owen in Scotland and England; and Louis Agassiz in the USA. These works all share a fairly well-defined set of commitments: to

[1] Jardine 1991, 2.

[2] *Ivi*, 1.

A. Gambarotto, *Vital Forces, Teleology and Organization*, History, Philosophy and Theory of the Life Sciences 21, DOI 10.1007/978-3-319-65415-7_3

interpretation of the diversity of living beings as unfolding from original archetypes, to the formulation of morphological laws, and to the tracing of parallels between individual development and the ideal succession of living beings, seen as a graded series of increasing complexity and perfection.[3]

Oken, though a controversial figure, had a solid international reputation as an anatomist and natural historian. He was the founder of *Isis*, a famous and longstanding scientific journal in natural history, and of the *Gesellschaft deutscher Naturforscher und Aerzte*, which became the model for the British Association for the Advancement of Science. He also enjoyed a wide discursive presence: he became involved in a bitter dispute with no less than Goethe (a figure so prominent that the period between 1770 and 1830 has often been named *Goethezeit* after him) over the formulation of the so-called "vertebrate theory of the skull," according to which the skull is derived from the transformation of a series of primordial vertebrae.[4] He had a lively epistolary exchange with Geoffroy,[5] and his homological views were highly influential on prominent British naturalists like Richard Owen.[6]

These facts should lead the historian to take *Naturphilosophie* seriously and to raise thoughtful questions about its role in the history of the life sciences in Germany at the turn of the nineteenth century. Yet in many cases the trend has instead been to rehabilitate eighteenth-century vitalism by arguing that it was more or less "naturalist-friendly" and placing it in stark opposition to Romantic *Naturphilosophie*, which stands in for the epitome of anti-naturalist metaphysics. The case of Lenoir, which I have discussed in the previous chapters, is a paradigmatic example of this opposition between naturalist "vital-materialism" and anti-naturalist *Naturphilosophie* – but it's not the only one.

Peter Hanns Reill also attempted a similar rehabilitation under the label of "Enlightenment vitalism." The category of "Enlightenment vitalism" includes for Reill both the authors of the Göttingen School and those of its French counterpart, the *école medicale* of Montpellier. He thus locates the most significant difference between Enlightenment vitalism and Romantic *Naturphilosophie* in their differing "epistemological tempers – fundamental attitudes towards what can be known, why it can be known, and how." In particular, "the *Naturphilosophen* shunted aside the Enlightenment's epistemological modesty, branding it timid and sterile, replacing it with an epistemological aggressiveness staking out new bold claims to the power of knowledge."[7] Reill, I would argue, thus proposes a binary opposition between a naturalist-progressive Enlightenment and a speculative-conservative Romanticism, which I believe is based on a partial reading of the original sources as well as limited appreciation of the biographical, conceptual, and metaphysical context of classical German philosophy.

---

3 Jardine 1996, 242.

4 Zittel 2001.

5 Kanz 1997, Wellmann 2001.

6 Schmitt 2004; Sloan 1992, 2007.

7 Reill 2005, 209.

In fact, as Nicholas Jardine has emphasized in his studies on the period, there is no canonical work of *Naturphilosophie*. Its most famous exponent, Friedrich Wilhelm Joseph Schelling (1775–1854), produced not one but half a dozen theoretical systems in as many years. Simultaneously, Karl Eschenmayer (1768–1852) and Franz Xavier von Baader (1765–1841) sketched alternative systems, and even some of Schelling's declared followers – including Johann Wilhelm Ritter (1776–1810), Henrik Steffens (1773–1845), and Lorenz Oken (1779–1851) – departed widely from his teachings. Of course, certain features of *Naturphilosophie* set it apart from other schools of natural philosophy and science of the period. Like many physicians and physiologists of their time, the *Naturphilosophie* thinkers postulated vital forces as explanations for the activities of individual living beings and used organic metaphors (growth, development, maturity, decay) to describe the activity of living nature as a whole.[8] These features look surprisingly similar to those emerging from the Göttingen school, and most notably those coming from Kielmeyer, which I discussed in the previous chapter.

In fact, if we assume a rigid distinction between Enlightenment vitalism and *Naturphilosophie*, we might find that a figure like Kielmeyer does not fit easily into the picture. As I will subsequently argue, Schelling and Oken saw themselves to be proposing a reform of natural history in opposition to Kant and Blumenbach but in strict continuity with Kielmeyer.[9] As far as natural history goes, a rupture can indeed be observed between the "Kant-Blumenbach program" and the classificatory approach laid out by the likes of Goethe, Schelling, and Oken. However, as I will also argue, this rupture is less monolithic than is sometimes assumed, and Kielmeyer does play an important role as model for the philosophical quest of Schelling and Oken. The distinctive feature setting Schelling and Oken apart from the Göttingen tradition is their call for systematic unity of knowledge, which they thought could be answered through a process of a priori deduction. Goethe on the other hand, based his morphology not on logical reasoning but on aesthetic appraisal.[10] Once again, a rigid categorization does not help us make sense of the role played by Romantic *Naturphilosophie* and its relation to nineteenth-century natural history.

A good starting point to rethink these categories might be the Kantian distinction between *Naturbeschreibung* and *Naturgeschichte*. Scholars have already commented on this distinction between "description of nature" and "history of nature." James Larson argues that Kant gave preference to the history of nature and thus "his opinions were considered unworkable or superfluous by working naturalists."[11] On the other hand, Phillip Sloan maintains that Kant's philosophical program led in a different direction, one which supports the claims of those after Kant who drew skeptical conclusions about the possibility of a historical science of nature that goes beyond description.[12] Sloan argues that Kant changed his position on the issue

[8] Jardine 1996, 232.

[9] Cf. Bach 2001a.

[10] Steigerwald 2002a, b.

[11] Larson 1994, 170.

[12] Sloan 2006, 628.

between 1775 and 1788, a move that restricted speculative natural history to limits that led, at least some of his successors, to find in critical philosophy grounds for rejecting a historical science of nature.

Sloan has stressed that the crucial backdrop for the Kantian distinction between the two forms of natural history is provided by Buffon, especially in his opposition to Linnaeus. In the *Premier discours* of the *Histoire naturelle* (1749), Buffon sets forth his main points of disagreement with the received tradition of natural history, exemplified most prominently by Linnaeus and Tournefort. In the later part of his discourse, Buffon presents a distinction between two orders of truth: "abstract" and "physical." Buffon's critique of the natural history of his day was based on distinction between these two orders. The prevailing form of natural history, illustrated by the works of Linnaeus, concentrated on the discovery of a logical system of nature. For Buffon, the latter imposed *abstract* logical categories on living beings rather than disclosing their real and physical relations in space and time. In Buffon's view, systematic arrangements of organs by their essential traits into a hierarchy of classes did not reveal the order of nature, as Linnaeus presumed, but only an arbitrary order imposed by the mind.[13]

Instead, Buffon based his classification on the empirical criterion of generation: two organisms are considered of the same species if and only if they can generate fertile offspring. Buffon's work on the problem of generation has been seen by several commentators as the fundamental foundations for his approach to classification. Inasmuch as Buffon by 1749 had broken with pre-existence theory and formulated his own explanation of generation in terms of the *moule intérieur* and *molécules organiques*, this conception might well have constituted the basis for his own theorization of a successional relationship of reproduction, which took primacy over relations of resemblance in the 1749 *Premier discours*. In fact, for Buffon the only category endowed with a physical reality is the species, which is defined by an inherent internal mold. Within the species, however, Buffon does admit some forms of variation, which he refers to as "varieties" or "races," and which derive from the original type through a process of degeneration.[14] It is important to remember that this idea denotes a system of historical divergence and modification *within* the species, not *from* one species *to* another. For Buffon modification is *intra*-specific, not *inter*-specific, and most importantly, it *does not* imply transformism.

Buffon seems to have changed his position in this regard later in his *Les époques de la nature* (1778), a supplement to the *Histoire naturelle*, in which he proposed a history of the earth divided into seven distinct epochs. The text seems to suggest a form of historical developmentalism of the cosmos and life itself. The seven epochs respectively dealt with: (1) the formation of the earth; (2) the consolidation of the earth into solid rock and the formation of its surface; (3) the advent of an ocean that would have covered the earth; (4) the retreat of the ocean; (5) the origin of species from "organic molecules" spontaneously organizing into complex organisms; (6) the separation of the continents; and (7) the transformation of the earth by man.

---

13 Sloan 1976, 359.

14 Schmitt 2010.

In 1779 Kant addressed Buffon's *Époques* as the "the single work which properly treats *Naturgeschichte*."[15] A few years later, in his *Ideen zu einer Philosophie der Geschichte der Menschheit* (1784–1791), Johann Goffried Herder (1744–1803) posed the issue of a developmental history of nature that in many ways resembles that of Buffon's *Époques*. Kant's critical reaction to this work and his subsequent debate with Georg Forster (1754–1794), a naturalist who defended Herder's views, probably led him to spell out his position in much stricter terms. More precisely, after the Herder-review and the Forster-controversy, Kant began to defend the immutability of species with much stronger arguments, thus accepting the Buffonian criterion of classification outlined in the *Premier discours* but ultimately rejecting a developmental history of nature like the one envisaged in the *Époques*. For this reason, in § 80 of the *Critique of the Power of Judgment*, Kant explicitly dismissed this kind of "archeology of nature" (*Archäologie der Natur*), i.e. the idea of a generation of all animal forms from a common archetype (*Urtypus*), as a daring adventure of reason.

Precisely this idea of an "archeology of nature" constituted the point of departure for the quest by Romantic philosophy of nature to identify a universal type, i.e. a unitary plan of organization, as the grounds of animal classification: an approach which per se points far beyond the framework that we find outlined in Kant's so-called "race papers." In this chapter I reconstruct this reform of natural history as it was advocated by major exponents of *Naturphilosophie*. My analysis is divided into five sections.

In Sect. 1, I consider Blumenbach's approach to natural history. In his influential *Handbuch der Naturgeschichte* (first edition 1779), Blumenbach proposes a classificatory framework for natural history based on the total relation of traits, the so-called *total-habitus*, which Blumenbach saw as the key to animal classification. This approach was combined with the Buffonian theory of degeneration, which Blumenbach reinterpreted in light of his theory of the *Bildungstrieb*, and which states that environmental conditions alter the formative drive particular to a specific animal, causing species degeneration.

In Sect. 2, I reconstruct Kant's position on natural history through a detailed analysis of the three "race papers," namely: *Von den verschiedenen rassen der Menschen* (1775), *Bestimmung des Begriffs einer Menschenrasse* (1785), *Über den Gebrauch teleologischer Prinzipien in der Philosophie* (1788). I argue that Kant endorsed *Naturgeschichte* over *Naturbeschreibung* as a legitimate domain of inquiry. This preference, however, must be understood properly. The distinction between "description of nature" and "history of nature" is based on the debate over artificial and natural systems of classification, which opposed two pivotal figures of eighteenth-century natural history: Linnaeus and Buffon. In the context of Kant's analysis, *Naturbeschreibung* refers to the former, while *Naturgschichte* refers to the latter. Neither, however, refers to a genealogical account of the history of life; both are founded upon the immutability of species. This is confirmed in § 80 of the *Critique of the Power of Judgment*, where Kant adds a third element to the picture,

[15] Quoted in Adickes 1924, 394.

namely the "archeology of nature" (*Archäologie der Natur*). This concept refers to the generation of all animal forms from a common archetype (*Urtypus*), which Kant ultimately excludes from the realm of proper natural science.

In Sect. 3, I take up Goethe's morphological works. In the *Versuch die Metamorphose der Pflanzen zu Erklären* (1790) and the *Ertster Entwurf einer allgemeinen Einleitung in die vergleichende Anatomie ausgehend von der Osteologie* (1795), Goethe works out the idea of a *Reihe der Formen* resulting from the transformation of a common archetype (*Urtypus*). The latter does not exist in nature but offers the possibility of ordering all real forms into an ideal sequence, through successive modifications of a universal type that provides the conditions for all possible transformations. The cornerstones of this morphological program are the notions of polarity (*Polarität*) and intensification (*Steigerung*). For Goethe the former corresponds to a state of constant attraction and repulsion involving a dynamic interplay of oppositions, which takes form according to a law by which nothing can be added to one part without subtracting from others and vice versa. The latter corresponds to a state of constant striving towards greater complexity and fuller expression of the morphological possibilities intrinsic to the archetype.

Section 4 is dedicated to Schelling's early *Naturphilosophie*. In the *Weltseele* (1798) and the *Erster Entwurf eines System der Naturphilosophie* (1799), Schelling considers the animal kingdom to be a series of functions (*Stufenfolge der Funktionen*) that occur by means of an antagonism that opposes the different vital forces and keeps them reciprocally in balance, such that while one increases the others decrease and vice versa. Each organism is understood as the expression of a determined proportion of vital forces: the variety of living nature results from a variation of this proportion, which gives rise to different combinations of organs corresponding to the various animal classes. For Schelling, these classes are arranged in ascending order from the simplest to the most complex in a series of increasing perfection, culminating with human beings.

Finally, in Sect. 5 I consider the work of Lorenz Oken. I show that his theory represents an extraordinary example of disciplinary integration that combines the description, classification, anatomy, physiology, and chemistry of living beings, which Oken significantly defines as "biology." In his view, the goal of this integration of disciplines was to turn natural history into a science, whose systematic unity would be grounded by the a priori foundation provided by *Naturphilosophie*. According to Oken, every animal class was characterized by the exclusive possession of specific organs, and all differences among animals were based on the excessive formation of one organ system at expense of the others. The goal of scientific classification thus becomes to individuate the dominating organ for each animal class: the respiratory, digestive, and cerebral systems.

I argue that the question raised by *Naturphilosophie*, and most importantly by Schelling, concerns the ontological significance and explanatory role of teleology, in the sense of *internal* purposiveness, for organic nature. By articulating this question in a philosophically compelling manner, Schelling makes explicit what was already implicit in the works of German naturalists like Blumenbach, namely the idea that organic nature behaves in accordance with purposes. He thus provided a philosophical understanding that opened up epistemological space for something like a general biology at the turn of the nineteenth century. Kant had also addressed this problem in the third *Critique*, but due to his philosophical commitment to the idea of teleology as intention, he stopped short of ascribing purposiveness as a constitutive feature to living organisms; he thus held a controversial position and argued that teleological judgment had only regulative significance and did not concern organized beings in themselves. While it is true that Kant was the first to provide a philosophical formulation for the notion of teleology as internal purposiveness, it was Schelling who first conceptualized the developments of the late-eighteenth century German scientific tradition as a philosophy of nature that attempted to overcome Kant's regulative teleological judgment by defining purposiveness as an inherent, constitutive feature of living organisms.

As Jardine has already argued, it is tempting to reduce these developments to a more general process of secularization, in which God's plan becomes a purposiveness immanent in nature. One may also seek to relate these transcendental natural histories to the global *episteme* change that took place around 1800, which Michel Foucault saw leading natural history away from static concern with classification and external characteristics toward a more dynamic concern with inner development, function, and structure.[16] If we approach the work of the *Naturphilosophen* from the right perspective, namely with an eye toward the questions they pose and the epistemological field those questions created, the work of these thinkers can also be appreciated for its historical significance. For *Naturphilosophie* transformed the paradigm of *classification*, moving it from a descriptive *natural history* based on the idea of the immutability of species (though one admitting degeneration) to an explanatory *comparative anatomy* based on a unitary type that constitutes, as it were, the condition of all possible forms. In short, *Naturphilosophie* marked a shift from discrete enumeration of differences to laws regulating expressions of continuity.

2 Blumenbach on Natural History

In this section I consider some passages from Blumenbach's *Handbuch der Naturgeschichte* to illuminate the main characteristics of his classificatory framework. In particular, I focus on Blumenbach's approach to natural history, which is characterized by two main aspects: (1) description of the "total-habitus" of animals, i.e. their overall lifestyle, which was supposed to complement the description of visible traits advocated by Linnaeus; and (2) a theory of degeneration analogous to the one we find in Buffon's *Premier discours*, which he integrated within his theory of the *Bildungstrieb*. With the theory of the *Bildungstrieb*, Blumenbach presented a principle that could connect embryology and physiology with natural history, i.e. connect the question of the *organization* of the living individual with that

[16] Foucault 1996; Jardine 1996, 242–243.

concerning the general *order* of living nature.[17] In this respect, Blumenbach's classificatory approach integrates two main traditions of natural history: Linnaeus' systematics and Buffon's theory of degeneration.

The *Handbuch der Naturgeschichte* opens by focusing on the role of the *Bildungstrieb* in the production of races and varieties through degeneration. As I have already emphasized in chapter "Generation: The Debate on the Formative Force and the Question of Ontogenesis," the formative drive is the origin of the progressive formation that takes place after conception; it supports the conceived structure during its life by offering nutrition and repairing the accidental injuries it may experience. The formative drive may deviate from its usual direction when disturbed or modified by extraneous circumstances originating from (1) material disturbances, which result in organized bodies with preternatural forms, i.e. monsters; (2) the presence of both sexual characteristics in the same individual, which results in a hermaphrodite; (3) procreation between two beings of different species, which results in a bastard; and (4) various causes of gradual degeneration, which result in races and varieties.[18]

Since for Blumenbach races and varieties are deviations from the original form of a species over time, his notion of race is applicable only to characteristics produced by degeneration that become hereditary. He points out that when particular deviations from an original species form have continued across a long series of generations, it often becomes difficult to decide whether they are races or originally distinct species. To determine such cases, Blumenbach sees no other criterion but analogy. What is unique about Blumenbach's approach is precisely the description of the "total-habitus," the specific lifestyle of each animal, which takes into account factors like the breeding period of birds and to the role of the female in the building of the nest, or the unique reproductive force of amphibians.

In fact, Blumenbach's *Handbuch der Naturgeschichte* is full of descriptive natural history which provides an index of animal characteristics – beginning with the traits common to the whole animal kingdom and moving through to those particular to single classes. He starts with mammals and goes on to birds, amphibians, fishes, insects, worms, plants, minerals, stones, and fossils. The common feature of all sections is the description of the total-habitus. To illustrate what Blumenbach means by this term, I will extract some of his discussion of mammals and birds.

Mammals are described as having red blood in common with birds. They are viviparous, and their leading characteristic is the presence of breasts by which the females suckle their young. The bodies of most mammals have hair of very various strengths, length, and thickness. In some it is frizzy like wool, in others stiff and strong like bristles, and in others, such as the hedgehog, it forms quills. The habitats of mammals differ greatly. Most live on the ground, though some, like monkeys and squirrels, live almost entirely in trees. A few, such as the mole, live underground.

Blumenbach's classification of birds follows the same procedure. He starts by describing external traits, recording information such as: all birds have two feet, two

[17] McLaughlin 1982, 358.

[18] Blumenbach 1825, §§ 10–16.

wings, a bill and a body covered with feathers; these four characters distinguish them from every other animal. After the external characters, Blumenbach moves on to consider their total-habitus: birds eat seeds by swallowing the grains unbroken; most birds pair in the spring; some birds remain in pairs only during the mating season, others, like the dove and house swallow, live constantly with their mate, while still others, the domestic fowl or the ostrich for instance, are polygamous; once impregnated, the female bird is impelled by instinct to provide for the future and to build a nest; the male has no instinctive involvement in this activity, except in species that mate for life, where the male helps gather materials for constructing the nest and feeds its mate during her pregnancy.[19]

Blumenbach's classification of amphibians, fishes, insects, worms, plants and minerals follows the same procedure. For each he provides a very traditional natural history, based on description of visible traits and analysis of the total-habitus. His approach to natural history is thus premised on classification by means of description of external traits that takes into consideration the total-habitus of the animal. Like Buffon, he sees degeneration within a context of the assumed immutability of species, yet the Buffonian theory of degeneration – along with its definition of natural species as the set of organisms that produce fertile offspring with one another – does not seem to play a central role in Blumenbach's classificatory framework. In this respect, his classificatory framework is essentially closer to the Linnean approach, since it is based on the description of visible traits, though enhanced by the integration with the idea of the total-habitus. Instead, as I show in the following section, it was Kant who made this Buffonian criterion the fundamental principle of his approach to natural history.

3 The "Kantian Principle" for Natural History

3.1 Kant on the Concept of Race: A New Principle for Natural History?

In the preface to his work *On the Kantian Principle for Natural History* (1796), Christoph Girtanner maintains that "in his three writings on human races, which have been published in different journals, the great philosopher of Königsberg has expressed highly perceptive thoughts which, if subjected to a careful analysis, would have given a new direction to the study of natural history. Yet I do not think recent naturalists have considered this view, except Lord Councilor Blumenbach in the new edition of his excellent writing: *de generis humani varietate nativa*." On these premises, Girtanner formulated his theoretical program, which consisted in laying down the system of thought proffered by his teacher Kant in a coherent way: "after a long thinking on the Kantian principle I have found that it is valid not only

[19] *Ivi*, §§ 66–67.

for the human races on which the famous philosopher used them, but that this principle is a universal law, that can be applied to the organized nature as a whole."[20] Girtanner is right in at least one respect: the Kantian "principle" for natural history indeed has an important feature in common with Blumenbach's, namely the adoption of Buffon's idea of degeneration. But is Kant's use of this principle as original as Girtanner seems to think?

In this section I argue that it is not. The framework from which Kant is in fact substantially derivative of Buffon. Indeed, like Buffon, Kant believes in the immutability of species while providing an account for the differentiation of four subspecies based on two main factors: "germs" (*Keime*) and "predispositions" (*Anlagen*). In general terms, germs are the pre-existent structures determining the characteristics of a specific organism; circumstantial causes, like climatic conditions, provoke the germ's specific development, which is predetermined by inherent predispositions.

According to Kant, things like the condition of the soil (humid or arid) or nutrition could gradually introduce a hereditary difference among animals of the same species, chiefly with respect to size or proportion of limbs (heavy or thin). In birds of the same species, for example, there are germs that unfold a new layer of feathers if they live in a cold climate or that are held back if they reside in a temperate one. Since in a snowy country the wheat kernel must be more protected against the humid cold than in a dry warm climate, the wheat kernel holds a previously determined capacity or a natural predisposition to gradually produce thicker skin.

The species is the same, but it can nevertheless adapt itself to different environmental conditions on account of its germs and predispositions. According to Kant, chance or universal mechanical laws could not produce such a correspondence between an animal and its environment, and thus "we must consider such occasional unfoldings as *preformed* (*vorgebildet*)," for "outer things can well be occasioning causes but not producing ones of what is inherited necessarily and regenerates."[21] There is no immediate relationship between organized beings and their environment; the relationship instead is mediated by the already given possibilities contained in the "germ," which are particular to every single species.

Some remarks about Kant's terminology might be useful here: by the term "class" (*Klasse*) Kant refers to what for Linneaus was an abstract classificatory unit, i.e. a set of animals that display similar external traits; by the term "species" (*Gattung*), he refers to what Buffon identified as a concrete, natural classificatory unit, i.e. a set of animals which can generate fertile offspring with one another. Species are divided into various "kinds" (*Arten*), which derive from the same "stem" (*Stamme*) or "original stem species" (*ursprüngliche Stammgattung*). This "derivation" (*Abstammung*) of various kinds from the same species is what produces different "races" (*Rassen*). They result from a process of "degeneration" (*Ausartung*) that produces "deviant kinds" (*Abartungen*). In other words, Kant defines races as hereditarily different kinds that belong to the same species and preserve themselves

[20] Girtanner 1796, 3.

[21] Kant 1968, Ak., II: 435.

over prolonged generations (*Zeugungen*) as they move to other regions, and he maintains that they always beget "half-breed" (*halbschlächtige*) young.[22]

In his first race paper, *Von den verschiedenen rassen der Menschen* (1775), Kant argues that the animal kingdom's natural division into species (*Gattungen*) and kinds (*Arten*) is grounded in the common law of propagation, and "the unity of the species is nothing other than the unity of the generative force (*zeugenden Kraft*) that is universally valid for a certain manifoldness of animals."[23] For this reason, Kant deems Buffon's rule – according to which animals that produce fertile young with one another (no matter what shape they take) as all belonging to the same physical species – a correct definition of natural species, and one in opposition with the underpinnings of more abstract systems. Abstract divisions rely on classes (*Klassen*), which divide animals according to resemblances (*Ähnlichkeiten*), whereas according to Kant and Buffon the natural division actually concerns stems (*Stämme*), which divide animals according to relationships (*Verwandschaften*) and generation (*Erzeugung*): "the former provides a school system for memory; the latter provides a natural system for the understanding. The first only aims at bringing creatures under titles; the second aims at bringing them under laws." According to this schema, all human beings on Earth belong to the same natural species, because they consistently beget fertile children with one another. One can adduce only a single natural cause for this unity of the natural species (*Naturgattung*), "[this] unity is the same as the unity of the generative force (*Zeugungskraft*) that they have in common: namely, that they all belong to the same stem (*Stamme*), from which, notwithstanding their differences, they originated, or at least could have originated."[24] Every species is endowed with a specific generative force that belongs to it exclusively, and whose modifications give birth to its different races.

There is no significant difference between this Kantian account and what Blumenbach defined as the specific *Bildungstrieb* of every species. Blumenbach suggests that a chick egg becomes a chick while a peacock egg becomes a peacock precisely because of the direction of their specific formative drive, which is passed from generation to generation. Since for Blumenbach races and varieties are deviations from the original form of a species (*Gattung*) over time, his notion of race is applicable only to characteristics produced by degeneration that become hereditary. Yet for Kant, it was far more important than for Blumenbach to define classificatory concepts and criteria. This reflects their two different goals: Kant was addressing a philosophical determination of the notion of race, whereas Blumenbach focused on the elements that fall under this category. As I have already stressed, Kant's attention to biological issues was in fact not primarily the result of scientific concerns but rather emerged from his general interest in metaphysics, e.g. the determination of concepts such as race and species.

---

[22] For a detailed discussion of the translation of these terms see Mikkelsen 2014, 32–40. I only partially abide by Mikkelsen's terminological choices and always report the German original.

[23] Kant 1968, Ak., II: 429.

[24] *Ivi*, 430.

His account, just like Buffon's *Premier discours*, does not imply support for a phylogenetic classification of species (like the mature Darwinian framework) – only a genealogical account of races grounded in the idea of the immutability of species. Kant notes that air and sun appear to be the causes that most deeply influence the generative force and produce an enduring development of germs and predispositions, thus establishing races within the same species. Although all variations still "need a *stem species* (*Stammgattung*),"[25] which can be either existing or extinct, the possible range of modifications resides only within the boundaries of the organism's given predispositions, i.e. its given species. Thus, it is not possible to talk of the degeneration of one species into another but only of a degeneration of different races from the same species. For this reason, although Kant's language might apparently suggest he is proposing a developmental history of life, he in fact is arguing that such an inquiry would have little epistemic foundation. This is especially evident in Kant's review of Herder's *Ideen* and in his second race paper.

3.2 *Ideas so Monstrous that Reason Recoils Before Them: Kant on Transformism*

In his major work, the *Ideen zu einer Philosophie der Geschichte der Menschengeschlechtes* (1785), Herder integrated contemporary discussions of vital forces into his global and historical vision of nature. In Herder's theologically permeated view, nature is a work of art of the Creator (or at least a *deus sive natura*), whose masterpiece is the human being. His analysis of the different relations among the vital forces across the series of living beings shows how they purposely converge in man.

It is from these premises that Herder deems it possible to distinguish among the different forms of different living creatures. His account of nature starts from inanimate matter and a moment when everything was subject to one single drive, with all parts of matter pressing against one another until they internal forces impelled them to form the first crystals. After crystals, plants were created and began to modify their parts through their internal drive. With the development of zoophytes, creatures on the boundary between the vegetable and animal kingdoms, nature started to differentiate particular organs and slowly progress towards higher degrees of complexity.[26] In this way, Herder's *Ideen* envisions a sort of developmental history of life, describing how lower forms of organization transformed over time into increasing degrees of perfection, culminating in man.

This view of natural history became Kant's main polemical target in the 1780s. Kant devoted two reviews to Herder's *Ideen*. The first appeared in January, the other in August, of 1785. In his January review on the *Allgemeine Literaturzeitung*, Kant

[25] *Ivi*, 440.

[26] Herder 1989, 77–115.

argued that the ideas of Herder, his former student, lacked philosophical rigor and permitted poetic imagination to substitute for clearheaded thinking. Kant saw Herder as trying to prove the progression of nature by assuming the existence of "spiritual forces" containing a principle that animated and organized everything, "and indeed in such a way that the schema of the perfection of this organization is supposed to be the human being."[27] For Kant, however, the diversity, separation, and immutability of species is so out of question that the claim according to which "one species (*Gattung*) would have arisen from the other and all from a single original species or perhaps from a single procreative maternal womb, would lead to ideas which, however, are so monstrous that reason recoils before them." These ideas, in fact, lie "entirely outside the field of the observational doctrine of nature" and belong merely to "speculative philosophy."[28]

Kant's second essay on the natural history of the human species, published right after this review, was very likely influenced by this view on Herder. While Kant's earlier race paper had addressed the unity of the human species and its differentiation into races, his second essay, *Bestimmung des Begriffs einer Menschenrasse* (1785), focuses on conceptual issues and argues that discussion of a human race cannot be based on observation alone but must be guided by a preliminary determination of what a race is. The essay contains a methodological clarification and corresponding alternative formulation of his earlier account.

As in the previous essay, the basic idea is that the preformed germs (*Keime*) of an original stem species (*ursprüngliche Stammgattung*) can develop into different races as a consequence of the different expression of "predispositions" (*Anlagen*) in response to different environmental conditions. If the reference to an "original species" might lead one to consider this idea of natural history as a developmental history of life, Kant's Herder review reminds us that this cannot be the right reading. Instead, what is at stake is the endeavor of providing a framework capable of accounting for the degeneration of a single species into different races in a context in which the species itself is considered immutable. For Kant, if one uses an abstract system of classification, one can look only for traits of comparison (similarity and dissimilarity) and thus can only obtain classes (*Klassen*) of creatures in a Linnaean sense. On the other hand, if one looks further into the natural origin of organisms, it becomes more apparent that what Linnaues defined as different classes are simply different races (*Rassen*), i.e. different kinds (*Arten*) of organisms derived from the same species (*Gattung*). In other words, Buffon's principle allows for what Kant identified as a correct classification of species, whereas he argued that the Linnean approach led us astray by considering different races as thoroughly different species.

This Kantian discussion of races might not seem obviously pertinent to the question I am addressing in this chapter, namely his principles for natural history, yet there is a strong link between the two. In fact, as I have emphasized in this section, the analysis of the concept of race leads Kant to a definition of the most important

[27] Kant 1968, Ak., VIII: 52.

[28] *Ivi*, 54.

concepts of animal classification such as class, species and kind. Just as Blumenbach integrated Buffon's theory of degeneration into his theory of the *Bildungstrieb*, Kant used Buffon to define the notion of race in the context of his theory of *Keime* and *Anlagen*. However, neither for Blumenbach nor for Kant does the Buffonian emphasis on degeneration imply a unified plan of organization that connects all living forms with one another. Kant does not envision a unique common archetype as the origin of all species, but rather the existence of several different archetypes that are independent from one another. For Kant, races degenerate on the basis of their common species; this does not imply, however, the idea of an historical transformation of a species into another.

3.3 Original Stem-Species: Kant and Girtanner on Archetypes

Kant's third race essay, *Über den Gebrauch teleologischer Prinzipien in der Philosophie* (1788), is entirely conceived as a reply to critiques raised by Georg Forster, who had defended Herder's views against Kant's critical remarks.[29] This polemical context forced Kant further refine the definition of his concepts. He thus comes back to his distinction between *Naturbeschreibung* and *Naturgeschichte*: *Naturgeschichte* is the consideration of nature according to the laws of reproduction and heredity, which establish real species; *Naturbeschreibung* is a mere description of nature, i.e. Linnean natural history, which only establishes abstract classes. In Kant's view, a history of nature (*Naturgeschichte*) can only trace the connection between an immutable species and its geographical variation, which results from different expressions of its germs in response to different environmental factors. Anything beyond this is for Kant mere speculation. On the other hand, he argues that simple description of nature (*Naturbeschreibung*) cannot account for races, which result from different interbreeding animals and which have a common cause, "namely a cause that lies originally in the stem (*Stamm*) of the species."[30]

A careful understanding of the terms at play here is crucial. By "stem" Kant does not mean a common archetype of all species but the *specific* archetype of the single species (*Gattung*). There are several "original stem species" (*ursprüngliche Stammgattungen*) on whose basis races (*Rassen*) and varieties (*Varietäten*) are formed. A modification of the original germs (*Keime*) and preformed dispositions (*Anlagen*) of these stem species was for Kant inconceivable. Thus his theory of germs and dispositions provided a theory of classification capable of explaining adaptation while maintaining a conceptual framework that implies the immutability of species. In this sense, Kant's "stem" (*Stamm*) is the stem of *one species* that accounts for *race differentiation*, not the archetype of *species differentiation*.

For Kant, the individuation of the common stem is just a single criterion of classification, one which refers to the "*physical* separation which *nature* itself makes

[29] Zammito 2002, Sloan 2006.

[30] *Ivi*, 163 (emphasis added).

among its creatures with respect to their *generation* (*Erzeugung*)." When classifying animal species one must thus pay attention to features that indicate the stem, not merely to resemblances among characteristics, "since in that case we are dealing with a problem of natural history (*Naturgeschichte*), not of the description of nature (*Naturbeschreibung*) and of mere methodical nomenclature."[31] From this perspective, persistence of hereditary characteristics is required to justify division into classes, even in the description of nature. In this sense, Kant stresses that the persistence of hereditary characteristics is not equivalent to supporting a transformationist position – but the opposite. According to Kant, the Buffonian criterion of classification, based on the possibility of producing fertile young, accounts for the unity of species through variations and explains adaptation, while at the same time granting the immutability of species. This determination of "natural" species, as opposed to "school," or abstract species, is all that is possible to achieve within the limits of reason: "where these come to an end, and one must bring in self-concocted forces (*selbst erdachten Kräften*) of matter following unheard-of and unverifiable laws, one has already gone beyond natural science."[32]

The "Kantian principle" of natural history advocated by Girtanner is nothing more than a synthesis of Kantian and Blumebachian perspectives, with no real element of originality. Following Kant, Girtanner claims that the contemporary *Naturbeschreibung* orders natural things in a way that feels very comfortable for the mind but does nothing to explain the natural division of nature. Instead, a physical natural system can be expected only from *Naturgeschichte*, which can teach us which changes living beings have undergone over time in response to events like natural migrations, floods, and violent natural changes.

In Girtanner's view, the history of nature "teaches us also (or tries at least to teach) what the archetype (*Urbild*) of the stem species (*Stammgattung*) of animals and plants was like and how the genera gradually modified."[33] Girtanner makes it explicit that this account is similar to that of several famous naturalists, "for example Ray, Frisch and especially Buffon," who have already tried to determine species "according to the laws of reproduction, or at least recognized the accuracy of the principle that animals which generate fertile young belong to one and the same physical species." It is in fact "a universal law of nature that in all organic creation the genera remain unchanged, although single creations are sometimes subject to modification. The degeneration of the species, in a philosophical sense, thus cannot take place because this goes against this law of nature."[34] The only kinds of degeneration Girtnner recognizes are (1) *Races* (*Rassen*): a variation that, when blended with others, always produces mixed young (e.g., black-skinned and white-skinned men); (2) *Strains* (*Spielarten*): a variation that maintains its distinctive characteristics despite transplants and transfers (e.g. blonde and brunette); (3) *Varieties*

[31] *Ivi*, 164.
[32] *Ivi*, 179.
[33] Girtanner 1796, 2.
[34] *Ivi*, 4.

(*Varietäten*): a variation that is often, although not always, modified through reproduction.

As I hope this synopsis demonstrates, Girtanner shared with Kant and Blumenbach a more or less common approach to natural history that can be characterized as modified Buffonian, which combines degeneration theory with the claim of the immutability of species. Yet their understanding of the relation between organism and environment is interpreted in light of Blumenbach's *Bildungstrieb* and the Kantian theory of *Keime* and *Anlage*. Still, this perspective is coherent with the Buffonian framework and does not imply the idea of a common stem species. As we will see in the next sections, the Romantic philosophy of nature turned away from this understanding of classification, shifting from descriptive natural history to a comparative anatomy grounded in the idea that all animal species are metamorphoses of a common archetype that constitutes the fundamental plan of all animal organization.

4 The Unity of Type in Goethe's Morphology

4.1 Metamorphosis as Idealized Epigenesis

In the following sections, I consider Goethe's, Schelling's, and Oken's stance on animal classification, arguing that their position should not be interpreted as unilateral opposition to the philosophical and scientific tradition represented by Girtanner, Kant, and Blumenbach. Rather, Goethe and Schelling considered themselves to be working to complete the project that Kant had left unfulfilled in his third *Critique*.

In § 80 of the *Critique of the Power of Judgment*, Kant formulates the notion of "archeology of nature" (*Archäologie der Natur*). Philippe Huneman has stressed that this discussion marks a shift from Kant's Herder review and from the theory of heredity laid out in the race papers, because it is implicitly based on the concept of type.[35] Type here is conceived as the result of a parental lineage existing among different species and is attested by the extensive correspondences among forms that comparative anatomy reveals. The concept of type leads to the hypothesis that morphological homologies are clues regarding the transformation process by which animal variety was produced. In his race papers, Kant understands *Naturgeschichte* to be consideration of nature according to the laws of reproduction and heredity, which establish real species; it is opposed to *Naturbeschreibung*, which is a mere description of nature, i.e. Linnean natural history, which only establishes abstract classes. Both notions, however, refer to a framework concerned with the classification of natural species, not with their production.

In the *Critique of the Power of Judgment*, Kant argues that the common plan of organization displayed by different species, "which seems to lie at the basis not only of

35 Huneman 2006, 13–15.

their skeletal structure but also of the arrangement of other parts, and by which a remarkable simplicity of basic design has been able to produce such a great variety of species by the shortening of one part and the elongation of another," allows for the possibility of a mechanical explanation of variety:

> this analogy of forms, insofar as in spite of all the differences it seems to have been generated in accordance with a common prototype (*Urbild*), strengthens the suspicion of a real kinship among them in their generation from a common proto-mother (*Urmutter*), through the gradual approach of one animal genus to the other, from that in which the principle of ends seems best confirmed, namely human beings, down to polyps, and from this even further to mosses and lichens, and finally to the lowest level of nature that we can observe, that of raw matter.[36]

According to Kant, the archeologist of nature would have to derive all organized beings from this communal type through mechanical laws like those at work in the production of crystals. This process would start from a condition of chaos that produces simple creatures "of less purposive form" from which complex creatures would then arise, finally producing species. The archeologist of nature would ultimately have to consider this process purposely oriented towards the origin of species, which could not be explained otherwise. In doing so, however, "he has merely put off the explanation, and cannot presume to have made the generation of those two kingdoms independent from the condition of final causes." Given the transcendental constraints laid down in the previous paragraphs, Kant considers the idea of an archeology of nature as a "daring adventure of reason."[37]

In a retrospective memoir, Goethe wrote that in the 1790s he had embarked together with Herder on precisely the adventure of reason that had been outlawed by Kant: addressing the *Urbild* behind all possible animal forms and trying to determine the laws of its transformation.[38] Goethe addresses the idea that a series of forms resulting from transformations of an original type (*Urtypus*) might explain continuities across animal forms by referencing the notion of *metamorphosis*. For Goethe this term did not imply a real transformation but the possibility of individuating among modifications of a form that assume different shapes but maintain its fundamental traits. During his Italian journey, Goethe had become convinced that he could discover a simple unity among the variety of Italian vegetation: an original or archetypal plant (*Urpflanze*), or ideal universal form to which all others could be reduced. Goethe located this universal form in the leaf, which he understood as the invariant common to all empirical forms – their transcendental condition. While this transcendental leaf does not exist in nature, its form is the condition of possibility for ordering all plant forms in an ideal sequence that proceeds by a process of intensification (*Steigerung*). Such intensification is a continuous ascent towards greater complexity and perfection, towards a fuller expression of the potential inherent to the fundamental element. Goethe saw evidence of intensification in the metamorphosis of plants from simple, vegetative stem leaves to finer petals and

[36] Kant 1968, Ak, V: 418.

[37] *Ivi*, 419.

[38] Huneman 2006, 17.

specialized reproductive organs. It occurred through polarity (*Polarität*), or a state of constant attraction and repulsion producing a dynamic interplay of opposites. He considered polarity most evident in the alternating forces of expansion and contraction displayed by the developmental process: during development certain external parts of the plant undergo frequent change and take on the shape of adjacent parts. For example, a single flower often turns into a double flower when petals develop instead of stamens and anthers. These petals are either identical in form and color to the other petals of the corolla or still bear visible signs of their origin. According to Goethe, this metamorphosis is the process by which nature produces one part by means of another, creating a variety of forms via the modification of a single organ: it is "the process by which one and the same organ appears in a variety of forms."[39]

Goethe's *Metamorphosis of Plants* follows the growth of the plant through its various transitional stages; it describes the plant's development from its early stages to the formed organism. It is thus worth questioning the relationship between his notion of metamorphosis and that of epigenesis, since the latter defines precisely the development of an animal form from undifferentiated substance to adult organism. In some notes taken in 1817–1818, Goethe defines Wolff, the founding father of modern epigenesis, as his forerunner (*Vorarbeiter*)*:*

> may the Parcae grant me the chance to express how in the course of so many years I have walked together and beside this extraordinary man, trying to penetrate his character, beliefs and doctrine, to which extent I found myself in agreement with him, how I felt stimulated to progress further, but always looking at him with gratitude. I will now speak only of his ideas concerning the metamorphosis of plants, which he had exposed in his demonstrative work and in the following German version.[40]

However, the alignment of Goethe's descriptions of the metamorphosis of plants with epigenetic development and the reference to Wolff obscure Goethe's true explanatory interests. Whereas Wolff was concerned with how generation occurs during embryogenesis, Goethe was instead interested in the construction of an ideal type. In this sense, he understood metamorphosis in purely morphological terms: it is not a real genealogical process, like epigenesis, but an ideal transcendental sequence. To spell out the meaning of Goethe's notion of metamorphosis, in the following section I take into account one of his most important works on animal morphology, where his position is articulated in particularly clear terms.

4.2 The Metamorphosis of Animals

As we have seen in the previous section, the concept of metamorphosis elaborated by Goethe in 1790 was essentially applied to the analysis of the changing forms of plants. In a later work, the *Erstster Entwurf einer allgemeinen Einleitung in die vergleichende Anatomie ausgehend von der Osteologie* (1795), Goethe applied the

[39] Goethe 2009, § 3.

[40] Goethe 1994, 74.

same idea to the analysis of animal morphology. Like the *Urpflanze*, the original animal type (*Urtypus*) does not objectively exist in nature; it is rather a methodological tool for comparative empirical work. Goethe's morphological framework is based on two basic tenets: (1) the idea that all animal forms are modifications of the same original archetype; (2) the idea of a graded series of organized forms. According to this framework, all species should conform to the universal type, forming a graded series of forms that result from one another by means of morphological modifications. Both of Goethe's principles are based on the theoretical framework produced at the Göttingen School, and notably by Kielmeyer. Indeed, Goethe met Kielmeyer personally in 1797 but had already been familiar with his *Rede*.[41] The influence of Kielmeyer is relevant for both aspects of his framework. As I argued in chapter "Functions: The Göttingen School and the Physiology of Vital Forces", in his seminal lecture Kielmeyer had formulated the idea of the animal kingdom as a graded series of organisms characterized by increasing functional complexity. As we have seen, this series was regulated by particular laws – the laws of compensation – according to which the increase of one vital force always implied the decrease of the others. In this section I show how Goethe applied these ideas to the study of comparative morphology.

In his 1795 text, Goethe argues that natural history is largely based on the comparison of visible traits, yet he finds this comparative process insufficient for a proper classification of organisms, since observed traits are isolated and incoherent with one another. Moreover, they do not account for the affinities among animals and those between animals and man. According to Goethe, it is difficult to unify the divergent criteria of classification that emerge from observed traits, since there is no norm to which the traits can be compared across different species. Goethe therefore proposes an anatomical type, a general picture containing the forms of all animals, that could provide the norm against which traits are compared and described in an orderly manner. This type "must be established from a physiological perspective," conceiving of the animal form as an integrated whole. The mere idea of a type implies that no particular animal can be used as point of comparison, since the particular can never serve as measure of the whole. Moreover, because of its exemplary perfection as an organism, the human being cannot serve as a gauge for analyzing animals. Instead, "empirical observations must first teach us what parts are common to all animals and how these parts differ. The idea must govern the whole, it must abstract the general picture in a genetic way."[42]

Goethe's statement of the necessity of a unitary morphological type as the basis of animal classification, must be understood in relation to the idea of a graduated series of organisms. Goethe refers to the constant succession of forms from which it is possible to deduce the ideal type. Once a type has been established, he argues that it would be easily tested through application of normal methods of comparison. Goethe stresses that, in natural history, there has been comparison of animals to one another or to man, the races of man to one another, and the two genders to each

[41] Giacomoni 1993, 128–149.

[42] Goethe 1994, 121.

other. These comparisons may still take place after the type has been established, but this comparison will be more consistent since they will be grounded not in man but a universal animal form. Once the ideal type has been established, Goethe argues that comparison could be performed in two ways: either by comparing individual species to the type or by descriptively tracing a particular part of the type through the major genera.

In attempt to individuate this universal archetype of all animal forms, Goethe points out that the outer structure of all relatively developed organisms exhibits three main parts. Goethe exemplifies this by referring to insects. Their bodies consist of three parts – the head, the mid-section, and the rear section – and each performs different vital functions. Auxiliary organs are affixed in a variety of ways. The head is always forward; it is where the different sensory organs are bound together in one or more ganglia, normally defined as the brain. The midsection instead contains the organs for maintenance of inner life and outward movement. The rear section contains the organs for nourishment and reproduction. In fully developed animals, the head is decisively separated from the second section, but the third section is joined to the second by a lengthened backbone and a common external covering. The parts of the animal, their respective forms, their relationship, and their particular properties determine the animal's vital needs and thus its specific lifestyle.

After recognizing these parts, Goethe argues that the many varieties of forms arise because one part or another outweighs the others in importance. For instance, the neck and extremities are favored in the giraffe at the expense of the body, but the reverse is the case in the mole. Based on these observations, Goethe formulates the law that "nothing can be added to one part without subtracting from another and vice versa."[43] It is hard not to see the proximity of this formulation to Kielmeyer's laws of compensation. According to Goethe, in fact, if the formative drive grants more emphasis to one part of an animal, it is bound to subtract from another. This is for Goethe the reason why nature always maintains a form of morphological equilibrium. For example, the body of a snake is very long because neither material nor energy are required for auxiliary organs. When those organs appear in another form, such as the lizard endowed with short legs, the length of the body must contract and a shorter body will be created, whereas a frog endowed with longer legs has a necessarily shorter body.

This idea of morphological compensation applied to the universal type is the core of Goethe's approach to the metamorphosis of animals. It frames the existence of specific organs not in functional terms but in terms of their origin. Instead of claiming that the bull has horns so it can butt, it investigates the morphological laws according to which the bull might have developed the horns it uses for butting.[44] Despite this emphasis on morphology, Goethe does not disregard the role played by external circumstances in the production of the astonishing variety of organic forms in nature. In fact, Goethe argues, the original type is also affected by the external

[43] *Ivi*, 124.

[44] *Ivi*, 125.

environment. Water for example influences the bodies it surrounds; the body of the fish is swollen to conform to its environment. According to Goethe's law of the ideal type, this swelling of the body must be followed by a contraction of the fish's extremities or auxiliary organs. Other environmental constraints that Goethe notices influence the metamorphosis of the original type are climate, altitude, and temperature.

Though Goethe did not work out a criterion for the homology of parts with any great clearness, he had an inkling of the "principle of connection" that would later be developed by Geoffroy. According to Geoffroy, the homology of a part is determined by its position relative to other parts. It is not clear if Goethe understood this to mean form was independent of function. Indeed, despite being essentially a morphologist, Goethe sometimes wavered between a purely formal, or morphological approach, and a functional one. For this reason, it has been claimed that Goethe's morphological views are neither very clearly expressed nor very consistent.[45] This seems particularly evident in his treatment of the relation between form and function. Sometimes Goethe takes the view that structure determines function, stating that the specific structure of the animal determine its habits and life, while elsewhere he writes that function may influence form.[46]

In the following section, I intend to show how this Goethean approach, developed after Kielmeyer's account of the distribution of vital forces and aimed at sketching an organizational logic for the gradual increase of organismal complexity, was taken up by Schelling's *Naturphilosophie*. Other studies have stressed the strong connection between *Naturphilosophie* and later transcendental morphology. Indeed, the conceptual proximity linking Oken to Geoffroy and Owen is by now well known.[47] As a matter of fact, the full development of transcendental thought in comparative anatomy comes a little later than the bulk of Goethe's scientific work and owes more to Kielmeyer and Oken than to Goethe himself. A great wave of transcendentalism passed over biological thought in the early 19th century. This transcendental approach arose mainly in Germany, but also powerfully affected the thought of Geoffroy and his followers, such as Étienne Serres. Many ideas were shared between the French and German schools of transcendental anatomy: the belief that there existed a unique plan of structure, the idea of the scale of beings, the concept of a parallelism between the development of the individual, and the evolution of the species. In the following section, I argue that some of the seminal ideas of this tradition, which were already reflected in the work of Goethe, form the heart of Schelling's early philosophy of nature.

[45] Russell 1916, 47.

[46] Goethe 1994, 126–128.

[47] Rehbock 1990; Sloan 1992, 2007, Wellmann 2001.

5 Animal Classification in Schelling's *Naturphilosophie*

5.1 A New Era of Natural History

In this section I take up Schelling's approach to animal classification. I first situate Schelling in relation to the thought of Kant, Blumenbach, and Kielmeyer as it is presented in *Von der Weltseele* (1798). I then analyze Schelling's views on natural history as they appear in the *Erster Entwurf eines Systems der Naturphilosophie* (1799). I argue that Schelling thinks of himself as developing what Kant's critical project had left unfulfilled. He thereby acknowledges Göttingen physiologists like Haller and Blumenbach as the pioneers of a new approach to vital organization capable of overcoming the limits of a mechanistic philosophy of nature, and he considers the work of Kielmeyer, probably the most influential of Blumenbach's students, as the beginning of a "new era of natural history."

In the *Weltseele*, which is subtitled "a Hypothesis of higher Physics for the Explanation of the Universal Organism," Schelling dedicates several pages to discussion of the physiology of his time. In particular, in the section dedicated to the "origin of the universal organism," Schelling argues that the "foundation of life is contained in opposed principles, of which one (positive) must be found outside the living being, the other (negative) must be found inside of the individual itself."[48] This was already implied by the theories of Haller, who was the first to "formulate a principle of life which cannot be explained through mechanical principles."[49] In Schelling's view, Haller's notion of irritability already implied that life can be conceived as the interaction of two opposing active and passive principles. Accordingly, he states that "*Haller* chose the truest and most perfect principle of physiology in his time, inasmuch as on the one hand he abandoned mechanical explanations (as the concept of excitability [*Reizbarkeit*] already implies that it cannot be explained on account of mechanical causes), without on the other hand overstepping, like *Stahl*, into hyperphysical inventions."[50] Such quotes should cause us to reconsider any quick dismissal of Schelling's work as firmly opposed to Enlightenment science, since Haller himself, the most important of Enlightenment physiologists, is explicitly recognized by Schelling as a fundamental stepping stone toward an adequate understanding of life. In fact Schelling believes that, had Haller considered the notion of excitability more closely, he would most certainly have seen that it necessarily implies "a *dualism of opposed principles*,"[51] and would have "spared us the conflict raised between his (in part very superstitious) followers and the upholders of a *unique* vital force, active only in the nerves."[52] The very notion of excitability

[48] Schelling 2000, 192.

[49] *Ivi*, 196.

[50] *Ivi*, 193.

[51] *Ibidem*.

[52] *Ivi*, 193–194.

(*Reizbarkeit*) for Schelling implies reference to those opposing principles that constitute the foundation of life.

Even more important for Schelling is the work of Kant. He considers himself to be working in continuity with the Kantian enterprise, or more precisely to be developing in a coherent way the theoretical foundations that had been laid down by Kant. In January of 1795, Schelling wrote a letter to Hegel, who had left the *Stift* of Tübingen, where they had studied together, to work as a tutor in Bern. To his friend, Schelling writes that "Kant has provided the results. The premises are still missing. But who can understand the results without the premises?" In Schelling's view, it was necessary to provide a foundation for the framework Kant had so rhapsodically presented in his *Critiques*. Kant had "swept *everything* away," but his teaching still needed to be developed systematically. Schelling's model for this systematic development was the philosophy of Johann Gottlieb Fichte, who "will raise philosophy to a height at which even most of the hitherto Kantians will become giddy."[53]

Schelling undertakes this work of systematically developing Kant's thought in both his works on philosophy of nature – the *Ideen zu einer Philosophie der Natur* (1797), *Von der Weltseele* (1798) and the *Erster Entwurf eines Systems der Naturphilosophie* (1799) – and the *System der transzendentalen Idealismus* (1800). In the *Weltseele* in particular he develops some of the ideas laid out in Kant's third *Critique* by arguing that "nature does not leave organic matter to the dead force of attraction." Rather, organic matter is "*forced* to assume a *determinate form and figure*, which precisely for this reason appear to human judgment as a *purpose* of nature."[54] As we have seen in chapter "Generation: The Debate on the Formative Force and the Question of Ontogenesis," Kant had emphasized the peculiar purposiveness displayed by "organized beings" in his *Critique of the Power of Judgment* (1790), but to him this purposiveness was something highly problematic, and thus confined to being merely a regulative principle of reason. To the contrary, Schelling saw in this purposiveness the central feature of vital organization.

The order displayed by living organisms can only be thought of as the "*purpose* of a personified nature, because natural mechanism cannot produce *necessarily* a determinate formation." In fact, "the properly *chemical* process of life explains only the blind and dead effects of nature, which take place in both living and dead bodies," but not "the *formation according to purposes* of animal matter," which can only be explained through a principle which "lies outside the sphere of chemical processes."[55] In fact, "*every truly individual being is at the same time cause and effect of itself*. But such an entity, that we must consider as if (*als ob*) at the same time cause and effect of itself, we call *organized* (the analysis of this concept has been provided by *Kant* in the *Kritik der Urteilskraft*) thus *what in nature has the character of individuality, must be an organization*, and vice versa."[56] On the other hand, none of the parts of an organism is itself an individual insomuch as it

---

[53] Schelling 2001b, 16.

[54] Schelling 2000, 204.

[55] *Ivi*, 204–205.

[56] *Ivi*, 209.

"expresses the *totality* of organization," which consists in the "*unity of the living process*." Consequently, every organization must be characterized by the "maximum *unity* of the living process in view of the whole."[57] Schelling hereby defines living organisms as organized systems in which all parts are present on account and in function of the whole. This definition is in explicit continuity with Kant in the third *Critique* – except for the role ascribed to teleology. As opposed to Kant, Schelling defines teleology as a constitutive property of organized beings that cannot be accounted for by reference to mechanical and chemical forces alone.

As we saw in chapter "Generation: The Debate on the Formative Force and the Question of Ontogenesis," to account for this purposiveness, Blumenbach had introduced the notion of *Bildungstrieb*, which he had postulated as a *qualitas occulta* analogous to Newton's notion of gravity – arguing that although we do not know the origin of the force, its effects could be easily detected through empirical observation. Schelling criticized this Newtonian analogy, deeming it still too weak as a definition of the teleological nature of living entities, and went on to claim that, if we consider the *Bildungstreib* as a *qualitas occulta*, then it cannot provide an "*explanatory foundation*" (*Erklärungsgrund*) of vital organization. To be understood as an explanatory foundation, "it must have *constitutive* significance."[58]

While Schelling felt he was developing a philosophy of nature that would complete what Kant and Blumenbach had begun but left unfinished, to do so he looked to Kielmeyer, a fellow naturalist working on a scientific project with similar goals. Schelling makes explicit reference to Kielmeyer in his concluding remarks to the *Weltseele*, where he argues that the animal kingdom is characterized by a "sequence of functions (*Stufenfolge der Funktionen*)," since nature has opposed reproduction with irritability and irritability with sensibility. He thereby posits an antagonism of vital forces that maintains a balance a balance between them. Readers are thus led to the idea that "*all these functions are just ramifications of one and the same force*, and that the *only natural principle we have to admit as the cause of life manifests itself in them as its single manifestation*."[59] This idea is confirmed if we consider "the *progressive development of organic forces* in the *series* of organizations, with regard to which I refer the reader to the lecture of Professor *Kielmeyer* that already appeared on this subject in 1793, a lecture from which a new era of natural history in the future is without doubt to be expected."[60] In this way, Schelling refers readers to a classificatory framework for nature based on the comparative physiology of organic forces, instead of the "Kantian principle" for natural history. In the following section I analyze the way in which Schelling took up Kielmeyer's comparative physiology of vital forces and made it the core of his approach to animal classification.

[57] *Ibidem*.

[58] *Ivi*, 216.

[59] *Ivi*, 252.

[60] *Ivi*, 253.

5.2 Animal Classification in the *Erster Entwurf*

Schelling developed his framework of animal classification especially in the *Erster Entwurf eines System der Naturphilosophie* (1799). The source of his elaboration is Kielmeyer, who is widely quoted throughout the work.[61] Accordingly, the text understands different animal classes as the result of different relations among organic forces. They differ from each other not primarily with regard to their material composition but in terms of the relative proportion of vital forces they display. Like Kielmeyer, Schelling thus develops a comparative physiology of vital forces whose aim is to establish the various degrees and proportions of each vital force in the animal kingdom. He defines every organism as a specific proportion of reproductive force, irritability, and sensibility. Every organism is defined not primarily by its external form but by the proportion of these forces active within it. Its form and organs follow from the nature and proportion of these forces. For instance, every organic being is suffused with all three, but plants have a prevalence of reproductive force while their sensibility is close to zero. On the other hand, in mammals sensibility is dominant but they produce few offspring; their reproductive force so narrows that they retain only the capacity to reproduce the organism itself through growth, assimilation, and maintenance. The variety present in organic nature results from variation in the proportion of these functions, which determines their intensity. They stand in inverse relationship to one another such that, as the one increases in intensity, the other must diminish, and conversely as the one diminishes, the other must increase.

The goal of the systematic animal classification that Schelling presents is thus "to determine the various organic functions and their various possible proportions *a priori*." Once this problem is successfully solved, "a *dynamically graded series of stages* would not only be brought into nature, but at the same time one will also have deduced that graded series of stages in nature itself *a priori*, and what was *formerly* called *natural history* would be raised to a *system of nature*." Here Schelling refers directly to Kant's distinction between *Naturbeschreibung* and *Naturgeschichte*, stressing that Kant understood natural history to be only a description of nature. Schelling thus employed the term *Naturgeschichte* to name a particular branch of natural science studying the gradual alterations experienced by the various organisms of the earth, how they were influenced by external nature, their migrations from one climate to another, and so on. Schelling notes that, if Kant's ideas were put into practice, "natural history" would be an actual *history* of nature as it progressively yields new organisms through continuous deviations from a common type.

In Schelling's terms, this history would allow for philosophical deduction of how the various stages of nature, or its different levels of organization, emerge out of the same principle. This deduction is not understood in merely epistemological terms, since for Schelling it reconstructs the logical structure of nature itself, from its most simple elements to its most complex organisms. Schelling does not believe the

[61] Schelling 2001a, 13, 28, 31, 210, 383, 425, 431, 440.

relation of the various natural forms to a universal type can be found by investigating external characteristics. Rather, it can be individuated only through comparative anatomy, which marks the discontinuities among living forms, or by using "the *continuity of organic functions* as principle of organization."[62] As I have already argued, this approach displays significant proximity to the one advocated by Kielmeyer: both account for the distribution of vital forces in the animal kingdom according to a framework of inverse relationships and both affirm an increasing complexity across the series of organizations. Thus Schelling's framework is one that Kielmeyer would subscribe to, but not Kant or Blumenbach, who conceived of natural history in a more traditional, primarily Buffonian fashion.

Also like Kielmeyer, Schelling uses the different vital forces and their inverse relationship to provide a systematic classification of animals. Thus "as *irritability increases in the phenomenon, sensibility must decrease*, and inversely *in the proportion that sensibility increases, irritability must decrease in the phenomenon*."[63] As in Kielmeyer's *Rede*, this law in Schelling is supported by several empirical considerations. The brain manifests its most perfect form in man, degenerating from that pinnacle into increasingly less perfect organization and smaller volume. For instance, among whales the brain is almost non-existent, in comparison with their body mass; among reptiles it is very small, likewise among fishes, and insects display merely a narrow medullary substance. In most worms the existence of a brain becomes completely unprovable, while among zoophytes all external signs of sensibility disappear. Just as the brain gradually dwindles away across the spectrum of the animal kingdom, until it finally disappears, the same occurs with the external organs of sensibility. The eye, for example, is preserved even in insects, but its structure loses its regularity across the spectrum. In some insects, the eye is very large, in others it is very small; some insects have only one eye, others have hundreds. Most worms do not have eyes, while polyps do not display any visible sight organ but still appear to seek light. As sensibility fades throughout the animal kingdom, irritability must rise in the same proportion, and as irritability fades, the reproductive force rises. As for Kielmeyer, in Schelling the lowest classes of the animal kingdom are endowed with high reproductive force while totally or mostly lacking all other vital functions; classes higher in the series of organisms display less reproductive force but higher irritability, which allows them to escape predators; finally, the highest classes, such as mammals, are characterized by sensibility and higher cognitive faculties, which culminate in the perfection of human beings.

Schelling outlines a similar account in the *System der gesamten Philosophie* (1804), where the distribution of the three vital functions in the animal kingdom is explicitly connected to many animal classes: *Reproduktionstiere* (polyps, mollusks, insects), *Irritabilitätstiere* (fishes, amphibians, birds), and *Sensibilitätstiere* (mammals). In this formulation, different manifestations of each function constitute the basis for the classification of species in each class. As in the earlier text, here the idea of a priori deduction plays a central role as the element differentiating

[62] *Ivi*, 116.

[63] *Ivi*, 211.

Naturphilosophie from other scientific enterprises of the period. This aspect has often been charged (sometimes with good reason) with being an empty formalism detached from empirical knowledge. Nevertheless, Schelling's philosophy of nature contributed to the genesis of German biology in a twofold sense: (1) it marked a shift in the philosophical understanding of teleology as *internal* purposiveness, which is definitively loosened from the idea of intention and considered, qua self-organization, as a distinctive feature of organized beings; and (2) it implemented a classificatory framework based on the comparative physiology of vital forces. Both cases express a complex relationship of continuity/discontinuity with both Kant and the life sciences of the late eighteenth century. On the one hand, Schelling considered himself to be completing what Kant had left unfinished, an interpretation of organic nature according to a fundamentally teleological regime, on the other hand, he gave considerable conceptual determinacy to what was already implicit in Kielmeyer's scientific enterprise: a system of classification based on the distribution of vital forces across the animal kingdom. It is this second aspect in particular which is taken up in Oken's system of comparative anatomy, which largely develops out of Schelling's classificatory framework. I take up Oken's account in the following section.

6 Natural History and *Naturphilosophie* in Lorenz Oken

6.1 Naturphilosophie as a Foundation for Biology

In Sects. 4 and 5, I have argued that in the domain of natural historical observation *Naturphilosophie* addressed a quest for primordial or ideal types from which the diversity of natural beings could be derived. Exemplary of this approach are Goethe's morphological studies, particularly his presentation of plant organs as successive transformations of the primordial leaf and the skull and vertebrae as successive modifications of the primordial vertebra. Similarly, Schelling turned to comparative anatomy and physiology to demonstrate not a genealogy of species but a process of natural development that realizes an original ideal. Both of these features of *Naturphilosophie* are present in the work of Lorenz Oken (1779–1851) – who was a student of Blumenbach in Göttingen, a disciple (and then rival) of Schelling, a friend (and then competitor) of Goethe, and a Chair in Medicine and in Natural History at the universities of Jena, Munich, and Zurich.[64]

In a speech given in Jena in 1809, entitled *Über den Wert der Naturgeschichte besonders für die Bildung der Deutschen*, Oken explicitly objects to the natural history of his time, which he considers to be based on a senseless enumeration and description of animals. Instead, he called for a natural history integrated with the new *Naturphilosophie*. He attempts to set out such a natural history in the *Lehrbuch*

[64] Jardine 1996, 238.

der Naturphilosophie (1809–1811), the *Lehrbuch der Naturgeschichte* (1813–1826), and the monumental seven-volume series *Naturgeschichte für alle Stände* (1839–1841). The *Lehrbuch der Naturphilosophie*, for instance, combines an elaborate dialectical construction of nature, similar to Schelling's, with a "plethora of often apparently weird analogies."[65] The work opens with a "mathesis" in which gravity, light, heat, and fire are considered direct manifestations of God, an "ontology" which draws on elements of Schelling's cosmogony and its account of the formation of the solar system, Earth, and principal rock formations and mineral types. Oken's account of living beings, which interestingly is entitled "biology," starts with the primordial units of life, the "Infusoria," and then reconstructs the emergence of all animal classes, which are formed by the addition and reduplication of successively more complex organs and which culminate in human beings, who possess all organs in their higher form. In outlining this reconstruction, Oken formulates a clear statement of what Ernst Haeckel (1834–1919) would later define as the theory of recapitulation (according to which ontogeny recapitulates phylogeny). This statement was supposed to account for how, in its development from fertilized egg to adult, an animal of a given class would progress through all the stages of all the classes below it. From this view,

> the foetus is a representation of all animal classes in time: At first it is a simple vesicle, stomach, or vitellus, as in the Infusoria. Then the vesicle is doubled through the albumen or shell, and it obtains an intestine as in Corals…. With the appearance of the osseous system, it is modified into the class of Fishes. With the evolution of muscles, into the class of Reptiles. With the ingress of respiration through the lungs into the class of Birds.[66]

In this sense, Oken's system is an extraordinary feat of synthesis. It takes a decisive stand on every major controversial issue in the debate over natural history of the period: the basis for generation, the method of classification, the relation between form and function. Moreover, his system "tightly integrates the description, classification, anatomy, physiology, and chemistry of living beings."[67] It is thus not surprising that Oken defines his account of living beings as "biology," a notion used since 1802 (when it appeared as the title of Treviranus' work) to describe integrated inquiry into the phenomena of organic nature.

This remarkable integration had constituted the hallmark of Oken's work since his lectures in Jena, which comprehensively covered natural philosophy, natural history, zoology, comparative anatomy, and physiology. Oken had obtained a professorship in Jena after concluding his studies in Würzburg (1804–1805) and after a period as *Privatdozent* at the University of Göttingen (1805–1807). His time in Würzburg was dominated by a close relationship with Schelling and his circle. During this period, Schelling had surrounded himself with a group of philosophers, physicians, and naturalists, including Ignaz Döllinger, Karl August Eschenmeyer, Dietrich Goerg Kieser, Heinrich Steffens, Wilhelm Ritter, and Gotthilf Heinrich

---

[65] *Ivi*, 239.

[66] Oken 1847, 45.

[67] Jardine 1996, 241.

Schubert. This group carried out a research program dedicated to organic nature that was founded on analogies between animal classes across the animal kingdom, tracing the development of nature in terms of successive levels of complexity, and it made considerable reference to the notions of polarity and to the organic vital forces (irritability, sensibility, reproduction).[68]

Oken arrived in Würzburg in 1804 to complete the medical studies he had begun in Freiburg. As a student, Oken had already composed the *Übersicht des Grundrisses des Systems der Naturphilosophie* (1802), a short writing strongly inspired by Schelling, in which he laid out his general research program for natural history. In this early work, Oken maintains that the animal classes are nothing other than an index of the sense organs and that they should therefore be arranged accordingly. Thus, strictly speaking, there are only five animal classes: *Dermatozoa*, or Invertebrates, *Glossozoa*, the Fishes, the first animals to appear with a true tongue; *Rhinozoa*, or Reptiles, which first exhibit a nose that opens into the mouth and inhales air; *Otozoa*, or Birds, in which the ear for the first time opens externally; and *Ophthalmazoa*, or Thricozoa, in which all the sense organs are present and complete and the eyes are moveable and covered with two palepebrae, or lids. As we shall see, this idea of classifying animals according to the organ dominant in their organization will remain a constant principle of Oken's natural history, even if this precise schema was partially altered in later elaborations.

In addition to Schelling's lectures, in the fall semester of 1804–1805 the young Oken also attended the lectures of the physiologist Ignaz Döllinger, under whose supervision he conducted research on a classic Wolffian subject: the formation of the intestines in the embryo. This also constituted the topic of the essay he wrote to obtain his professorial qualification in Göttingen, where he was sent by Schelling to study under Blumenbach's patronage. In this essay, *Die Zeugung* (1805), Oken argues that all organic beings originate from and consist of *vesicles* or *cells* and that these vesicles are the infusoria (aquatic organisms at the boundary between the plant and animal kingdoms) from which all larger organisms fashion themselves. This was one of the main topics of Oken's lectures at Göttingen. The Göttingen 1805 *Vorlesungsverzeichnis* reports that Oken lectured on two topics: *Die Lehre von der Zeugung* and *Biologie, gegründed auf den gesamten Organismus der Natur*. The latter was later into a monograph entitled *Abriß der System der Biologie* (1805). As Oken himself acknowledged, behind this *Biologie* was his attempt to formulate a system of comparative physiology of animals, or to elaborate his "theory of the sense" (*Theorie der Sinne*), which was already present in his earlier writings.[69] This theory was to be part of a theoretical framework, grounded upon *Naturphilosophie*, capable of turning natural history into a science by providing a compelling principle of classification – a principle that, in Oken's view, was completely missing from Blumenbach's natural history.

In a letter dated May 1805, Oken reports to Schelling his impressions of Blumenbach's lectures: "Between you and me, in his lectures Blumenbach is, I

[68] Gerabek 2001, 53.

[69] Bach 2001a, b, 81.

don't want to say a charlatan, but a buffoon and a rarities trader (*Raritätenkrämer*)… He hardly speaks about what is important… but [only] about trifles, little details, trivialities, as he himself calls them, he chatters for hours… He lectures on the classification of animals as if it were a mathematical truth that they must be divided just as he has divided them – not a word to justify this classification, or about others. Not a hint as to any improvement." Then again in July Oken claims that Blumenbach is "the worst professor… I have ever heard in my life, and that means a lot."[70] On the other hand, in a passage from *Die Zeugung*, Oken argues that Blumenbach "was the first and only scholar with the courage and spirit to stand against the crude mechanics that... had entered physiology, and was able to cut that mechanics off even if it had taken firm roots everywhere."[71] In fact, a careful reading of Oken's various writings presents us with several shades of gray: his relationship to Blumenbach seems variable, rather than a distinct opposition. In this latter passage, for instance, Oken demonstrates explicit appreciation for Blumenbach's physiology, despite his criticism of the latter's natural history. As I argue in the following section, Oken's scientific project in fact constituted an attempt to provide the scientific foundation for natural history that he thought Blumenbach lacked using the a priori method of *Naturphilosophie*.

6.2 The Animal Kingdom and Human Anatomy: Oken's Classification

A good example of Oken's program for animal classification is found in a short essay contained in the *Beiträge zur vergleichenden Zoologie, Anatomie und Physiologie* titled "Entwicklung der wissenschaftliche Systematik der Tiere" (1806). Here Oken characterizes every animal class according to the exclusive possession of specific organs. Animals are nothing but "natural functions attained to the highest vital degree," and each of these functions "bestows [the animal] with its own form and its proper mode of action."[72] Therefore "all the differences among animals are based on the excessive formation of a system at the expense of the others." Since differences among animals result from the uneven growth of organs, the criterion for classification that Oken proposes consists in individuating the dominating organ of every organism: "if all the difference in animals resides in the inequality of organs, then every classification must be grounded on the same principle."[73] He argues that classificatory systems must highlight the central organ of every animal class.

[70] Quoted in Gerabek 2001, pp. 58–59.

[71] Oken 1805a, 101.

[72] Oken 1806, 103.

[73] *Ivi*, 104.

In Oken's view, whoever endeavors to establish an animal system on the basis of external traits is left with a mere description of the envelope, which leads to mistakes because it does not take into account the essential character of organs. We can achieve an animal classification system only by considering the totality of animal anatomy, i.e. surpassing mere description of the single organs and instead considering their specific functional roles in the whole organism. Oken finds it is necessary to know which organs develop individually in the animal kingdom and become characteristic of each class.

The fundamental organs of Oken's animal kingdom, the organs around which all the others organs are positioned, are the *respiratory*, *digestive*, and *cerebral* systems. These three systems have an identical anatomical basis, the vesicle, which had served as the essential embryological idea in Oken's work since *Die Zeugung.* The pulmonary vesicle is situated in the lowest area of the animal; the stomach vesicle is on top of it, and the brain vesicle on top of both. Together these three vesicles form the principal parts of the body: the thorax, the abdomen and the head – which Oken identifies as the three pillars of animal structure. Accordingly, there are three animal groups, corresponding to the creatures in which the respiratory, digestive, or cerebral system has supremacy over the others. The animal kingdom is thus divided into three kingdoms, placed not beside each other but one above the other: "that of *respiration*, that of *digestion* and that of *cerebral action*; these sub-kingdoms are defined in a clear and precise way, they are so well placed one above the other that it is difficult to suppose another relation among them."[74]

The first animal kingdom, respiration, is inhabited by invertebrate animals; the middle kingdom, digestion, is inhabited by birds, fishes and amphibians, which are more complex than the former; and finally, the superior kingdom, cerebral action, is inhabited by mammals, the most perfect animal organisms. The lower the kingdom, the less developed its organs and the more one dominates all the others. The higher the kingdom, the more developed the organs, since higher animals develop more complex organs than the simple ones displayed by inferior ones.

As an example of Oken's system of classification I report some of his statements concerning the lower classes of the animal kingdom. The kingdom of respiration, for instance, includes three main organs: epidermis, dermis and lungs. Characterized by the respiratory system, it is divided by Oken into three classes, according to the organ dominating each organism: worms (epidermis), insects (skin), and mollusks (lung). Animals characterized by respiration have the most of these organs, and since they are the lowest of the lower kingdom, they are deprived of the organs characterizing mature animals in other classes. The lowest class of this kingdom, worms, is simply confined to a prolonged epidermis produced through an excess of skin; it is the class, "in which all the organs are covered with epidermis: it is the *animal-epidermis.*" On the other hand, "the animal class whose characteristic organ is the dermoid system are the insects."[75] In contrast with worms, insects are animals of the inferior kingdom with a separated epidermic system, which is articulated in

[74] *Ivi*, 107.

[75] *Ivi*, 111.

circles, wings, legs, and abdominal rings: “the epidermic system dominated by the dermis is the insect, the latter is thus the *animal-skin*.”[76] Above them is the mollusk, which is characterized by a respiratory organ: “the mollusk is thus the animal where the epidermis and dermis are dominated by the lung: it is the *animal-lung*.”[77]

The second kingdom, digestion, is also divided into three main organs, i.e. bones, liver, and stomach: “the bone system has become the *bird*, the hepatic system has become the *fish*, the digestive system, the most alive, the most considerable, unfolds under the form of an *amphibian*.”[78] In birds, everything is organized in the service of the bones, even the respiratory function is subordinated to them, thus “they should be called *bone-animals*.”[79] In fishes, everything is displaced to make space for the liver. The liver pushes the heart toward the head and extends from there through the entire trunk of the animal. The whole body is thus formed around the liver, while all the organs that do not harmonize with it are excluded: “they must be called *liver-animals*.”[80] Conversely, the digestive system is the principal organ among amphibians, and, as in the other classes, here the whole body is harmonized around this predominant trait; this class is thus defined as *stomach-animals*.[81] Consequently, the middle-kingdom is also divided into three classes, according to the dominant organ: birds (bone), fish (liver), and amphibians (stomach).

Oken’s analysis of the dominant organs of each animal class concludes with the six inferior classes, because the objective of the paper was not to build an entire system but only to formulate a new classificatory framework, in which every animal class could be subdivided according to differences in how this principal organ organizes the organism. Still, he argues that the third kingdom is marked by the presence of sensory organs. The fundamental difference between the animals of the third kingdom and those of the former two is that the latter are organized around one single organ and must thus be called “animalia monorganica,” which can be distinguished from mammals, which are “animalia panorganica.”

Since in Oken’s system, each animal has an organ system that dominates its life, Oken envisions the entire animal kingdom as one great animal. Each animal class, from infusoria to amphibians and mammals, corresponds to a different organ of the universal organism, which is best represented by human beings, in which every organ is developed to the highest degree of perfection. This analogy is synthesized in the opening statements of the *Abriß des Systems der Biologie*, where Oken declares: “what else is the animal kingdom than the anatomy of humans, the macrozoon of microzoons?” In this sense, humans gather in one individual organism all the organs expressed across the whole animal kingdom.

Another notable aspect of Oken’s comparative anatomy is his vertebrate theory of the skull. In his inaugural lecture at Jena, *Über die Bedeutung der Schädelknochen*

[76] *Ivi*, 112.

[77] *Ivi*, 113.

[78] *Ivi*, 114.

[79] *Ivi*, 116.

[80] *Ivi*, 117.

[81] *Ivi*, 118.

(1807), Oken argues that "the skeleton is just an awakened, branched and repeated vertebra; and the vertebra is the preformed Germ (*Keim*) of the Skeleton."[82] A single generalized vertebra constitutes for Oken the basic unit of animal design (equivalent to Goethe's primal leaf), and a sequence of such units constitutes the *Urtypus* of vertebrates. Carl Gustav Carus later synthesized these ideas of Goethe and Oken in his *Von den Ur-theilen des Knochen- und Schalengerüstes* (1828). There he provided a sketch of the archetype of the vertebrate skeleton and its elementary part, the vertebra. Like Oken, Carus conceives of the latter as the fundamental building block of vertebrate organization: the primitive vertebra (*Urwirbel*) can be multiplied and transformed to form the backbone and the head, ribs, and limbs. This idea, which we have also encountered in the analysis of Goethe, is a fundamental tenet of German transcendental morphology and its portrayal of organic nature as the metamorphosis of one original type that serves as the template of all vertebrate organization.

Oken's *Lehrbuch der Naturphilosophie* brings all his doctrines together, trying to show that the Mineral, Vegetable, and Animal classes cannot be arbitrarily arranged in accordance with single or isolated characteristics but are instead based on cardinal organs or anatomical systems, from which a firmly established number of classes result. In the *Lehrbuch der Naturgeschichte* and in the *Allgemeine Naturgeschichte für alle Stände*, Oken arranges genera and species in accordance with these principles, in attempt to frame a scientific natural history. In his introduction to the last edition of the *Lehrbuch der Naturphilosophie*, he explicitly argues that "natural history is not a closed department of human knowledge, but presupposes numerous other sciences, such as anatomy, physiology, chemistry and physics, with even medicine, geography and history."[83] As I will subsequently argue, this synthetic attitude played an important role in the emergence of German biology, one which implied the unification of several disciplinary matrices into one single discipline concerned with the phenomena of organic nature. The following chapter will show how this synthesis found its most paradigmatic realization in Treviranus' *Biologie, oder Philosophie der lebenden Natur für Naturforscher und Aerzte* (1802–1822).

7 Concluding Remarks

In this chapter, I have considered the reform of natural history promoted by Goethe, Schelling, and Oken in relation to the one proposed by Kant and Blumenbach. In doing so, I have emphasized that the attempt to make sense of their scientific and philosophical projects by means of general categories like "Enlightenment Vitalism" and "Romantic *Naturphilosophie*" can be historically misleading. Certainly a break can be identified between the "Kantian principle for Natural History" advocated by Girtanner and the approach to animal classification developed in Goethe's

[82] Oken 1807, 5.

[83] Oken 1847, xvi.

morphology, Schelling's philosophy of nature, or Oken's transcendental anatomy. An accurate reading of the sources shows that these thinkers saw themselves working to complete a project that Kant and Blumenbach had begun but left unfinished. Notably, the Kantian idea of an "archeology of nature," outlined in § 80 of the *Critique of the Power of Judgment* but later stigmatized as a "daring adventure of reason," constituted the point of departure for Goethe's quest for a universal type as the ground for a new approach to animal classification. Schelling also worked toward a systematic development of some key notions of Kant's third *Critique*, but his attention was especially focused on the assessment of teleology. In particular, he strove to overcome the Kantian construal of teleology as a regulative principle, and moved towards an interpretation of purposiveness as (the most) constitutive feature of organic nature, which in his view had only partially been laid out in Blumenbach's notion of *Bildungstrieb*. Accordingly, Schelling considered organic nature to be characterized by an ascending sequence of functions, which were different manifestations of the same vital principle. He referred to Kielmeyer, one of Blumenbach's most distinguished students, as the founder of this idea and thus saw him as initiating a "new era of natural history." Oken also aimed to lay a scientific foundation for natural history, which in his view had to be provided by *Naturphilosophie*. This project implied for Oken the synthesis of different fields such as anatomy, physiology, chemistry, and physics, with medicine, geography and history. It constituted a unified inquiry concerned with a scientific treatment of the laws of vital organization in organic nature as a whole. In his *Abriß der System der Biologie*, Oken argued that "biology is actually only the natural philosophy of organized bodies, but since the organic world is quite the image of the inorganic, the fundamental functions and fundamental matters must be enumerated and sorted, so that we can identify the viscera (*Eingeweide*) of the organic already in the inorganic world."[84] This fact compelled him not "to start directly at the origin of the organic world, but rather to go back to the first stirring (*Regung*) of the universe, and to let the whole nature emerge gradually (*stufenweise*) from there."[85] This quote emphasizes precisely how the method of a priori deduction, which then as now was the main target of criticism, resulted from a need for systematic unity. Drawing on Schelling, Oken believed that a form of "transcendental deduction" could be applied to nature to rationally connect all the different aspects of natural science into one all-encompassing theoretical framework. This striving for systematic unity allowed Oken to connect different disciplinary matrices concerned with the phenomenon of life – i.e. the theory of generation, physiology, and natural history – with the idea of a unified life science, i.e. biology. Though with less emphasis on a priori deduction, Treviranus' *Biologie*, which I take into account in the next chapter, made a very similar call.

[84] Oken 1805b, ix.

[85] *Ivi*, x.

Biology: Treviranus and the Life Sciences as a Unified Field

1 Introduction and Outline: A New Scene of Inquiry

The term “biology” has traditionally been traced back to Jean-Baptiste Lamarck (1744–1829) and Gottfried Reinhold Treviranus (1776–1837), who first used it in significant way in 1802, in the *Recherches sur l’organisation des corps vivants* and the *Biologie, oder Philosophie der lebenden Natur für Naturforscher und Aerzte* respectively. Other authors have been discovered to have used the term *en passant* slightly earlier: Georg August Roose, in the *Lehre von der Grundzüge Lebenskraft* (1797), and Karl Friedrich Burdach, who in his *Propädeutik zum Studium der gesamnten Heilkunst* (1800) defined “biology” as the sum of knowledge about living phenomena (morphology, physiology, psychology). As scholars have recently stressed, the word itself was used to mean “biography” even earlier, meaning we may have to move the date of the first use of the term another 30 years earlier.[1] For instance, from 1762 to 1768, Michael Christoph Hanov, a minor disciple of Christian Wolff, published a four-volume Latin compendium entitled *Philosophia naturalis sive physica dogmatica*, whose third volume (1766) bore the subtitle: *Geology, Biology, General Phytology and Dendrology, or the Science of the Earth, of Living Things and of Vegetating Things in General, as well as of Trees*. However, if one discounts the running heads, Hanov does not use the word “biology” in the text of the volume itself. The term rather seems to have been an afterthought, since it can otherwise be found only in the book’s front matter (title, preface, conspectus). Moreover, in terms of meaning, biology seems to be just one among other disciplines like phytology and zoology. There is thus no historical evidence that Hanov’s use of “biology” is the source of a tradition nor that it had any influence on later uses of the term. Such an influence, though possible, seems unlikely since the word plays no role in the content of Hanov’s own philosophy. Other, more minor Wolffians could also be taken into account, but “none of this really affects the more important

[1] McLaughlin 2004.

A. Gambarotto, *Vital Forces, Teleology and Organization*, History, Philosophy and Theory of the Life Sciences 21, DOI 10.1007/978-3-319-65415-7_4

question of the mechanisms of the historical development and institutionalization of the life sciences in the nineteenth century."[2]

The grand baptism of the concept of biology is thus still generally located in 1802 when Treviranus and Lamarck first used it. Yet if a lot has been said about Lamarck's contributions to the development of biology,[3] much less has been said about the other pioneering endeavor on the part of Treviranus,[4] who endorsed the idea of a unified science of life with stronger arguments. The reasons for this silence are at least twofold. The first is almost certainly the magnitude of Treviranus' opus: a nine-book treatise divided into six volumes (each around five hundred pages) poses an obvious challenge to scholarly work. Secondly, the over three thousand pages that compose this work are filled with references to countless eighteenth-century scientific texts, and, even more importantly, are written in a language that can be properly understood only with solid knowledge of the jargon employed by the German life sciences in the second half of the eighteenth century.

I will offer an analysis of the relevant sections of Treviranus' work, but first it is useful to sketch the overall division of the opus. As mentioned above, the *Biologie* is composed of nine books, divided in six volumes: (1) The first volume (1802) entails a long introduction, where Treviranus defines the fundamental concepts and theoretical framework of biology as a new scientific field. This first book, which he refers to as a "history of physical life" (*Geschichte des physischen Leben*), is dedicated to the general "classification of living organisms." (2) The second volume (1803) contains the second book on the "organization of living nature," wherein Treviranus provides a detailed account of the distribution of living bodies in different areas of the earth, depending on different environmental conditions. (3) The third volume (1805) contains the third and the fourth books on the history of physical life: the former is concerned with revolutions that occurred in living nature over time, while the latter is dedicated to exposition of Treviranus' theory on "generation, growth and decrease of living bodies". (4) The fourth volume (1814) is occupied by the fifth book and is concerned with the formulation of a general theory of nourishment. (5) The fifth (1818) is concerned with physiological issues and is comprised of three books (the sixth, seventh, and eighth), respectively dedicated to "warmth, light, and electricity of living bodies," the "automatic movement of living bodies," and the "functioning of the nervous system." (6) The sixth (1822) and final book is dedicated to the "connection of the physical with the intellectual world," and provides an outline of brain physiology in the animal kingdom.

Goffried Reinhold Treviranus (1776–1837) did not have a brilliant academic career. Coming from a humble family, he was led to the study of medicine chiefly by financial considerations. He began his studies at Göttingen in 1793, where he also attended lectures on mathematics and natural science. After obtaining his doctoral degree under Blumenbach's supervision, he moved to Bremen, where he spent almost his entire life teaching in a local gymnasium while carrying out his medical

[2] *Ivi*, 4.

[3] Barsanti 1979; Corsi 1988; Laurent 2001; Corsi et al. 2006.

[4] DeJager 1991; Steigerwald 2014.

practice. In his lifetime, Treviranus composed two main works, the six-volume *Biologie, oder Philosophie der lebenden Natur für Naturforscher und Aerzte* (1802–1822), and the two-volume *Die Erscheinungen und Gesetze der organischen Leben* (1831–1832).

Treviranus' work provides probably the best example of the general conceptual framework elaborated by the Göttingen naturalists and developed by *Naturphilosphie*. In this respect, to characterize the *Biologie* as ground-breaking research would probably be an overstatement. Nevertheless, two aspects need to be stressed. First, that despite its synthesizing nature, this massive collection of material is the end result of a conceptual course that began with the endeavor to provide an adequate account – and a corresponding explanatory framework, endowed with its own laws – of the way living nature organizes itself. This is a path of inquiry with origins in Wolff's account of epigenetic development that culminated in the idea, explicit in Schelling, of nature as "universal organism," i.e. as a self-organizing system. According to Schelling, nature organizes itself as a hierarchy of levels, each more complex and perfect than the previous ones, culminating in humans with the appearance of higher mental faculties like spirit. However, in his writings on philosophy of nature from the late eighteenth century, Schelling does not seem to understand this organization as the result of a historical process. The second, and most important, aspect of the *Biologie* that needs to be stressed is that Treviranus understood this self-organizing process as something historical, i.e. as a gradual historical development. This idea is introduced in the third book of the *Biologie* (in the first section of the third volume), which, for this reason, is the most relevant section of Treviranus' work.

In this chapter, I provide a thorough analysis of Treviranus' *Biologie* and later works. The aim of this analysis is to show how Treviranus succeeded in pulling the theories of earlier German scholars together into one treatment of the life sciences as a unitary field. My analysis unfolds as follows: in Sect. 2 I take into account the introduction of the *Biologie*, in which Treviranus lays the groundwork for the new science of biology, whose core is the distinction between mechanical force and vital force. I underscore Treviranus' definition of vital force as the ability of organic nature to maintain relatively uniform reactions, as opposed to variable responses to environmental conditions. In Sect. 3 I reconstruct the role played by the conceptual framework of epigenesis for the genesis of Treviranus' idea of biology. The conceptual framework of epigenesis as it was laid out by Wolff and Blumenbach gravitates around self-organization, which is considered the essential character of living beings. Kielmeyer was the first to apply this idea to organic nature as a whole, which he saw as capable of organizing itself according to purposes. He therefore majorly transformed the aim and scope of natural history, turning it into comparative physiology, i.e. analysis of the distribution of different vital forces in the animal kingdom. As I have stresses in the previous chapter, Schelling saw Kielmeyer's project as the beginning of a new era of natural history and, along with Oken, capitalized on this idea by turning it into a concrete program to reform animal classification, based on the idea of nature as a universal organism. In Sect. 4 I consider the role *Naturphilosophie* played in the conceptual framework of Treviranus' *Biologie*, especially with regard to the idea of nature as a system of degrees, articulated as a hierarchy of levels from the most simple to the most complex. Section 5 stresses the most innovative aspects of Treviranus' *Biologie*, namely his ecological approach, which emphasizes the relation between organism and environment, and his transformist position, which is based on a remarkable use of the fossil record. Finally, in Sect. 6 I consider Treviranus' *Erscheinungen und Gesetze der organischen Leben* (1831–1832), where he reinforced the idea that the notion of a general biology is bound to an interpretation of teleology as the distinguishing character of organic nature.

2 Life and Vital Force

Treviranus opens the first volume of the *Biologie* by stating that mere possession of a large quantity of data is useless per se, if not employed for a higher explanatory goal. True science must be based on fundamental principles and deduce all its propositions from them, if it wants to form an organic whole. Treviranus argues that the final goal of every natural science is the inquiry into the forces through which "the great organism that we call nature" is preserved in its eternal activity. In terms of accomplishing this goal, previous classificatory systems were not even a first step. These predecessors had provided a mere catalog, not a natural science. In fact, a work capable of connecting the scattered facts lying in the writings of natural scientists would have to aim to offer more than just descriptions of new animals and plants.[5]

These statements should be read in view of the complex semantics of the notion of "science" in the context of classical German philosophy, and particularly its convergence with the idea of "system." *In the Architectonic of Pure Reason*, Kant claims for instance that "systematic unity is that which first makes ordinary cognition into a science, i.e. makes a system out of a mere aggregate of it." In fact, true knowledge cannot "constitute a rhapsody but must constitute a system, in which alone they can support and advance its essential ends. I understand by a system, however, the unity of the manifold cognitions under one idea. This is the rational concept of the form of a whole." This whole "is *articulated* (*articulatio*) and not *heaped together* (*coacervatio*); it can, to be sure, grow *internally* (*per intus susceptionem*) but not *externally* (*per appositionem*), like an animal body, whose growth does not add a limb but rather makes each limb stronger and fitter for its end without any alteration of proportion."[6]

In the last decade of eighteenth century, this idea had been fully developed at the University of Jena, first in Fichte's *Grundlage der gesamten Wissenschaftslehre* (1794/1795) and then by Schelling, especially in the *Erster Entwurf eines System der Naturphilosophie* (1799) and the *System der tranzendentalen Idealismus* (1800). Both thinkers called for a scientific methodology characterized by systematic unity

[5] Treviranus 1802, V–VI.

[6] Kant 1968, Ak. III: 691.

and transcendental deduction. For Fichte, scientific method involved the assumption of a first *principle* (*Grundsatz*). Once this principle has been established, a comprehensive account of the system would require the content of science to be deduced as a consequence of that same principle. In his opening remarks, Treviranus argues in continuity with Kant, criticizing the systems of natural history circulating in his time of being mere aggregates of data and claiming that science should deduce its content from a principle of unity. Throughout the introduction, he refers especially to Kant's *Metaphysische Anfangsgründe der Naturwissenschaft* (1786) in order to provide the foundations of biology as a science.

Treviranus contends that while inorganic nature had long been the object of a particular science that goes by the name of "physics," organic nature had thus far been neglected. Only small parts of it were tackled, as objects of episodic research, by sciences such as medicine and natural history. He thus argues that a theory of living nature should be taken more seriously and raised to the rank of a proper science. Accordingly, "the objects of our natural researches will be the different forms and phenomena of life, the conditions and laws under which it takes place, and the causes by which it is produced. We will call the science that deals with these objects with the name of *biology* or *theory of life*."[7] Since these topics had historically only been treated by natural history and medicine, Treviranus intended to gather the knowledge learned in these fields into a general biology that could isolate unitary principles and connect various data in a systematic way. Understanding of living nature, at that time the purview of natural history and medicine, required turning an aggregate of knowledge into a systematic science grounded on fundamental principles. In the case of biology, that principle was the definition of life, which, in Treviranus' view, constituted the most important brick in the architecture of the new biological science.

To substantiate his definition Treviranus refers to the definition of matter provided by Kant in the *Metaphysische Anfangsgründe der Naturwissenchaft* (1786), where matter is defined by a peculiar attractive and repulsive force. For Treviranus, this implies that no part of the universe undergoes change without influencing every other part of the universe. In this sense, "every single force in this immense swarm [...] is for the sake of all the others, and all others are for the sake of it. Every single one is simultaneously cause and effect, means and purpose, and the whole an endless organism (*gränzanloser Organismus*)."[8] These claims have a manifest Schellingian, rather than Kantian, flavor to them, and in fact Treviranus refers here to the *Ideen zu einer Philosophie der Natur* (1797). Yet in these pages he also criticizes Schelling for his "hyperphysical hypothesis" of a "world soul"[9] that serves as the explanatory ground for the ongoing activity of the universe.

This criticism should be put in context. A few pages before, in fact, Treviranus addresses the work of Alexander von Humboldt – his senior at Göttingen and a student of Blumenbach – whose definition of the vital force he considers "even

[7] Treviranus 1802, 4.

[8] *Ivi*, 34.

[9] *Ivi*, 33.

more useless" than that provided by Stahl.[10] Shortly afterwards, he criticizes Kant for his mechanistic conception of matter[11] and explicitly agrees with Schelling that the reduction of fundamental forces to "attraction" and "repulsion" makes it impossible to explain the "specific qualities and forms" of living nature.[12] In this sense, though Treviranus criticizes Schelling's assumption of a world-soul, he adopts an overall organicist framework considerably indebted to *Naturphilosophie*.

Treviranus' most evident debt to the Schellingian framework is his idea of nature as a universal organism. At the same time, Treviranus defines physical life as "*a state produced and maintained by accidental effects, but which in spite of this contingency, maintains uniform manifestation*."[13] Indeed, he argues that every living body grows, reproduces, and carries out its vital functions in different environmental conditions: this is the distinctive character of life. But if nature is a universal organism in which the change of any part necessarily influences all the others, how is it possible for living bodies to respond uniformly to variable external forces? For Treviranus, the only possible answer is the existence of a force inherent only to living bodies that allows them to adapt to the changing influences of the environment. This force, by means of which living organisms maintain relative uniformity, cannot be the same as the fundamental forces active in inert matter, and he thus refers to it as the "vital force."[14] Here Treviranus looks again to Schelling's *Erster Entwurf eines Systems der Naturphilosophie* (1798) and to his critique of Kant, for whom the only two forces in nature were the attractive and repulsive forces of matter. In fact, since living bodies react uniformly to the effects of the external environment, they must be endowed with a special force that is absent in inert matter. Therefore, a single attractive and repulsive force is not enough to explain all of the properties of matter. Two fundamental forces are necessary, namely the *repulsive force* and the *vital force*, to account for the phenomena of both organic and inorganic nature.

We could probably translate Treviranus' definition of life as the later notion of "homeostasis," the idea of a system in which a variable (such as body temperature) is actively regulated to remain nearly constant. According to Treviranus, this function was performed by a vital force inherent to organic matter. In order for this homeostasis to be possible, we have to assume that: (1) every part of a living body must be at the same time the "means and purpose for the whole"[15] (the reference here is undoubtedly to Kant). (2) Since the vital force constitutes a boundary between the living body and the rest of nature, which we do not find in lifeless bodies, then it must bear the characteristics of organization: in living organisms the arrangement of parts is determined in the most precise way and never left to chance. (3) Since the purpose of both the living organism in general and its parts differ from inert matter, the organization of the former must be distinctive from the latter. (4)

[10] *Ivi*, 19.
[11] *Ivi*, 27, 30.
[12] *Ivi*, 54.
[13] *Ivi*, 23.
[14] Treviranus 1802, 52.
[15] *Ivi*, 58.

Organized beings have a far clearer relation between means and ends, and they also behave more uniformly under different conditions. According to this logic, if we define the relations among the different parts of inert bodies in physical terms as "actions," we need to distinguish them from the relations among the parts of a living organism, which are better defined as "functions."[16]

Based on these premises, Treviranus underscores another fundamental characteristic of living beings, namely "irritability" (*Reizbarkeit*) or "excitability" (*Erregbarkeit*)": the "ability (*Vermögen*) to receive external impressions and to react against them as the distinguishing characteristic of living bodies."[17] More precisely, irritability is defined as "the capacity to perceive effects of the external world in a way that their relative force, in spite of their absolute difference, remains unchanged."[18] For Treviranus this uniformity of reaction is the measure of irritability: the higher the degree of irritability, the more uniform the reaction. In cases of a high degree of irritability, a low degree of susceptibility (*Empfänglichkeit*) to the influences of the external world will take place, and vice versa: high susceptibility corresponds with low irritability.

According to Treviranus we thus must assume that: (1) a disturbance emerging from the reaction of a single part of the living individual to the external world will be stopped by the remaining parts; (2) the number of random external events against which the living organism can act uniformly has a limit, and the overstepping of this limit causes the destruction of the organism itself; (3) the whole kingdom of living organisms constitutes a part of the universal organism (*allgemeinen Organismus*), and every individual contributes its preservation.[19]

In this picture, the variety of living forms is grounded in the different types of organization displayed by the various parts of nature's universal organism. Differences among types consist in two elements: the different "vital degree" (*Grad des Lebens*), or resistance to external effects, and the different "receptivity to the effects of the external world."[20] No matter how high the degree of vital force displayed by a life form, it always has a limit beyond which its organization will fall apart. Dissolution of organization implies the living organism's transition to lifeless nature, i.e. death. The death of one organism would cause a disturbance in the universal natural organism, if this loss were not balanced by the appearance of another individual. For this reason, Treviranus maintains that a living organism has not fulfilled its aim until it has been in a condition to reproduce its species.

In the following sections I reconstruct the main arguments that, based on these premises, Treviranus presents in volumes two through six of his *Biologie*. As I mentioned above, in doing so my goal is to emphasize that the idea of organization behind Treviranus' biology implies an understanding of nature as a universal organism that functions according to purposes, the main one being its own self-preservation.

---

[16] *Ibidem*.

[17] Treviranus 1802, 61.

[18] *Ivi*, 62.

[19] *Ivi*, 64–68.

[20] *Ivi*, 69.

This purposiveness is not the result of conscious design, but rather a form of teleology without intention, which Treviranus considers as the general hallmark of life.

3 Nature as an Organism

In this section I stress the importance of epigenesis as a conceptual model for Treviranus' understanding of self-organization. As we have seen earlier in this book (Generation: The Debate on the Formative Force and the Question of Ontogenesis, Sect. 3) this idea of self-organization was addressed philosophically for the first time in Kant's *Critique of the Power of Judgment* (1790). If we look at the scientific backdrop to Kant's *Critique of Teleological Judgment*, namely Caspar Wolff's *Theoria generationis* (1759) or Blumenbach's *Bildungstrieb* paper (1781), the prevailing idea was that there exists a self-organizing process that turns amorphous substance into an adult organism, not an etero-organized "evolution" of the organism, as was upheld by preformationists (Generation: The Debate on the Formative Force and the Question of Ontogenesis, Sects. 1 and 2). As we have seen (Functions: The Göttingen School and the Physiology of Vital Forces, Sect. 4), Kielmyer applied this idea to the domain of natural history, shifting focus from the distribution of vital forces in an organism, seen as a result of individual ontogenesis, to the harmonic distribution of vital forces in the animal kingdom, framed as a result of the law of compensation. Here I reconstruct the role played by this tradition in Treviranus' *Biologie*. This reconstruction reveals a consistent lack of originality on the part of Treviranus, who took up the ideas of Wolff, Blumenbach and Kielmeyer relatively straightforwardly, but emphasizes the crucial role of epigenesis in the genesis of his idea of biology.

Treviranus addresses the phenomena of generation, growth, and reproduction of living bodies in the second half of the third volume of the *Biologie* (1805). He starts from the following question: "how is every living individual produced, how does it develop, change and eventually disappear from living nature?"[21] His analysis begins with consideration of the "germs" (*Keime*) from which living organisms are formed. In particular, Treviranus strove to define the laws governing how those germs are formed, grow, and then progressively return to lower levels of vitality; this is part of his attempt to account for the material and formal conditions of generation in living individuals.

Treviranus' notion of germs is the same one used by Kant in the race writings, but unlike Kant, Treviranus interprets the notion in strictly epigenetic terms. According to Treviranus, in fact, every living body emerges from a liquid (the female semen), and the first expressions of life become visible only when this liquid has been transformed into a solid body and becomes a germ. Treviranus identifies two kinds of germs as material conditions of generation: those that belong to the seed corn and the egg (*das Saamencorn und das Ey*) and those that belong to the

[21] Treviranus 1805, 299.

shoot and the bud (*die Sprosse und die Knospe*). The seed corn is the original germ for plants; the egg is the original germ for animals. For Treviranus these constitute the material conditions of development and are the organic structures that make generation and growth possible in the first place.

The formal conditions of generation instead consist in the environment in which the germ itself develops. The development of the shoot and the bud depend on substances and forces that lie outside of them and are mainly found in the mother. Treviranus describes the various stages of plant development as follows: "the first beginning of organization of living beings is an aggregate of vesicles that have no connection whatsoever to one another. From these originate the living body, in which all of them are dissolved."[22] Indeed, Treviranus distinguishes three main categories of animal generation: living bodies whose female egg requires the effect of male seed for its development; those whose female seeds develop by themselves; and those that can reproduce in both ways.[23] He uses this division, which was proposed by Blumenbach in the *Handbuch der Naturgeschichte* (1779), to classify three animal classes based on how organisms are formed: (1) The first class includes mammals, birds, amphibians, fishes, several mollusks, crustaceans, and insects; in this class, if not impregnated by the male, the female egg dies without developing. (2) The second class is populated by organisms among which it is impossible to observe sexual difference, which leads to the assumption that they lack sex organs; this class includes polyps, whose generation results from an outgrowth of external cells that produce the young polyp, as well as infusoria, worms, plant-animals (*Tierpflanzen*) (like mushrooms), and seaweed. (3) The third class consists of organisms that reproduce by means of partenogenesis, like the lumbricus, earthworms, and aphids.

Treviranus argues that "every lifeless body grows as long as the source of its formative substance does not dry out, but to every living body is ascribed a limit that it can never exceed, if the nutritive material always flows into it in the same quantity"[24] For example, if provided with infinite nutrition, the Diana's tree or other metallic vegetation grow without limitations, while living organisms do not, because their growth simultaneously affects the body as a whole instead of just its individual parts; this kind of growth marks a fundamental difference between organic and inorganic bodies.[25]

In chapter "Generation: The Debate Over the Formative Force and the Question of Ontogenesis", I have emphasized how the phenomena of generation and growth of living beings caused many philosophers and naturalists of the mid-eighteenth century to question standard beliefs on the nature of life. In particular, I have reported the famous experiment conducted by Abraham Trembley on the remarkable regenerative features displayed by the green hydra, whose results were published in 1744 (Generation: The Debate on the Formative Force and the Question of

[22] *Ivi*, 233.

[23] *Ivi*, 254.

[24] *Ivi*, 464.

[25] *Ivi*, 465.

Ontogenesis, Sect. 1). Once cut in two, the animal was able to generate two whole organisms from the separated parts. The echo of this experiment was still present, more than half a century later, in the third volume of Treviranus' biology (1805). In fact, Treviranus argues, the wonders of the polyps have been "so famous since Trembley's time, that it is almost superfluous to mention them, even the smallest part of this plant-animal develops itself in a full hydra, and this does not happen only for small special pieces, but even if one cuts it lengthwise. If cut in six, seven or even more parts, but in a way that the inferior end remain united, a new hydra will rise with just as much heads. If one cuts these heads as well, new ones grow in their stead and the separated polyps grow to just as much new ones."[26] This kind of reference to the unique features of the polyp is quite frequent among the Göttingen naturalists. The case of Blumenbach is paradigmatic: he opened his essay on the *Bildungstrieb* with reference to an experience involving Trembley's famous animal. Indeed, reference to the polyp indexes the crucial role of epigenesis for these authors. As I argued in chapter "Generation: The Debate Over the Formative Force and the Question of Ontogenesis," Trembley's polyp became for them the symbol of the formative force inherent to organic nature. This idea was expressed in philosophically cogent terms for the first time in Kant's framing of organized beings as natural purposes.

In Functions: The Göttingen School and the Physiology of Vital Forces (Sect. 4), I argued that Kielmeyer was the first to apply an idea of self-organization, based on the model of epigenesis, to the animal kingdom as a whole, which came to be considered a natural purpose itself. In this respect, he transplanted the Kantian idea of natural purpose from its context of individual ontogenesis to the animal kingdom as a whole. Likewise, in the third volume of his *Biologie* (1805), Treviranus argues that organic nature is itself a whole living organism: "the living individual is dependent from the kind, the kind from the species, this from the whole living nature, and the latter from the organism of earth. The individual indeed possesses a proper life and constitutes, in this respect, its own world. But precisely because its life is limited, it also constitutes an organ of the universal organism."[27] Here Treviranus again employs Schelling's vocabulary to develop Kielmeyer's program for a general biology. Accordingly, he is not concerned with the reproductive faculty of the single organism but rather with individuating the relation among the reproductive faculties of different species.

Treviranus explains this relation among reproductive faculties using Kielmeyer's law of compensation. He identifies a quantitative difference in the degree of vitality expressed by different living organisms, so that "the higher an organism is with regard to one function, the lower it must be with regard to the others. If this was not the case, a gradation would take place among living bodies such that, in this respect, some of them would stand on higher levels of life than the rest, so that these would soon be repressed and would remain just one living individual."[28] In other words, the distribution of vital functions in the animal kingdom must be balanced, otherwise

[26] *Ivi*, 519.

[27] *Ivi*, 552.

[28] *Ivi*, 553.

the plurality of life forms would be destroyed. Therefore, Treviranus concludes, "the greater are the effects that every individual of a kind has on the external world, the bigger the modification it can produce in the organization of the rest of nature, the more limited must be its reproductive faculties. But the influence of an organism on the external world is greater and more versatile, the more formed and manifold are its organs and this plurality increases in an uninterrupted series from the most simple zoophytes to humans. Hence the zoophytes are the most fertile while mammals, and especially man, the less fertile among living bodies." This passage is essentially a quote from Kielmeyer's *Rede*, which accounted for the general variety of animal forms through a differential distribution of vital forces among the animal classes that ultimately safeguards the equilibrium of the animal kingdom as a whole.[29] In fact, if all bodies were endowed with the same degree of reproductive faculties, species lower in the series of organizations would face extinction.

In this way, while Treviranus' empirical description of the phenomena of generation aligns with that of Wolff and Blumenbach, his treatment of nature as an all-encompassing, self-regulating organism is in conversation with the laws of compensation formulated by Kielmeyer. We have already seen that this idea was developed by Schelling and Oken into a program to reform animal classification. In the next section, I assess the role played by the theories of Romantic *Naturphilosophie* in Treviranus' biological framework. I focus especially on the idea of nature as a hierarchy of levels, i.e. as a system of stages that move from the simplest to the most complex animal forms culminating in the spiritual faculties of human beings.

4 The Levels of the Organic

In the previous section I considered the role played by the epigenetic framework in Treviranus' understanding of nature as a universal organism. In this section, I turn to the role played by Romantic *Naturphilosophie* in Treviranus' understanding of nature as a system of stages, i.e. a hierarchy of levels characterized by increasing organizational complexity.

The first element important to this account is the relationship between mechanism and teleology, which Treviranus discusses in some passages of volume four of the *Biologie* (1814). I have already reconstructed Kant's arguments in the *Critique of the Power of Judgment* about the problem of whether the specific form of a living being can be considered as organized according to specific purposes (Generation: The Debate on the Formative Force and the Question of Ontogenesis, Sect. 3). In many ways, the form of a bird, especially its bone structure and the position of its wings, suggests a positive answer to that question, because they seem intended for flight. Kant, however, finds this interpretation tantamount to conceiving of nature in technical terms, i.e. as the product of a maker, because "nature, considered as a mere mechanism, could have formed itself in a thousand different ways without hitting

[29] *Ivi*, 554–555.

precisely upon the unity in accordance to such a rule".[30] This opposition between mechanism and teleology is at the heart of Kant's so-called antinomy of teleological judgment: on the one hand, "all generation of material things is possible in accordance with merely mechanical laws," while on the other hand, "some generation of such things is not possible in accordance with merely mechanical laws."[31] As I have shown in Generation: The Debate on the Formative Force and the Question of Ontogenesis (Sect. 3), the Kantian solution to this dilemma is the introduction of a distinction between "determinant" and "reflective" judgment. The former refers to a constitutive property of the object in question, the latter to the way in which our cognitive faculty makes sense of things. According to Kant, we must consider living organisms *as if* they were the products of intentionally acting causes, while nonetheless dealing with them within a mechanistic explanatory framework. How Kant resolves this antinomy is controversial. In § 77 of the third *Critique*, for example, Kant's solution is to claim that both mechanism and teleology are merely regulative, rather than constitutive – or, in other words, to claim that both mechanism and teleology arise from the unique nature of human cognitive faculties.

Schelling was the first to explicitly challenge this view. In the *Erster Entwurf eines System der Naturphilosophie* (1799), he defines mechanism, chemical affinity and teleology as different "potencies" (*Potenzen*) that characterize different levels of the natural system. At lower levels, elementary compounds are extrinsic from one another and interact only through mechanical relations; at higher levels, magnetism and chemical affinity testify to the existence of other intrinsic interactions, whose character is determined by the relation among the terms in play. According to Schelling, the realm of living organisms is holistic, as the whole thoroughly determines the structure and function of single parts. This framework was also utlined in the *Objectivität* section of Hegel's *Science of Logic* (1816), which is explicitly divided into three parts entitled "mechanism," "chemism," and "teleology." The idea behind this schema is that the teleological features manifested by living organisms are not merely inherent to our faculty of judgment, as Kant claimed, but a constitutive property of their structure.

Treviranus makes similar claims in the fourth volume of the *Biologie* (1814), which is entirely dedicated the physiology of living bodies. Here Treviranus argues for a shift from a mechanical to a teleological understanding of organisms. He argues that, "in an organism every part lives for the whole, and the whole for every part." In a plant, "the roots supply nourishment to the stems and every single leaf absorbs on the other hand not only for itself but for the whole plant."[32] In this sense, the organism acts with the specific purpose of maintaining the general structure and overall organization of the living body.

Previously, "since mechanical principles still dominated, one assumed the process of organic generation and preservation to be completely different from the secretion of fluids, and thus looked for different explanatory grounds. But both

[30] Kant 1968, Ak, 5, 360 (234).

[31] *Ivi*, 387 (259)

[32] Treviranus 1814, 47.

phenomena are essentially the same."[33] Generation and preservation in living organisms result not just from "the form and mixture of solid parts." Rather, "the same force producing organs causes also their maintenance and the secretion taking place in them," although "after the formation of the organs the original formative force (*Bildungskraft*) ceases" and "only in the reproduction of amphibians, fishes, worms and zoophytes etc. whole parts can be replaced." Like many others before him, Treviranus considers the formative force to be the most distinguishing character of living organisms. His goal is thus to understand "the right concept of the essence of the formative force."[34] Indeed, at the time he was writing, the concept of life was so obscure "that one considered this state as the result either of unconditioned or of conditioned effects. The former is the idea of Van Helmont and Stahl, the latter can be found in the most systems of biology from Haller's time, especially in Brown."[35] As Treviranus points out, Jean-Baptiste Van Helmont and Georg Stahl had claimed that life cannot be reduced to mere mechanism and defended an animist position. They assumed the soul to be entirely non-physical, while on the other hand, most physiologists endeavored to reduce the phenomenon of life to mere mechanical causes. Treviranus instead maintains that teleology must be envisioned as the truth of mechanism: in other words, as an explanatory principle necessary to explain organic nature – a realm characterized by higher organizational complexity than the physical world. If the principle of mechanism could be employed to account for physical phenomena, such as the movement of inert bodies, biological entities should also be considered according to the principle of purposiveness, i.e. their functions should be understood as serving specific purposes.

Treviranus argues that life is "the product of the interaction between excitable substances and the external exciting powers," and it is vain to look for an explanation if we do not assume that its emergence "is grounded on a principle to which must be ascribe a certain degree of independence from external influences, of self-determination to effectiveness, an analogous of spontaneity."[36] This principle is relevant to the procreation of species, which was hard for most biological systems to explain. The unexplainable aspect lies in the fact that this phenomenon displays teleological features that appear irreducible to mere mechanism. Plants vegetating under unfavorable conditions quickly produce flowers and fruits before they pass away, so that healthy progeny can germinate. Vegetation acts as if it were the product of a spiritual principle: "precisely this similarity between the action of a spiritual being and the effects of the vital principle points to some kind of spontaneity."[37]

Even in so-called "monsters," body parts are "purposefully organized only as much as the degree of external deformity allows, in all of them is expressed a tendency of the formative drive (*Bildungstrieb*) to produce a possibly complete organism also under unfavorable conditions." These phenomena involve ontogenesis as

[33] *Ivi*, 624.
[34] *Ivi*, 625.
[35] *Ivi*, 626.
[36] *Ibidem*.
[37] *Ivi*, 627.

much as "the formative levels (*Bildungsstufen*) climbed by living nature as a whole."[38] Like Blumenbach, Treviranus considers monsters a manifestation of the purposive features of organic nature. In fact, only a body inherently characterized by an unusual rule of internal cohesion, i.e. by an unusual form of organization, can be called monstrous. He thereby understands monstrosity as a deviation from the intrinsic goal of organic bodies: normal organization.

Treviranus explains that each animal species, like an individual animal, has its periods of formation, bloom and death: "the whole as the single is in a state of eternal transformation."[39] He maintains that these transformations cannot be reduced to mere modifications of the effect exerted by cosmic influences and must instead be grounded in the laws that regulate life: "the vital force (*Lebenskraft*) of every individual, inasmuch it expresses itself as formative force (*Bildungskraft*) is the outflow of a common fundamental force (*Grundkraft*) that, as the light broken with a prism, splits itself into countless rays and produces the plurality of kinds and individuals of the kingdom of living organisms."[40] This idea that all vital forces are branches of the same fundamental force and that this fundamental force is in fact a general excitability of the organism related to its external environment is strikingly convergent with Schelling's *Naturphilosophie*. Indeed, in the *Erster Entwurf* general excitability was considered the general principle from which all other forces could be deduced. Formative drive, irritability and sensibility were conceived of as further determinations of this fundamental force.

In the fourth volume of the *Biologie* (1814), Treviranus continues to follow Schelling by maintaining that the vital principle (*Lebesprinzip*) of every organism depends on a communal fundamental force (*Grungkraft*). Thus "every living being takes part in the modification of the original source of life and thus living nature displays phenomena whose cause lies much higher than the effect of mechanical or chemical powers."[41] Like Schelling, Treviranus envisions teleology as the result of a level of organization higher than mechanism or chemical affinity. Accordingly, the formative principle (*Bildungsprinzip*) of living bodies is ascribed a certain degree of independence from external influences. Treviranus maintains that this independence and the spontaneity that results from it had previously been defined differently. Perspicacious thinkers assumed a purposeful principle independent from external stimuli to be the origin of life, such as Blumenbach's *Bildungstrieb* or Schelling's world-soul (*Weltseele*).

The assumption of such a principle was necessary because chemical principles can only explain the elements of which living bodies are composed. One can also investigate "all the traces of electricity, magnetism and all further physical forces in the living body and pursue them as far as possible." The result of such investigations will thereby always be that "the actual secret of living nature will not be disclosed."[42]

---

[38] *Ibidem*.

[39] *Ivi*, 628.

[40] *Ibidem*.

[41] *Ivi*, 629.

[42] *Ivi*, 631.

In Treviranus' view, the nourishment of living bodies is regulated by specific laws of the formative drive that cannot be reduced to the laws of physics or chemistry. In this respect, the realm of living organisms is different from that of mechanism or of chemical affinities and requires a reference to teleological principles. In fact, Treviranus understands organic nature as a higher level of organization than mechanism or chemical affinity, one that can be explained only with reference to the principle of purposiveness.

This notion of teleology as inherent to biological beings shows a proximity between the framework Treviranus lays out in the *Biologie* and the philosophy of nature of German Idealism, which emerged in response to Kant. It is hard to see how the striking similarity between Treviranus' work and *Naturphilosophie* could be explained except by the sharing of fundamental assumptions. The way in which Treviranus articulates the relationship between nature and spirit provides further evidence in favor of this proximity.

For instance, Schelling frames the purposive characteristics displayed by living organisms as early manifestations of the intrinsic spiritual character of nature. This spiritual character is completely concealed in the phenomenon of mechanism and only begins manifesting itself in chemical affinity and magnetism, when the relation between the terms in play becomes more internal and less extrinsic. It is, however, at the biological level that the spirit within nature fully manifests itself. A first mark of this spirituality is the fact that living organisms display a form of independence and spontaneity that is absent in mechanical and chemical phenomena. This spontaneity is attested by animal instincts, and it is completely realized in human consciousness.

Treviranus formulates a very similar argument, claiming that organisms display characteristics that have a determined purpose. These are the instincts or natural drives (*Naturtriebe*), which can relate to either the individual or the genus. In the former, they encompass self-preservation and self-defense, in the latter the drive to reproduction. All of these drives share "the characteristic of purposiveness (*Zweckmässigkeit*)."[43] The development of instincts results from "the continuing and partially modified activity of the original formative drive, the only one among the vital forces (*Lebenskräfte*) which, like the instincts, displays purposiveness and an appearance of spontaneity in its effects."[44] Like Schelling, Treviranus considers the mind to be an internal development of nature that manifests intrinsic teleological features.

The domain of intellect is taken up in the last volume of the *Biologie* (1822). Treviranus maintains that throughout history scholars have expressed two opposing views on the mental faculties of animals: they have either considered mind and matter completely different in nature or related to one another. Treviranus, by contrast, claims that life "lies in a principle, whose essence is self-activity." The use of the notion of self-activity is very innovative in a biological context, even though it was frequently used in the philosophical context of German Idealism. For Treviranus,

[43] Treviranus 1818, 430.

[44] *Ivi*, 443.

self-activity "expresses itself as formative drive and is merely immanent. It also persists in the formed organism and expresses itself through further formation and preservation."[45] From this perspective, autonomy is the fundamental characteristic of life. An organism that displays autonomy behaves "with the appearance of conscience and freedom, but nevertheless unconsciously and according to necessary laws."[46]

This framework bears the clear influence of the theory elaborated by *Naturphilosophie*, demonstrating the importance of the later in laying the foundations for the emerging biological science comprehensively outlined by Treviranus. Schelling's organicist views are especially notable in Treviranus' account, as they conceive of nature and mind as different developmental levels within a single universal organism. For Schelling and Treviranus, the hierarchical order connecting those levels proceeds from mechanism, magnetism, chemism, and teleology (inherent all living organisms) to finally reach the spirit (*Geist*, inherent to higher animal classes, and most notably to man). This framework implied a crucial shift from the Kantian understanding of teleology as a mere regulative principle, since it reconceived teleology as a constitutive property of living beings. In the following section, I explain how Treviranus came to adopt this schema and extend it to the empirical research of his time, thereby elaborating a consistent theory of transformism.

5 Ecology and Transformism

Despite their important convergences there is one notable difference between Schelling's and Treviranus' theories. For the former, the succession of different levels of organic life is conceived of as essentially logical: it describes the way nature is synchronically structured and accounts for its overall organization. Schelling sees nature as a hierarchy of levels, each more complex and perfect than the former, which culminates in the appearance of higher mental faculties like spirit. However, in his writings from the late eighteenth century, Schelling does not seem to understand this organization as the result of a historical process – at least not explicitly. As I have argued in the previous section, Treviranus draws key ideas from Schelling's philosophical framework, chiefly the overall principle of nature as an organism, but he interprets this notion in explicitly diachronic terms. In other words, Treviranus considered the hierarchical organization of the different levels of organic life as the result of historical development. Emphasis on the geographical distribution of organisms was fundamental to this reinterpretation. In fact, Treviranus dedicates the entire second volume of the *Biologie* (1803) to outlining how different organisms are distributed in various areas of the world. In this section, I look in detail at this geographical analysis and how it influenced Treviranus' view on historical transformism, which was presented in the third volume of the *Biologie* (1805).

[45] Treviranus 1822, 5.

[46] *Ivi*, 6.

Treviranus starts by considering all the areas on Earth that are inhabitable for living creatures. We find life in the ground and upon it, in the air and the water, in ice fields and tropical deserts, on the peaks of the highest mountains and in the deepest chasms.[47] To ground his analysis, he quotes several exploration reports[48] and states that "not only every part of the earth, but also every one of its living inhabitants is the living space for other living bodies."[49] Animals can be found at the highest altitudes on peaks full of harsh rocks, in deep gaps in the earth that the sun cannot reach, in the frigid polar ice caps and at the equator. This testifies to the adaptability of animal organization, since even at the north and south poles one can find penguins and no desert is so hot that it cannot support insect life.

Treviranus considers first plants, then zoophytes, and finally animals, carefully classifying them according to their geographical distributions and drawing the conclusion that "the closer to the poles" a geographical area is, "the less kind and species of plants it contains."[50] Based on this analysis, Treviranus addresses what he defines as the "fundamental problem of biology,"[51] i.e. the distribution of living bodies according to different environments. His idea that "all living forms are the product of a physical influence"[52] is a significant advancement with regard to the German tradition that I have been tracing.

As we have seen (Functions: The Göttingen School and the Physiology of Vital Forces, Sect. 4), Kielmeyer had stressed for the first time the necessity of a general theory of animal organization concerned with the laws regulating the distribution of vital functions in the animal kingdom. We have seen that this program was then developed by Schelling, who envisioned Kielmeyer's *Rede* as the beginning of a new era of natural history (Classification: *Naturphilosophie* and the Reform of Natural History, Sect. 5). Albeit with some differences, both of these thinkers aimed to formulate universal laws capable of accounting for biological variety. These laws involved the idea of nature as a self-regulating organism that maintains its internal equilibrium through equal distribution of vital functions among different species. This work, however, did not address the relationship between organism and environment, which plays a role for the first time in Treviranus.

Indeed, Treviranus argues that an account of the relationship between organism and environment can only be provided by attending to specific generative features connected to the vital force: (1) In nature there is always an active, absolutely indivisible and indestructible matter by the means of which every living being – from the byssus to the palm, from infusoria to sea monsters – possesses life. Although immutable in its essence, this matter is mutable according to its shape (*Gestalt*). (2) This matter is in itself formless and capable of taking on different shapes, and it obtains a particular shape only through the influence of external causes with

[47] Treviranus 1803, 7.

[48] *Ivi*, 8–19.

[49] *Ivi*, 20.

[50] *Ivi*, 57.

[51] *Ivi*, 265.

[52] *Ivi*, 264.

persistent duration. It takes on another shape as soon as other forces act on it.[53] Accordingly, our research must focus on "the forms of which living matter is capable of, and to the causes by means of which it obtains these forms." Matter here is defined as "vital principle (*Lebensprinzip*), vital substance (*Lebenstoff*) or vital matter (*Lebensmaterie*)," and these causes as formative or plastic potencies (*formenden oder plastischen Potenzen*)."[54] These principles constitute the framework for a general theory of the historical transformation of living forms as they respond to changing environmental conditions.

While the idea of the transmutation of species, also formulated by Herder, had been criticized by Kant as a daring adventure of reason (Classification: *Naturphilosophie* and the Reform of Natural History, Sect. 3), Treviranus embraced this adventure more than any of his contemporaries. Indeed, not only did he admit the possibility of historical transformation, he considered it the fundamental concern of the emerging biological science. This concern involved questions such as: "how did living nature obtain its present shape (*Gestalt*)? Did all the different species (*Gattungen*) of living bodies emerge from formless matter, or only from certain original forms (*Urformen*), by which the rest arose by a process of degeneration or the formation of bastards?"[55] To answer these questions meant accounting for the modifications of living nature over time. Indeed, the third volume of the *Biologie* (1805) aims to investigate "which transformation living nature has suffered before obtaining its present formation (*Bildung*),"[56] using the only tools that can be employed to lead this kind of inquiry: "the remains of ancient nature," or fossils.

Looking at the fossil record, Treviranus believes it is possible to assume that "the organism of living nature, just as everything else that exists in space and time, is subject to infinite transformations. So should not the organization of living bodies change as well? Should not entire kinds (*Arten*) perish and new ones emerge?"[57] Yet he points out that a species (*Gattung*) cannot completely disappear without effecting the overall organization of living nature: the disappearance of a kind must necessarily result in the emergence of another. Therefore, the animals and plants that we consider "newly found" are perhaps better named "newly produced." These kinds (*Arten*) were already present in some form in the beginning of human history and have always been reproduced, but now are considerably different from their former shape (*Gestalt*).[58]

If a complete transformation of *all* kinds of animals ever took place, it thus must have occurred in very early times. For this reason, part of Treviranus' book is devoted to discussion of the different layers of the earth's surface and fossil records found there. The oldest layers, composed of limestone, contain only small numbers of fossils of polyps and crustaceans. These are covered by different kinds of slate

[53] *Ivi*, 403.

[54] *Ivi*, 404.

[55] Treviranus 1803, 499.

[56] Treviranus 1805, 3.

[57] *Ivi*, 21.

[58] *Ivi*, 23.

that contain the fossil of both vegetable-animal organisms (*Tierpflanzen*), mollusks, and phytozomes. The number of these organisms gradually increases in rocks that have been more recently formed, where we find layers with skeletons from fish and invertebrate animals. These data suggest that there was a natural transformation, in the which several of the previous kinds of marine animals progressively disappeared while new ones emerged in their stead. None of these layers contain traces of land animals: bones of quadrupeds can be found only in the most recent layers.

These facts have rich implications: "we see now that the formation of living nature began from polyps and mollusks, i.e. from the lowest levels of organization, progressing from those to plants, and only afterward to land animals."[59] A similar process from the simple to the complex takes place in the spontaneous generation of vegetable and animal substance from formless matter. Accordingly, we can assume that organic nature was produced by a vital force (*Lebenskraft*) that is still active in the same way but more limited in its effects than in the times of the ancient world (*Urwelt*).

In those times, Treviranus argues, there was no separation between living and inert matter; this division emerged only after individual organisms developed on the earth.[60] Even now the opposition between the living and the lifeless is only the result of our point of view, not something essential to nature itself. Indeed, "everything, the universe itself, has life."[61] From this perspective, Treviranus maintains that the emergence and succession of stages in the development of nature as a whole took place in accordance with the same laws regulating the generation, growth, metamorphosis, and reproduction of every individual life form. Once again, we find a strong *naturphilosophish* tone in these statements, which refer to the entire universe as a living organism and argue for the parallelism between individual ontogenesis and the hierarchical levels of the organic world.

In fact, living nature "appears to us as an eternally self-transforming organism that in these changes, however, progresses regularly towards a certain state of development (*zu einer gewisser Grade der Entwicklung*)."[62] But how did the manifold forms of living nature originate? Were they direct descendants of the earth? Or were only the zoophytes created this way, while complex organisms emerged through the transformation of forms from generation to generation? If one considers all of living nature to have gradually progressed from the simpler to the more complex, "it is clear that all life can reach the higher levels of organization only from the lower." But how could this happen "if not through the fact that the simple organisms are progressively formed from generation to generation?" Therefore, the original forms that we find in the fossil record "are the original forms from which all the organisms of the higher classes emerged through gradual development (*Entwicklung*)."[63]

---

[59] *Ivi*, 39.

[60] *Ivi*, 39.

[61] *Ivi*, 40.

[62] *Ivi*, 173.

[63] *Ivi*, 255.

From this framework, it seems to follow that animals of the ancient world were not destroyed by great catastrophes, as was supposed by some of Treviranus' contemporaries (notably by Cuvier), but rather that many survived and "disappeared because the kinds to which they belonged completed the cycle of their existence and transformed in other species (*Gattungen*)." Everything on Earth is volatile and temporary, both the kind and the individual, both the species and the kind – "even man will maybe elapse and transform." For Treviranus it is even possible to assume "that nature has not yet reached the highest level of organization in humans, but rather that it will produce even more advanced and elevated beings, more noble forms."[64]

This idea of the transformation of living forms is a sort of historical version of the "transcendental" succession of the levels of the organic, the graded series of organisms, proposed by Schelling after Kielmeyer, and by Oken after Schelling – and it is indeed the most important contribution Treviranus made to the German biological tradition. As I have argued, the premise of this contribution is an idea of nature as a universal organism, or self-organizing system, molded after the conceptual framework of epigenetic development. As a consequence, nature was understood as a system of stages self-organized into a hierarchy of levels characterized by increasing functional and morphological complexity.

In the previous section, I stressed that Treviranus' theory on the distribution of the vital forces in the animal kingdom is unoriginally molded after Kielmeyer's. In this section, I have argued that the resulting hierarchical order – including the relation between mechanism and teleology, or between nature and spirit – is at the very least convergent with Schelling's *Naturphilosophie*. Yet, Treviranus' emphasis on geographical distribution and on the transformation of living forms is an original formulation with great impact on the development of the idea of a unified biology. This conceptualization of nature implied a historical interpretation and extension of the Schellingian framework, and it led Treviranus to write an important page in the pre-history of modern ecology.

6 Teleology and Organization

Throughout this book, I have argued that, from the conceptual point of view, the project of a general biology in Germany should be regarded first and foremost as the result of a conceptual shift from the Kantian conception of teleology as a regulative principle to the idea of teleology as the most constitutive characteristic of organized beings. This point is made especially clear in Treviranus' later work, namely in the *Erscheinungen und Gesetze des organischen Leben* (1831–1832). This two-volume work was published 29 years after the first volume of the *Biologie* and entails a new statement of Treviranus' theory. This statement is essentially coherent with the *Biologie*, but it is also more mature and allows a clearer assessment of his ideas concerning life, teleology, and organization.

[64] *Ivi*, 226.

Treviranus' *Erscheinungen und Gesetze der organischen Leben* consists of two volumes. The first involves a classification of various physiological traits found in plants and animals, such as generation, growth, blood circulation, respiration, digestion, or animal electricity; the second is dedicated to the general relation of the nervous system to the life of organisms, and especially to an analysis of how the five senses manifest in the animal kingdom. This analysis is primarily a matter of empirical research, but in the introduction, Treviranus ventures some theoretical statements clearly influenced by the debate on natural purposes that followed Kant's *Critique of the Power of Judgment*, which I have partially reconstructed in the present book.

Here Treviranus argues that, in living beings, every part exists only for the sake of the others and on account of the whole, and that "only the living has this kind of purposiveness,"[65] which can be observed by microscope in even its smallest parts. All external movements of animals, and in some cases also those of plants, display a form of spontaneity that is especially notable in animal instincts. Accordingly, "purposiveness is a characteristic of every living being." Those claiming that "this purposiveness is transferred by us into nature," as Kant did, "should also explain how we could operate this transfer, if nature did not give us any reason to do so."[66] Such statements by Treviranus are a clear criticism of the Kantian conception of teleology as a regulative principle. In fact, natural life might have several different purposes, "but the first is always its own preservation and development. In this lies the difference between mechanical and organic activity. The mechanism destroys itself by working towards the purpose for which it is determined, on the other hand, the organism persists only through its own activity."[67] The conditions for the activity of an organism are fundamentally different from those of a machine. In the former case activity serves the preservation of the organism itself, in the latter it serves a purpose external to the machine itself.

This self-activity presupposes a form of spontaneity that is the same as animal instinct, and it is often misinterpreted in higher animals. In fact, Treviranus asks: "where is the limit between the expression of instincts in higher animals and the impulses of life at its lower levels?" In Treviranus' view, the expression of instinct cannot be the result of conscious reason (*Vernunft*), but "how is purposive action possible without consciousness? This is the big riddle we come across at every step of the doctrine of living nature."[68] On this score, Treviranus seems to agree with Kant that "purposive activity cannot be conceived of without an analogy with reason," and thus "every expression of life must be the effect of a principle similar to reason." In his view, this principle can be identified either with the soul of the individual living being or with a world-soul, as Stahl and Schelling argued respectively, but for Treviranus it is inadequate to explain the phenomenon of life. In this respect, he agreed with Kant that reference to conscious agency was not enough to explain

[65] *Ivi*, 4.

[66] *Ivi*, 8.

[67] *Ibidem*.

[68] *Ibidem*.

purposive self-maintaining characteristics, which are the "principle of life, both of animals and plants."[69] Indeed, these were inexplicable without first assuming a principle at the core of every living form that acts purposively and draws the organism instinctively toward self-preservation.

For Treviranus, this drive towards self-preservation takes place in a phenomenon that he had already described as the hallmark of life in the introduction to the *Biologie*: the living organism's ability to maintain uniformity despite differences in the external environment. As I have previously argued, this characteristic can be interpreted as analogous to the notion of homeostasis. Treviranus explains that "it is possible to define the striving towards uniformity of reactions with regard to variable influences as a hallmark of life."[70] He uses as an example the case of a sphere rolling down an inclined plane on an uneven surface. If this sphere always happened to display uniform reactions to that uneven surface, one would be forced to suppose it were acted upon not only by the mechanical force of gravity but also by another non-mechanical force. This force is precisely what Treviranus defines as the vital force. He argues that preservation of an organization against variable external conditions is possible only by assuming another force, not merely mechanical, that acts against the changing influence of the environment and expresses "the highest of life: the purposive action of a self-acting principle, whose goal is the persistence of the action itself. This action must take place in a specific form, whose external expression is organization."[71] Such later (and more developed) elaborations of Treviranus' theory explicitly testify to the role played by teleology (as internal purposiveness) in his determination of an autonomous epistemological field for biological inquiry. In this way, the rise of biology in Germany implied an understanding of teleology as a constitutive feature of living systems – a position at the very least convergent with the one held by Romantic *Naturphilosophie*.

7 Concluding Remarks

Analysis of Treviranus' *Biologie*, along with later elaborations of his theory, confirms that the formalization of biology as a unified field implied a conceptual turn form the Kantian consideration of teleology as a regulative principle of our cognitive faculties to an idea of teleology as the constitutive feature of what is living. This shift was first philosophically formulated in Schelling's *Naturphilosophie* and, as I argue in the following section, was later endorsed by Hegel. Both Schelling and Hegel considered teleology an explanatory principle different from mechanism and chemical affinity, one that was necessary to provide an adequate conceptual account of living organisms. In Schelling's organicist view, the teleological features displayed by living organisms are understood as the link between the lower levels of

[69] *Ivi*, 13.
[70] *Ivi*, 18.
[71] *Ivi*, 23.

nature (such as mechanism) and higher ones (such as chemical affinity and teleology). "Spirit" or "mind" (*Geist*) appear as the final, most advanced expression of this gradual series.

I hope to have shown that Schelling's views were frequently employed in key passages of Treviranus' *Biologie*, the text that first attempted to provide a unified treatment of life as a natural phenomenon essentially characterized by intrinsic purposiveness. At the same time, Treviranus' emphasis on the geographical distribution of organisms and the importance he granted to environment moves his *Biologie* beyond the Schellingian framework, which is premised in *logical* deduction of an *ideal* series of organizations. Treviranus instead interprets the graded hierarchy of organisms as a *real* sequence, thereby founding biology as a *historical* science. This suggests that German Idealism played a crucial role in the genesis of the explanatory framework for biological organization. Only a historiographical bias could lead us to think otherwise.

Conclusion: Hegel on Vital Forces, Teleology and Organization

1 Introduction and Outline: Hegel as a Philosophical Reporter

Unlike his peers Kant and Schelling, who played a significant role in the debate on vital forces and contributed concretely to the formulation of empirical research programs in natural history, Hegel did not actively join in scientific controversies. Although he had been well aware of the developments occurring in most scientific disciplines of his time since his early years in Jena, his overall attitude was one of external observation and comment.[1] In this sense, it is worth mentioning that while Hegel was composing his *Jaener Entwürfe* in the early years of the nineteenth century, the epistemological space for the emergence of biology as a unified field had already been opened and the process of its institutionalization had already begun. Nevertheless, or perhaps precisely because of this non-involvement, Hegel was able to disinterestedly criticize both Kant and the Romantic *Naturphilosophie*, as well as to offer one of the most lucid accounts of the main philosophical points at stake in this debate.

In these concluding remarks, I reconstruct Hegel's positon on the issues I have treated throughout the book, most notably his position toward Kant and Romantic *Naturphilosophie*, his philosophical understanding of the vital forces, and his assessment of the relation between teleology and organization in living systems. Ideally, concluding with Hegel as a "philosophical reporter" should enable us to make sense of the overall significance of the historical shift I have traced from the Kantian construal of teleology as a regulative principle to an understanding of teleology as a constitutive feature of organized beings.

In chapter "Generation: The Debate Over the Formative Force and the Question of Ontogenesis" (Sect. 3), we saw why Kant deemed the machine-model, or "technical" understanding, of organized beings insufficient to account for their most

[1] Poggi (2000), 16–66.

A. Gambarotto, *Vital Forces, Teleology and Organization*, History, Philosophy and Theory of the Life Sciences 21, DOI 10.1007/978-3-319-65415-7_5

important feature: organization. In rejecting this model, he formulated a distinction between external and internal purposiveness, i.e. between teleology as intention and teleology as self-organization. Since he did not find teleology explainable without reference to intention as an inherent foundation, Kant considered the purposiveness displayed by organized beings a mere regulative principle. In this sense, I have argued that he held an unstable position: on the one hand arguing that organized beings are mechanically inexplicable and that they should be the object of teleological consideration, while at the same time conceiving purposiveness as always ultimately related to a subjective intention. Kant thus finally rejected the idea that vital organization could be explained without reference to some original intention (*Absicht*).

Hegel's critique of Kantian teleology focuses precisely on this unstable position and notably on the fact that Kant ultimately understood teleology as the result of conscious intention. In fact, in the *Critique of the Power of Judgment*, Kant had stressed that the specific features of an artifact are grounded in the intentional project of a conscious designer. The constitutive features displayed by organized beings could only be understood according to some analogous kind of causation, since in Kant's view there was no other way to explain the appearance of purposive features than their being produced according to the intentions of a conscious maker. Hegel argues that, by restricting the legitimate use of teleological principles to artifacts, Kant ended up downplaying the conceptual distinction between internal and external purposiveness put forward by his critique of teleological judgment, essentially interpreting the former in the guise of the latter by understanding teleology solely as the result of conscious intention. Understood in "technical" terms, the notion of purpose cannot find an absolute foundation in our experience of nature. Nevertheless, as we have seen in chapter "Generation: The Debate Over the Formative Force and the Question of Ontogenesis" (Sect. 3.1), Kant continued (with particular emphasis in the *Erste Einleitung* to the third Critique) talking about a "technique of nature" (*Technik der Natur*).

As I will subsequently argue, Hegel's point is precisely that understanding natural purposiveness in the same terms as intention renders it impossible for us to make sense of the process through which an organized being is constituted. Such a "technical" understanding of purposiveness cannot account for the inherent capacity of living organisms to produce themselves, to be simultaneously causes and effects of themselves. In fact, as Kant had already emphasized in the third *Critique*, the form of an organized being is not externally determined but internally produced. To understand this specific kind of causality for Hegel meant addressing the essence of organic processes by making sense of the nature of the very formative force (*Bildungskraft*) that Kant had declared inexplicable.

The aim of this final section is to show how Hegel recognized the post-Kantian tradition to have taken the first steps in this direction. In doing so, he praises both the Göttingen tradition and Romantic *Naturphilosophie* for formulating the first outline of this enterprise, but he also criticizes them for doing so only inadequately. He charges Kielmeyer with holding an abstract conception of the vital forces as isolated properties, without reference to their specific functions in the living system as a whole; Treviranus is accused of formulating empty tautologies and criticized for his “twisted” ideas on transformism; Schelling and Oken are charged with empty formalism, superficial analogies, and a lack of universal intelligibility that gives them the appearance of esotericism. In Hegel’s view, both the Göttingen tradition and Romantic *Naturphilosophie* lacked a consistent theory of living individuality as an organized and functionally integrated whole.

The main reason for Hegel’s critique is that both philosophies of nature emerged during a “period of transition to a new era,”[2] when the basis for a new science was being laid out. Just as a small building is finished long after its foundation has first been laid, so too “science, the crown of a world of spirit, is not complete in its beginnings.” Only what is completely determined “is at once exoteric, and capable of being learned and appropriated by all.”[3] Yet while in its early stages, and without yet having attained completeness of detail or perfection of form, this new science was vulnerable to criticism, “it would be unjust for such criticism to strike at the very heart of Science, as it is untenable to refuse to honor the demand for its further development.”[4] Indeed, in Hegel’s view *Naturphilosophie* was a legitimate philosophical attempt to move beyond the Kantian understanding of teleology as a regulative principle and to conceive of purposiveness as constitutive of living systems. However, it did so only *inadequately* and ended up hiding behind an empty formalism, i.e. applying a stiff schema of oppositions in order to provide an easy and unitary interpretation of nature.

Hegel did not appreciate the speculative excesses of *Naturphilosophie*. At the same time, however, sections of the *Phänomenologie des Geistes* also demonstrate that Hegel did not considered the *naturphilosophisch* project something to be thoroughly rejected but rather corrected and integrated. In this respect, as an external observer, Hegel appears to provide a balanced account of the role of *Naturphilosophie* both with regard to Kant and to the life sciences at the turn of the nineteenth century.

If one is interested in the role that Romantic *Naturphilosophie* played for the German life sciences at the turn of the nineteenth century, Hegel’s account offers an interesting perspective. In fact, Hegel’s point is neither a mere criticism of *Naturphilosophie* nor a simple adoption of its tenets, but rather an assessment of the movement’s overall meaning as a historical phenomenon. In order to reconstruct how he did this, in Sect. 2 I take into account Hegel’s critique of the Göttingen tradition and of Romantic *Naturphilosophie* in the *Phänomenologie des Geistes* (1807). In Sect. 3 I analyze Hegel’s critique of Kant’s idea of teleology as presented in the *Wissenschaft der Logik* (1816); Finally, in Sect. 4 I pull together the results of my overall narrative into a general conclusion.

[2] Hegel (1980), 14.

[3] *Ivi*, 15.

[4] *Ivi*, 16.

2 The Limits of Observing Reason: The Critique of *Naturphilosophie* in the *Phenomenology of Spirit*

Hegel carries out his criticism of Romantic *Naturphilosophie* primarily in the section of the *Phänomenologie des Geistes* dedicated to Observing Reason (*beobachtende Vernunft*). Within the phenomenological path of consciousness, observing reason is for Hegel that form of knowledge in which consciousness tries to make sense of objectivity through the formulation of laws. These laws, however, prove inadequate to account for living organisms. An organism is in fact a concrete manifestation of what Hegel defines as "the concept," i.e. a form of internal unity that occurs by means of the relation to something else. A living being is not composed of isolated elements but rather of members that are nothing without their relation to one another and to the whole. In the organic being "every determinateness through which it is open to an other is controlled by the organic simple unity," in such a way that none of its parts "shows itself as essential, as free to enter into relation with an other, and consequently what is organic maintains itself in its relation."[5] It is precisely this unique relation among the parts of an organic whole that phenomenological reason is unable to understand, and the laws that it formulates reflect this failure.

It is especially important to note that, in the eyes of an illustrious observer like Hegel, there is no clear distinction between "empirical" and "speculative" philosophies of nature. This distinction, as I have tried to show, has been arbitrarily imposed by historians and is not supported by historical evidence. Hegel's account instead draws attention to the several shades of grey blurring together these approaches. In the *Phänomenologie des Geistes*, Hegel critically addresses the *naturphilosophisch* culture of his time, which he associates with a vast array of authors, spanning from Kielmeyer and Treviranus to Schelling and Oken. Indeed, according to Hegel, all these figures belonged to the same unfulfilled but nonetheless important historical process of developing an adequate understanding of living organisms. In Hegel's terms, the most important limit to Observing Reason, which for him stood as the symbol of the *naturphilosophisch* movement, was its inability to elevate itself to the level of the concept, i.e. to provide a truly holist account of living beings. Instead, *Naturphilosophie* focuses only on the increase and decrease of vital properties, which are considered in abstract terms. In this way, Observing Reason assumes that vital properties are isolated elements and disregards their concrete relation to the whole to which they belong.

The first laws formulated by the Observing Reason concern the relation between organic and inorganic nature. Without explicit quotation, Hegel refers here to the second volume of the *Biologie*, where Treviranus discusses the taxonomic characteristics of organisms in relation to their geographical distribution. As we have seen in chapter "Biology: Treviranus and the Life Sciences as a Unified Field" (Sect. 4), in the second volume of the *Biologie* Treviranus considered plants, zoophytes and

[5] *Ivi*, 145.

animals, classifying them according to their geographical distributions and drawing the conclusion that "the closer to the poles" a geographical area, "the less kind and species of plants it contains." Based on this analysis, Treviranus defends the idea that "all living forms are the product of a physical influence" and defined the distribution of living bodies according to different environment as the "fundamental problem of biology."[6]

Hegel thus criticizes Treviranus' ecological approach by maintaining that the relationship of organisms to the environment in which they live cannot be called a law, because it expresses no necessity whatsoever. In fact, often as we may find a thick, airy pelt associated with northern latitudes or the structure of a fish associated with water, "the notion of north does not imply the notion of a thick airy pelt, the notion of sea does not imply the notion of the structure of fish, or the notion of air does not imply the structure of birds."[7] Hegel argues that relation to the surrounding environment is not enough to account for the structure of living organisms.

An even sharper criticism of Treviranus is found in § 249 of the *Encyclopedia*, where Hegel targets the very idea of *transformism* that we saw in chapter "Biology: Treviranus and the Life Sciences as a Unified Field" (Sect. 4.5). Like Goethe, Hegel argued that the process of *metamorphosis* should be considered solely as an *ideal* process, one concerned with the deduction of all forms from the same original type, not a real transformation of existing organisms. In fact, nature is to be regarded as a system of stages, each proceeding necessarily out of the other. This, however, is not a "*natural* engendering of one out of the other," but rather an "engendering within the inner Idea which constitutes the ground of nature."[8] This means that the sequence of stages does not correspond to the *real* hierarchy of living forms, nor to their *historical* emergence, but only to the *ideal* reconstruction carried out by philosophy.

Therefore "thinking consideration must reject such nebulous and basically sensuous conceptions as for example the so-called emergence of plants and animals out of water, and of the more highly developed animal organizations out of the lower."[9] The system of stages is in Hegel's view merely a way of ordering things, just as the division of nature into three kingdoms is, "but one must not think one makes such a dry series dynamic, philosophical, more comprehensible, or what you will, merely by using the concept of emergence (*Vorstellung von Hervorgehen*)." Hegel is straightforward in claiming that in fact "a land animal has not proceeded by natural process out of an aquatic animal, and then flown into the air, neither has the bird returned to the earth again."[10] Indeed, Hegel firmly rejected any notion of transformism according to which "the course of evolution (*Evolution*) begins with what is imperfect and formless, such as humidity and aquatic formations, leads to what emerged from water, such as plants, polyps, Mollusca, and fishes, progresses to land animals, and arrives finally to man, as he emerges out of animals." In this specific

---

[6] Treviranus (1803), 264–265.

[7] Hegel (1980), 146.

[8] Hegel (1992), § 249.

[9] *Ivi*, § 249, An.

[10] Hegel (1986), § 249, Z.

quote, Hegel is probably referring to Herder's *Ideen zur Philosophie der Geschichte der Menschheit* (1784–1891) as much as to Treviranus' *Biologie* (1802–1822). The doctrine underwriting both accounts "is derived from [Romantic] *Naturphilosophie* and is still widely prevalent,"[11] but although it is said to be an explanation of nature, it actually explains nothing.

Hegel's criticism of Kielmeyer is not any milder. In chapter "Functions: The Göttingen School and the Physiology of Vital Forces" (Sect. 4), we saw how Kielmeyer attempted to formulate quantitative laws concerning the inverse quantitative relations among these forces. It is precisely this quantitative treatment that is the main target of Hegel's criticism in this section of the *Phänomenologie des Geistes*. According to Kielmeyer, in fact, the laws particular to organisms concern the relationship among organic properties in such a way that "a specific sensibility would find its expression, *qua* moment of the *whole* organism, in a specifically formed nervous system, or it would also be linked up with a specific *reproduction* of the organic parts of the individual or with the propagation of the whole, and so on."[12] In this way every organic property is immediately related to the relative organ system through which it is given objective existence. According to Hegel, since these organs are different members belonging to the same whole, their distinction is *qualitative*, since it implies a specific functional difference. Yet Observing Reason considers them isolated properties and distinguishes them only *quantitatively*. Their qualitative difference is thus reduced to a difference in *magnitude*, and thus "arise laws of this kind, e.g. that sensibility and irritability stand in inverse relation to their magnitude, so that as one increases the other decreases."[13] To exemplify this, Hegel quotes a passage from Kielmeyer's 1793 lecture without explicit reference, as often occurs in his writings, and frames it as an embodiment of the fallacies of the observing consciousness.

Indeed, in Hegel's view, Kielmeyer considered the relation among vital functions only in abstract terms, i.e. by considering sensibility, irritability, and reproduction as isolated properties not assimilated into a functionally integrated organism. Considered in abstract terms, the inverse relationship between these functions no longer has anything to do with the nature of sensibility or irritability as specific features of a living organism. This for Hegel is "an empty play of formulating laws" that rests "on a lack of acquaintance with the logical nature of these antitheses."[14] It is an "empty play" trying to account for the properties of living organisms by taking the organism apart and considering its components as abstract terms isolated from the whole – when in fact it is only in relation to the whole that the functions of different parts of an organized being can be accounted for.

To Hegel, living systems appear to be purposes in their own selves. In fact, an organism appears as "a being that *preserves* itself, that *returns* and *has returned* into itself." But the Observing Reason "does not recognize in this being the notion of

[11] *Ibidem*.

[12] Hegel (1980), 151.

[13] *Ivi*, 152.

[14] *Ivi*, 153.

purpose, or that the notion of purpose exists just here and in the form of a thing, and not elsewhere in some other intelligence. It makes a distinction between the notion of purpose and being-for-self and self-preservation, a distinction which is none."[15] A living organism is in fact something that preserves itself in relation to its opposite. Through its metabolic process, an organism is in constant open relation with its otherness, i.e. the environment, and in virtue of this relation also with its own organization. The apparently static structure of an organism is established through this continuous process, which constitutes its most essential hallmark. Hegel characterizes this feature as "being-for-self," since its purpose does not fall outside of itself and its activity always returns to itself. It is precisely this inner movement of living organisms that cannot be grasped by the observing consciousness, which always conceives of purposiveness as external to organized being.

For Hegel, the nature of an organic whole is that its parts are "moments," i.e. members that have meaning only in relation to one another. At its core, a living organism "is the *simple*, *unitary* soul, the pure *notion of purpose*" which, although composed of different parts, always remains in "universal fluidity."[16] In order to make sense of its functioning, the observing consciousness freezes this fluidity and separates moments into simple organic properties. In this way, Hegel makes explicit reference to the notion of vital forces, as he identifies those properties as "sensibility, irritability and reproduction."[17] These vital properties occur by means of three different organic systems: sensibility via the nervous system, irritability via the muscular system, and reproduction via the visceral system. This is a schema that had already been emphasized by Oken and is a variation on the classificatory system outlined in Schelling's *Erster Entwürf eines Systems der Naturphilosophie* (1798) and in his *System der gesammten Philosophie und der Naturphilosophie insbesondere* (1804), which in turn was based on the framework put forward by Kielmeyer.

Hegel maintains that the actual living organism manifests the important differences between vital functions but that such a difference results from its concrete organization and does not belong to those properties in abstract terms. From this perspective, its moments "pertain to anatomy and the corpse, not to cognition and the living organism." In such parts "the moments have really ceased to *be*, for they cease to be processes."[18] A living organism essentially consists in its overall organization, and thus its parts cannot be considered isolated properties. In chapter "Functions: The Göttingen School and the Physiology of Vital Forces" (Sect. 4), we noticed how Kielmeyer formulated his laws of compensation to account for the inverse relationship among the fundamental organic forces of sensibility, irritability, and reproduction. Hegel charges Kielmeyer's laws with considering those vital functions as isolated elements and not as parts of an organized being. He argues to the contrary that "the actual expression of the whole, and the externalization of its moments, are really found only as a movement which runs its course through the

[15] *Ivi*, 148.

[16] *Ivi*, 150.

[17] *Ibidem*.

[18] *Ivi*, 155.

various parts of the structure, a movement in which what is forcibly detached and fixed as an individual system essentially displays itself as a fluid movement." Consequently, the static existence of an organ, as described anatomically, is not its real being "but only that existence taken as a process, in which only the anatomical parts have a meaning."[19] Laws like those formulated by Kielmeyer try to express vital processes as immediate properties, abstracted from their concrete relation to one another and to the whole, and this, in Hegel's view, is their most essential fallacy.

Accordingly, Observing Reason conceives of the vital functions of living organisms as immediate properties and tries to account for them in quantitative terms. As a consequence, "we may find that something which perception takes to be an 'animal with strong muscles' is defined as 'animal with high irritability,' or what perception takes to be a 'condition of great weakness' is defined as a 'condition of high sensibility,' or, if we prefer it, as an 'abnormal affection' and, moreover, 'a raising of it to a higher potency – expressions which translate sensuous facts into Latin, and a bad Latin at that, instead as into the concept."[20] This quote includes a reference to Schelling, for whom the notion of potency played a central role. In the context of Schelling's philosophy of nature, the notion of potency is used to define different degrees in the graded series of natural organisms, a series that moves from magnetism, electricity and chemical phenomena to the complexity of living organisms.

In the opening paragraphs of the *Philosophy of Nature*, Hegel expresses his position in even rougher terms. In those pages, he holds as "*indisputably* true" that the philosophy of nature of his time suffered from a "very considerable lack of favor." He sees this situation as caused by the fact that philosophy of nature "has been variously transformed into an external formalism, and perverted into a notionless instrument for superficiality of thought and unbridled powers of imagination." Through these "extravaganzas," it had been perverted into "death-struck forms" that include "crude empiricism and travestied thought-forms, capriciousness of fancy and the flattest method of proceeding according to superficial analogy," which "have been mixed into a complete chaos" and "served up as the Idea, reason, science, divine perception." As a result, the "complete lack of system and scientific method has been hailed as the very peak of scientific accomplishment": "it is on account of such charlatanism that the philosophy of nature, especially Schelling's, has become discredited."[21]

In his assessment of Observing Reason, Hegel criticized both Kielmeyer and Treviranus, Schelling and Oken for having an "abstract," i.e. static, conception of living processes and vital properties. Yet, despite this criticism, for Hegel *Naturophilosophie* had made a significant step toward developing an adequate understanding of vital organization by overcoming the Kantian assessment of teleology and considering purposiveness as a constitutive feature of nature itself. As I argued in chapter "Generation: The Debate Over the Formative Force and the

[19] *Ibidem*.
[20] *Ivi*, 158.
[21] Hegel (1986), § 245, Z.

Question of Ontogenesis" (Sect. 3), Kant in fact held a controversial position with regard to the epistemological status of purposiveness and had hesitated to recognize it as the most unique ontological feature of living systems. I address Hegel's criticism of Kantian teleology in the next section.

3 Teleology and the Idea of Life: The Critique to Kant in the *Science of Logic*

Hegel criticized the Kantian account of purposiveness with vehemence in the *Teleology* section of the *Science of Logic* and the *Encyclopedia*. This is the section of his System in which Hegel takes into account the conceptual structure of "external" purposiveness, i.e. utility. Here Hegel discusses the logical structure of the final causes proper to instrumental or technical entities, whose essence lies in the fact of their being *for* something. "Internal" teleology, in Kant's sense, as the specific purposiveness displayed by organized beings, is discussed in the following section, which in fact is entitled "Life." The idea of life as already containing inner purposiveness stands for Hegel "infinitely far beyond the concept of modern teleology which has only the *finite*, the *external* purposiveness in view,"[22] since here "there is the perception of *purposiveness*, an *intelligence* is assumed as its author."[23] However, in Hegel's view, the concept of an extra-ordinary intelligence is proximate to the teleological principle, and thus seems to depart from the true investigation of nature.

With his peculiar philosophical methodology, Hegel intended to disclose the conceptual potentialities implicit to the notion of purpose and to show that technical purposiveness, i.e. *external* purposiveness, is a derivative form of teleology, presupposing a more fundamental kind of purposiveness, namely *internal* purposiveness. Hegel argues that whenever the teleological relation is understood as external purposiveness, organization is not conceived as the result of processes internal to the living individual itself but rather as the result of an external agency. As we saw in chapter "Generation: The Debate Over the Formative Force and the Question of Ontogenesis"

(Sect. 3), Kant criticized Leibniz's understanding of artifacts as *human* machines and of living organisms as *divine* machines. For Leibniz the only difference between the two categories is that the latter are *infinitely* organized, unlike the former. This conceptual distinction is a quantitative matter; it does not imply a qualitative, categorical difference between machines and organisms. Hegel upholds Kant's rejection of this idea in the *Critique of the Power of Judgment*, but at the same time argues that Kant was not able to consistently move beyond this position either. Kant's controversial resolution to the antinomy of teleological judgment and his regrets

[22] Hegel (1992), § 204, An.

[23] Hegel (1981), (651)

concerning the Newton of the grass blade, which we have discussed, are at least partially the result of his middle-position on the argument about intelligent design.

As Hegel points out, on the one hand, Kant criticized modern metaphysics for understanding natural purposiveness in terms of mere utility and emphasized the incongruence of referring to a divine maker when talking about natural objects. His distinction between "internal" and "external" purposiveness is aimed precisely at discarding this metaphysical assumption. On the other hand, Kant is quite firm in maintaining that we can only conceive of natural organization according to the model of artefactual organization. He therefore construes purposiveness as a regulative principle: we cannot claim that organized beings are the result of divine design, but we do not seem to have other options for conceiving of them. Thus we must consider organized beings *as if* they were the result of intention, while looking for mechanical explanations of biological organization. It is worth stating Kant's position again, "we can boldly say that it would be absurd for humans even to make such an attempt or to hope that there may yet arise a Newton who could make comprehensible even the generation of a blade of grass according to natural laws that no design (*Absicht*) has ordered; rather, we must absolutely deny this insight to human beings."[24] Indeed, according to Kant, biological organization cannot be explained without reference to an intention, but this reference is unsustainable on empirical grounds alone: it must be understood as a heuristic device. Thus, despite his distinction between types of purposiveness, Kant like Leibniz still conceives purposiveness as always related to an intention.

Hegel argues that when we consider living organisms in this way, we do not really understand them as purposes. Instead they are merely means that are used and used up to realize some purpose lying outside of them. According to this framework, a living organism is not considered a natural purpose *per se*; its purposiveness is rather understood as the result of an external agency, and in this sense there is no substantial difference between organisms and artefacts, between a living being and a clock. On the other hand, Hegel's aim is precisely to comprehend the living organism "*by itself* as a *whole* that has no need for an other for *its* concept – a totality that is not found in purpose and the extra-mundane intelligence associated with it."[25] For Hegel, conceiving purposiveness as *external* always implies a conscious intelligence that previously defined the object under consideration through reference to an idea that exists in and for itself – an idea which is not the result of a process of *self*-organization.

In Hegel's view such external teleology underlies the conceptual structure of artefactual entities, whose purpose is not identical to them but something external. In this case, the content of a concept, which for Hegel is the specific form of organization proper to a living individual, is externally given rather than autonomously produced. On this score, Hegel maintains that "one of Kant's greatest services to philosophy was in drawing the distinction between relative or *external* purposiveness and *internal* purposiveness; in the latter he opened up the concept of *life*, the

[24] Kant Ak, V: 401.

[25] Hegel (1981), 155–156.

idea." At the same time, however, he finds Kant's ultimate treatment of this teleological principle essentially unsatisfactory and laments that Kant confused and essentially ruined this great insight. This censure of Kant's treatment of teleological judgments is as constant in Hegel's writings as is his praise of the idea of inner purposiveness.[26]

For Hegel an adequate understanding of the notion of internal purposiveness is what opens up the idea of life. He defines life as that phenomenon which is a purpose in and for itself. Something is alive when there is no opposition between purpose and organization, because the organization is both the cause and effect of itself. Since the organization of a natural purpose is not the result of some external design but internally produced, it implies a form of self-determination, which Hegel calls *subjectivity*. This form of self-determination is the hallmark of autonomy: "this *subject* is the idea in the form of singularity, as simple but negative self-identity – the *living individual*." This individual, or subject, is characterized by Hegel as "the initiating self-moving *principle*."[27]

Within this framework, because of its self-determination, "the *purposiveness* of the living being must be grasped as *inner*"[28] and must be understood as the living being's most essential characteristic, which distinguishes it from externality and pervades it thoroughly: "this objectivity of the living being is the *organism*; it is *means* and *instrument* of purpose, fully purposive." For this reason, the organism is a manifold not of *parts* but of *members*: when separated from it, "they revert to the mechanical and chemical relations common to objectivity."[29] This idea of inner purposiveness is for Hegel "the *concept of the living subject* and of its *process*," whose hallmark is a form of "self-referring *negative unity*."[30]

In other words, what makes something *living* is precisely the peculiar organization of its parts: this organization is not something static but a dynamic process in which every part contributes to the subsistence of the whole, and thus the whole can be said to be at the same time the cause and the effect of itself. This form of relation to oneself (which in Hegelian terms is subjectivity) constitutes the fundamental structure of life and is described according to three different levels of autonomy: (1) the *living individual* (*das lebendige Individuum*), (2) the *living process* (*Lebensprozess*), and (3) the *species* (*Gattung*). These three determinations constitute the core of Hegel's theory of biological individuality, a theory that is expounded in the *Science of Logic*.

In that text, Hegel discusses (1) the living individual by means of close conceptual analysis of the form of organization that characterizes biological individuals. Here Hegel makes reference to the vital forces. The notions of *sensibility*, *irritability* and *reproduction* are transfigured to fit the theoretical framework of Hegel's logic and made to correspond to the three logical instances of *universality*, *particularity*

26 Dahlstrom (1998), 167.

27 Hegel (1981), 183.

28 *Ivi*, 184.

29 *Ibidem*.

30 *Ivi*, 185.

and *singularity*. Hegel depicts sensibility as the "external existence of the inward soul," which reduces externality to the "complete simplicity of the self-equal universality"[31]; irritability is instead defined as the "vital force of resistance (*Widerstandkraft*)" by means of which the living individual reacts to its surrounding environment. It is only in reproduction, however, that "life is *something concrete* and vital; in it alone does it also have feeling and power of resistance."[32] In this context, reproduction should be understood not as the reproduction of the *species* but rather as the reproductive process internal to the *individual* itself: its faculty of continuously regenerating its own members.

Hegel goes on to account for (2) the living process as the dialectical relation of an organized individual to the world external to it. This process begins with *need* (*Bedürfnis*), which is defined by Hegel as a form of "self-determination of the living being." Somewhat paradoxically, the identity of an organism is marked by its continuous exchange with the environment. Through the experience of need, the living subject is connected with the outside world and seizes hold of the objects it finds there by means of the metabolic process.

Finally, Hegel characterizes (3) the species (*Gattung*) as "the completion of the idea of life," because in the species a living individual displays an "identity of itself with its hitherto indifferent otherness." This means that the living individual is at the same time identical to and different from the rest of its species. *Identical* since they belong to the same universal set, *different* because that set is made up of particular individuals who are *ipso facto* different from each other. In other words, "externality is the individual's immanent moment and is, moreover, itself a living totality; an externality in which the individual has certainty of itself not as *being sublated*, but as *subsisting*."[33] For this reason, the defining characteristic of living individuals is their impulse to self-replicate: "from this side the species obtains *actuality* through its reflection into itself, for the moment of negative unity and individuality is thereby *posited* in it – the *propagation* of the species."[34]

Through analysis of these three determinations – the individual, the living process and the species – the *Science of Logic* offers the conceptual basis for Hegel's treatment of biological teleology. Here Hegel provides a conceptual framework that describes the essential characteristics of the living: organization, need, and self-replication. Through these ideas, Hegel provides the outline for his theory of living subjectivity, which is defined as the form of being-for-self that realizes itself in relation to its otherness.

I hope that this analysis shows how Hegel's treatment of living organisms brings together the most important aspects that have emerged in my narrative, especially the role of teleological principles in shaping the emergence of a scene of inquiry dedicated to life as a natural phenomenon. Throughout the book, I have emphasized that the common trait among all the authors is their explicit critique or implicit

---

[31] *Ibidem.*

[32] *Ivi*, 186.

[33] *Ivi*, 190.

[34] *Ivi*, 191.

overcoming of Kant's understanding of teleology as a regulative principle and their movement towards an interpretation of purposiveness as the hallmark of natural life. Hegel resumes this critique and brings it to its fullest philosophical potential by making explicit everything that was largely left implicit in previous criticisms. The most important result of his philosophical analysis is his observation that Kant's account of teleology is underwritten with the unspoken assumption that purposiveness can only be understood as analogous with conscious intentions. To the contrary, in accordance with the rest of the post-Kantian tradition, Hegel interprets teleology in terms of self-organization and autonomy.

4 General Conclusion

The account Hegel provides as an "external observer" points out once again that the post-Kantian philosophy of nature was a multifaceted phenomenon combining several approaches all characterized by a conception of teleology as the most unique characteristic of living organisms. These approaches cannot easily be divided in two clearly opposing camps. This one-sided approach to historicizing the rise of biology in Germany must be overcome if we want to reach an accurate understanding of the multiple conceptions of organic nature characterizing this period. In this sense, emphasizing the limits and excesses of *Naturphilosophie* does not imply the need to discredit it *tout court* as a historical phenomenon but rather the importance of aiming for a more objective assessment of its role within the epistemological history of the life sciences.

In his well-known reconstruction of the relationship between teleology and mechanics in nineteenth-century German biology, Timothy Lenoir envisions the *Biologie, oder Philosophie der lebenden Natur für Naturforscher und Aerzte* (1802–1822) as the most paradigmatic realization of the Göttingen research program for the life sciences. The "transcendental biology" of the Göttingen School, Lenoir claims, thereafter concluded its formative period, as Treviranus succeeded in consolidating various aspects of the program that had been under intense debate since the 1750s with Haller's translation of Buffon's *Histoire naturelle* and synthesizing them into a dynamic theory of organic nature. Lenoir does not disregard the relationship between Göttingen's conceptual framework and Romantic *Naturphilosophie*. Indeed, through careful reading of Schelling's early philosophy of nature, in conjunction with the critical edition of his correspondence, Lenoir in fact argues that while in Leipzig, a period during which Schelling devoted himself almost exclusively to acquiring background in natural science, he studied the works of the Göttingen School, especially Georg Christoph Lichtenberg (1742–1799), Blumenbach, and Kielmeyer. Through direct personal contact with Christian Heinrich Pfaff (1773–1852) and Karl August Eschenmayer (1768–1852), Schelling also gained in-depth knowledge of Kielmeyer's *Physik der Tierreichs*.

In addition to these personal connections and influences, Lenoir highlights other intellectual ties between the two traditions, such as the concepts of *Einheit*, *Stufenfolge*, *Polarität*, *Metamorphose*, *Urtyp* and *Analogie*. Similarly, the dynamic interaction of vital forces in the work of Kielmeyer bears strong similarity to Schelling's notion of polarity, as well as to the use Nees von Esenbeck (1776–1858) and Oken make of that notion. Surprisingly, however, after stressing the proximity between Göttingen and Jena (the capitol city of Romantic *Naturphilosophie*), Lenoir maintains that, besides the strong similarities across key concepts of these approaches, there are major differences in the way they interpret and grant significance to those concepts. Most importantly, he argues that the Göttingen tradition worked hard at remaining consistent with Kant's philosophy of organic nature, while *Naturphilosophie* worked to overcome it. I believe that the narrative I have traced shows this distinction to be arbitrary and historically untenable.

I agree with John Zammito that "vital materialism," as it was developed at Göttingen, is not quite the Kantian "transcendental philosophy of nature." On the contrary, we find the Göttingen School far closer to the *Naturphilosophen*. Instead of viewing the closeness of the Göttingen School to Romantic *Naturphilosophie* as a form of contamination, we might instead view it as a historical index of something essential to the character of biology as a distinct science.[35] I hope to have shown that what was at stake in this proximity was a shift from a regulative to a constitutive understanding of teleology, which, at least in the German-speaking world, can be regard as the historical condition for the emergence of biology as a field. In particular, this implied two key-elements: (1) transition from a *technical* understanding of teleology as *external* purposiveness, i.e. as intention and intelligent design, to an understanding of teleology as *internal* purposiveness, i.e. as an *autonomous* process of self-organization; and (2) a program for a systematic reform of natural history aimed at turning it into a form of comparative physiology endowed with specific principles and laws that differed from those of physics and chemistry. It is thanks to these historical developments that biology emerged in Germany as the general science dealing with the teleological laws regulating the organization of living nature.

[35] Zammito (2012), 130.

References

Sources

Adickes, E. (1924). *Kant als Naturforscher*, Vol. I. Tübingen: De Gruyter.

Blumenbach, J. F. (1787). *Institutiones physiologicae*, Göttingen: Dieterich. English translation: Ellioston, J. (1828). *The elements of physiology.* London: Spottiswoode.

Blumenbach, J. F. (1781). *Über den Bildungstrieb und das Zeugungsgeschäfte*. Göttingen: Dieterich.

Blumenbach, J. F. (1789). Erste Abhandlung über die Nutritionskraft. In *Zwo Abhandlungen über die Nutritionskraft*. St. Petersburg: Kaiserliche Akademie der Wissenschaften.

Blumenbach, J. F. (1791). *Über den Bildugstrieb*. Göttingen: Dieterich.

Blumenbach, J. F. (1814). *Handbuch der Naturgeschichte*. Göttingen: Dieterich. English translation: Gore, R. T. (1825). *A manual of the elements of natural history*. London: Smith.

Blumenbach, J. F. (1825). Handbuch der Naturgeschichte, Göttingen: Dieterich, English translation by R. T. Gore, *A manual of the elements of natural history*. London: Smith.

Bonnet, C. (1985). Considérations sur les corps organisés, ou l'on traite de leur origine, de leur développement, de leur reproduction, etc. Amsterdam: M. M. Rey, 1762; 2nd ed., 1768; 3rd ed., 1779. Vol. 22 *of Oeuvres d'histoire naturelle et de philosophie*. Neuchâtel: Fauche, 1779–83. Rpt., Paris: Fayard, pp. 467–468.

Boury, D. (2004). *La philosophie médicale de Théophile de Bordeu (1722–1776)*. Paris: Honoré Champion.

Boury, D. (2008). Irritability and sensibility: Key concepts in assessing the medical doctrines of Haller and Bordeu. *Science in Context, 21*(4), 521–535.

Carus, K. G. (1828). *Von den Ur-theilen des Knochen- und Schalengerüstes*. Leizig: Gerhard Fleischer.

Dahlstrom, D. O. 1998. Hegel's appropriation of Kant's account of teleology in nature. In S. Houlgate, (Ed.), *Hegel and the philosophy of nature* (pp. 167–188). New York: SUNY Press.

Girtanner, C. (1796). *Über das Kantische Prinzip für Naturgeschichte: ein Versuch diese Wissenschaft philosophisch zu behandeln*. Göttingen: Vandenhoef und Ruprecht.

Goethe, J. W. (1994). In D. von Kuhn & W. von Engelhardt (Eds.), *Die Schriften zur Naturwissenschaft, vollständige mit Erlauterungen versehene Ausabe in Auftrage der Deutschen Akademie der Naturforscher Leopoldina*, *Band 9*. Weimar: Böhlau.

Goethe, J. W. (2009). *The metamorphosis of plants*. Cambridge, MA: MIT Press.

Guyer, P. (2001). Organisms and the Unity of Science, In E. Watkins (Ed.), *Kant and the sciences* (pp. 259–281). Oxford University Press.

A. Gambarotto, *Vital Forces, Teleology and Organization*, History, Philosophy and Theory of the Life Sciences 21, DOI 10.1007/978-3-319-65415-7

Haller, A. (1752). Preface to *Allgemeine Historie der Natur*. Reprinted: Roe, S. (1981). *The natural philosophy of Albrecht von Haller*. New York: Arno Press.

Haller, A. (1753). *De partibus corporis humani sensilibus et irritabilibus*. Göttingen: Vandelhoeck. English translation: Roe, S. (1981). *The natural philosophy of Albrecht von Haller*. New York: Arno Press.

Haller, A. (1767). *Primae lineae phyiologiae: in usum praelectionum academicarum, ad editionem tertio auctam & emendatam expressae*. English translation: Cullen, W. (1801). *First lines of physiology*. Neill: Edinburgh.

Haller, A. (1981). Dissertation on the sensible parts and irritable parts of animals. In S. Roe (Ed.), *The natural philosophy of Albrecht von Haller* (pp. 651–699). New York: Arno Press.

Hegel, G. W. F. (1980). In W. von Bonsiepen & R. Heede (Eds.), *Phänomenologie des Geistes*. Hamburg: Felix Meiner.

Hegel, G. W. F. (1981). In F. von Hogemann & H.-C. Lucas (Eds.), *Wissenschaft der Logik, zweiter Band, Die Subjektive Logik*. Hamburg: Felix Meiner.

Hegel, G. W. F. (1986). *Enzyklopädie der Philosophischen Wissenschaften im Grundrisse (1830), II: Die Naturphilosophie*. Frankfurt: Surkhamp.

Hegel, G. W. F. (1992). In W. von Bonsiepen & R. Heede (Eds.), *Enzyklopädie der Philosophischen Wissenschaften im Grundrisse (1830)*. Hamburg: Felix Meiner.

Herder, J. G. (1989). In M. von Bollacher (Ed.), *Ideen Zur Philosophie der Geschichte der Menschheit*. Frankfurt am Main: Deutscher Klassischer Verlag.

Kant, I., Ak III. (1968). *Kritik der Reinen Vernunft 2. Auflage 1787*. Berlin: Akademie Ausgabe/Band III. English translation: Guyer, P. & Wood, A.P. (2000). *Critique of pure reason*. Cambridge: Cambridge University Press.

Kant, I., Ak IV. (1968). *Metaphysische Anfangsgründe der Naturwissenschaft*. Berlin: Akademie Ausgabe/Band IV. English translation: Friedman, M. (2004). *Metaphysical foundations of natural science*. Cambridge: Cambridge University Press.

Kant, I., Ak V. (1968). *Kritik der Urteilskraft*. Berlin: Akademie Ausgabe/Band V. English translation: Guyer P., Matthews, E. (2000). *Critique of the power of judgment*. Cambridge: Cambridge University Press.

Kant, I., Ak VIII .(1968). *Abhandlungen nach 1981*. Berlin: Akademie Ausgabe/Band VIII. English translation: Zöller, G., Louden, R. B. *Anthropology, History, and Education*. Cambridge: Cambridge University Press.

Kant, I. (1972). *Briefwechsel*, *Selected and annotated by Otto Schöndörffer*. Hamburg: Felix Meiner Verlag.

Kanz, K. T. (1997). Nationalismus und internationale Zusammenarbeit in den Naturwissenschaften. *Die deutsch-französischen Wissenschaftsbeziehungen zwischen Revolution und Restauration*, 1789–1832, Franz Steiner: Stuttgart.

Kielmeyer, K. F. (1938). *Natur und Kraft. Gesammelte Schriften, hsgb. von F.-H. Holler unter Mitwirkung von J. Schuster, nach den Handschriften zum erstenmal veröffentlicht*. Berlin: Keiper.

Kielmeyer, K. F. (1993). *Ueber die Verhältniße der organischen Kräfte untereinander in der Reihe der verschiedenen Organisationen, die Geseze und Folgen dieser Verhältniße*. Marburg: Basiliken-Presse.

Lamarck, J. B. (1986). *Recherches sur l'organisation des corps vivants*. Paris: Fayard.

Link, H. F. (1795). *Beyträge zur Naturgeschichte, Vol. 2: Ueber die Lebenskräfte in naturhistorischer Rücksicht, und die Classification der Säugthiere*. Rostock/Leipzig: Karl Christoph Stillers Buchhandlung.

Link, H. F. (1806). *Über die Naturphilosophie*. Leipzig et Rostock: Stiller.

Mikkelsen, J. M. (Ed.). (2014). *Kant and the concept of race*. New York: SUNY Press.

Newton, I. (1999). *Philosophiae Naturalis Principia Mathematica*. Third edition (1726). English translation: Cohen, I. B., Whitman, A. *mathematical principles of natural philosophy*, Berkeley/Los Angeles: University of California Press.

Oken, L. (1805a). *Die Zeugung*. Bamberg und Würzburg: Joseph Anton Göbhardt.

Oken, L. (1805b). *Abriß der System der Biologie*, *Zum Behufe seiner Vorlesungen*. Göttingen: Vandenhoek und Ruprecht.

Oken, L. (1806). In L. Oken & D. G. Kieser (Eds.), *Beiträge zur vergleichenden Zoologie, Anatomie und Physiologie*, *Band I*. Bamberg und Würzburg: Joseph Anton Göbhardt.

Oken, L. (1807). *Über die Bedeutung der Schädelknochen*. Ein Programm beim Antritt der Professur an der Gesamt-Universität zu Jena von Dr. Oken, correspondirendem Mitgliede der königl. Societät der Wissenschaften zu Göttingen, Christian Gottfried Göpferdt.

Oken, L. (1847). *Elements of physiophilosophy*. English translation: Alfred Tulk, *Lehrbuch der Naturphilosophie*. London: Ray Society.

Owen, R. (1848). *On the archetype and homologies of the vertebrate skeleton*. London: Taylor.

Owen, R. (1849). *On the nature of limbs*. London: van Voorst.

Reil, J. C. (1795). In K. von Sudhoff (Ed.), *Von der Lebenskraft*, *Neuauflage (1916)*. Leipzig: Barth.

Schelling, F. W. J. (2000). *Von der Weltseele. Eine Hypothese der höhern Physik zur Erklärung des allgemeinen Organismus*, *hrgb. Von J. Jantzen unter mitwirkung von T. Kisser*. Stuttgart: Frommann-Holzboog.

Schelling, F. W. J. (2001a). *Erster Entwurf eines Systems der Naturphilosophie*, hrgb. von W.G. Jacobs und P. Ziche, Stuttgart: Frommann-Holzboog. English translation: Peterson, K.R. (2004). *First outline of a system of the philosophy of nature*. New York: SUNY Press.

Schelling, F. W. J. (2001b). *Briefe 1: Briefwechsel 1786–1799*. von I. Möller und W. Schieche, Stuttgart: Frommann-Holzboog.

Schmitt, S., 2010. La question de l'espèce, de sa constance et de ses variations chez Buffon et chez ses contemporains. In Georges Louis Leclerc de Buffon (Ed.), *Œuvres complètes. Volume 5, Histoire naturelle, générale et particulière, avec la description du Cabinet du Roi, Tome Cinquième (1755)* (pp. 12–68). Paris: Honoré Champion.

Treviranus, G. R. (1802). *Biologie, oder Philosophie der lebenden Natur für Naturforcher und Ärzte*, *Band I*. Göttingen: Röwer.

Treviranus, G. R. (1803). *Biologie, oder Philosophie der lebenden Natur für Naturforcher und Ärzte*, *Band II*. Göttingen: Röwer.

Treviranus, G. R. (1805). *Biologie, oder Philosophie der lebenden Natur für Naturforcher und Ärzte*, *Band III*. Göttingen: Röwer.

Treviranus, G. R. (1814). *Biologie, oder Philosophie der lebenden Natur für Naturforcher und Ärzte*, *Band IV*. Göttingen: Röwer.

Treviranus, G. R. (1818). *Biologie, oder Philosophie der lebenden Natur für Naturforcher und Ärzte*, *Band V*. Göttingen: Röwer.

Treviranus, G. R. (1822). *Biologie, oder Philosophie der lebenden Natur für Naturforcher und Ärzte*, *Band VI*. Göttingen: Röwer.

Weber, A., & Varela, F. (2002). Life after Kant: Natural purposes and the autopoietic foundations of biological individuality. *Phenomenology and the Cognitive Sciences, 97*(1), 97–125.

Wolff, C. F. (1759). *Theoria generationis*. Halle: Hendel.

Wolff, C. F. (1764). *Theorie von der generation*. Berlin: Birnstiel.

Wolff, C. F. (1789). *Von der eigentümlichen und wesentlichen Kraft der vegetablischen sowohl als auch der animalischen Substanz*. In *Zwo Abhandlungen über die Nutritionskraft*. St. Petersburg: Kaiserliche Akademie der Wissenschaften.

Wolff, C. F. (1793/1973). *Objecta meditationum pro theoria monstrorum* (T. A. Lukina Ed.). Leningrad: Nauk.

Zimmerman, J. G. (1751). *Dissertatio physiologica de irritabilitate*. Göttingen: Vanderhoeck.

Literature

Amundson, R. (2005). *The changing role of the embryo in evolutonary thought*. Cambridge: Cambridge University Press.

Appel, T. A. (1987). *The Cuvier-Geoffroy debate. French biology in the decades before Darwin*. Oxford: Oxford University Press.

Bach, T. (1994). Kielmeyer als Vater der Naturphilosophie? Anmerkungen zu seiner Rezeption in deutschen Idealismus. In K. T. Kanz (Ed.), *Philosophie des Organischen in der Goethezeit: Studien zu Werk und Wirkung des Naturforschers Carl Friedrich Kielmeyer (1765–1844)* (pp. 232–251). Stuttgart: Steiner.
Bach, T. (2001a). *Biologie und Philosophie bei C.F. Kielmeyer und F.W.J. Schelling*. Stuttgart/Bad Cannstatt: Frommann-holzboog..
Bach, T. (2001b). Was ist das Thierreich anders als der anatomirte Mensch …? Oken in Göttingen (1805–1807). In O. von Breidbach, H.-J. Fliedner, & K. Ries (Eds.), *Lorenz Oken (1779–1851). Ein politischer Naturphilosoph* (pp. 73–91). Weimar: Böhlau Nachfolger.
Baker, J. (1954). *Abraham Trembley of Geneva, scientist and philosopher, 1710–1784*. London: Arnold.
Balan, B. (1979). *L'Ordre Et Le Temps: L'Anatomie Comparee Et L'Histoire Des Vivants Au XIXe Siècle*. Paris: Vrin.
Barsanti, G. (1979). *Dalla storia naturale alla storia della natura: Saggio su Lamarck*. Milano: Feltrinelli.
Barsanti, G. (1992). *La scala, la mappa, l'albero: Immagini e classificazioni della natura tra sei e ottocento*. Firenze: Sansoni.
Benton, E. (1978). Vitalism in nineteenth-century thought: A typology and reassessment. *Studies in History and Philosophy of Science Part A, 5*(1), 17–48.
Brady, R. (1998). The idea in nature: rereading Goethe's organics. In D. Seamon & A. Zajonc (Eds.), *Goethe's way of science: A phenomenology of nature* (pp. 83–111). Albany: SUNY Press.
Breidbach, O., Fliedner, H. J., & Ries, K. (Eds.). (2001). *Lorenz Oken (1779–1851). Ein politischer Naturphilosoph*. Weimar: Herman Böhlhaus.
Caneva, K. L. (1990). Teleology with regrets. *Annals of Science, 47*, 291–300.
Canguilhem, G. (1962). *Du développement à l'évolution au XIXe siècle*. Paris: Puf.
Canguilhem, G. (2008). *Knowledge of life*. New York: Fordham University Press.
Cheung, T. (2006). From the organism of a body to the body of an organism: Occurrence and meaning of the word 'organism' from the seventeenth to the eighteenth centuries. *The British Journal for the History of Science, 39*(3), 319–339.
Chiereghin, F. (1990). Finalità e idea della vita. La ricezione hegeliana della teleologia di Kant. *Verifiche, 19*(1), 127–230.
Coleman, W. (1973). Limits of the recapitulation theory. Carl Friedrich Kielmeyer's critiuque of the presumed parallelism of earth history, ontogeny, and the present order of organisms. *Isis, 63*(3), 341–350.
Coleman, W. (1977). *Biology in the nineteenth century: Problems of form, function, and transformation*. Cambridge: Cambridge University Press.
Corsi, P. (1988). *The age of Lamarck*. In *Evolutionay theories in France: 1790–1830*. Berkeley: University of California Press.
Corsi, P., Gayon, J., Gohau, G., & Tirard, S. (2006). *Lamarck, philosophe de la nature*. Paris: Puf.
Cunningham, A. (2002). The pen and the sword: Recovering the disciplinary identity of physiology and anatomy before 1800. *Studies in History and Philosophy of Science Part C: Biological and Biomedical Sciences, 33*(4), 631–665.
Cunningham, A., & Jardine, N. (Eds.). (1990). *Romanticism and the sciences*. Cambridge: Cambridge University Press.
DeJager T. F. (1991). *G.R. Treviranus (1776–1837) and the biology of a world in transition*. PhD dissertation, University of Toronto.
Duchesneau, F. (1982). *La physiologie des Lumières. Empirisme, modèles et théories*. La Hague/Boston/London: Nijhoff.
Duchesneau, F. (1985). Vitalism in late eighteenth-century physiology: The cases of Blumenbach, Barthez and John Hunter. In W. F. Bynum & R. Porter (Eds.), *John hunter and the eighteenth-century medical world*. Cambridge: Cambridge University Press.
Duchesneau, F. (2017). *Organisme et corps organique de Leibniz à Kant*. Paris: Vrin.

Dupont, J. C. (2007). Pre-Kantian Revival of Epigenesis: Caspar Friedrich Wolff's De Formatione Intestinorum (1768–69). In P. Huneman (Ed.), *Understanding Purpose. Kant and the Philosophy of Biology*, *North American Kant society studies in philosophy, 8* (pp. 37–50). Rochester: University of Rochester Press.

Dupont, J. C., & Perrin, M. (Eds.). (2003). *Caspar Friedrich Wolff. De formatione intestinorum. La formation des intestins (1768–1769)*. Turnhout: Brepols.

Fabbri-Bertoletti, S. (1990). *Impulso, formazione e organismo. Per una storia del concetto di Bildungstrieb nella cultura tedesca*. Firenze: Olschki.

Fichant, M. (2003). Leibniz et les machines de la nature. *Studia Leibnitiana, 35*(1), 1–28.

Fischer, M. (2007). Kant's explanatory natural history: Generation and classification of organisms in Kant's natural philosophy. In P. Huneman (Ed.), *Understanding purpose. Kant and the philosophy of biology*, *North American Kant society studies in philosophy, 8* (pp. 101–122). Rochester: University of Rochester Press.

Friedman, M. (1992). *Kant and the exact sciences*. Cambridge, MA: Harvard University Press.

Gambarotto, A. (2010). Struttura e significato metacategoriale della soggettività nella logica di Hegel. *Verifiche, 39*(1–4), 215–249.

Gambarotto, A. (2014a). Vital forces and organization: Philosophy of nature and biology in K.F. Kielmeyer. *Studies in History and Philosophy of Biological and Biomedical Sciences, 48* (2014), 12–20.

Gambarotto, A. (2014b). Teleology beyond regrets: On the role of Schelling's organicism in Treviranus' biology. In A. Gambarotto & L. Illetterati (eds.), *The Notion of Organism. Historical and Conceptual Approaches, Verifiche*, 43(1–4), 137–164.

Gerabek, W. E. (2001). Lorenz Oken und die Medizin der Romantik: Die Würzburger Zeit des Naturforschers (1804–1805). In *Lorenz Oken (1779–1851). Ein politischer Naturphilosoph*. Weimar: Herman Böhlhaus.

Giacomoni, P. (1993). *Le forme e il vivente: morfologia e filosofia della natura in J.W. Goethe*. Napoli: Guida Editori.

Giglioni, G. (2008). What ever happened to Francis Glisson? Albrecht Haller and the fate of eighteenth-century irritability. *Science in Context, 21*(4), 465–493.

Ginsborg, H. (2001). Kant on understanding organisms as natural purposes. In E. Watkins (Ed.), *Kant and the sciences* (pp. 231–258). Oxford: Oxford University Press.

Ginsborg, H. (2006). Kant's biological teleology and its philosophical significance. In G. Bird (Ed.), *The blackwell companion to Kant* (pp. 455–469). Oxford: Blackwell Publishing.

Gould, S. J. (1977). *Ontogeny and phylogeny*. Cambridge: Harvard University Press.

Goy, I., & Watkins, E. (Eds.). (2014). *Kant's theory of biology*. Berlin/New York: De Gruyter.

Guyer, P. (2005). Purpose in nature: What is living, and what is dead in Kant's teleology? In P. Guyer (Ed.), *Kant's system of nature and freedom* (pp. 343–372). Oxford: Oxford University Press.

Huneman, P. (2006). Naturalizing purpose: From comparative anatomy to the adventure of reason. *Studies in History and Philosophy of Biological and Biomedical Sciences, 37*(4), 621–656.

Huneman, P. (2007a). *Understanding purpose. Kant and the philosophy of biology*, *North American Kant society studies in philosophy, 8*. Rochester: University of Rochester Press.

Huneman, P. (2007b). Reflexive judgment and Wolffian embriology: Kant's shift between the first and the third critique. In *Understanding purpose. Kant and the philosophy of biology*, *North American Kant society studies in philosophy, 8* (pp. 75–100). Rochester: University of Rochester Press.

Huneman, P. (2008). *Métaphysique et biologie. Kant et la constitution du concept d'organisme*. Paris: Kimé.

Huneman, P. (2011a). Vie, vitalisme et émergence: une perspective contemporaine. In P. Nouvel (Ed.), *Répenser le vitalisme*. Paris: Puf.

Huneman, P. (2011b). Adaptation et hérédité: la conception kantienne des espèces et des races. In *Kant: L'anthropologie et l'histoire* (pp. 97–114). Paris: L'Harmattan.

Illetterati, L. (1992). Sulla posizione di Hegel nei confronti della *Naturphilosophie* romantica. *Verifiche, 21*(4), 413–452.

Illetterati, L. (1995). *Natura e ragione: Sullo sviluppo dell'idea di natura in Hegel*. Trento: Verifiche.

Illetterati, L. (2008). Being for. Purposes and functions in artifacts and living beings. In L. Illetterati & F. Michelini (Eds.), *Purposiveness: Teleology between nature and mind* (pp. 135–161). Ontos: Frankfurt.

Illetterati, L. (2010). Biologia. In S. Besoli, C. La Rocca, & R. Martinelli (Eds.), *L'universo kantiano: Filosofia, scienze, sapere* (pp. 53–96). Macerata: Quodlibet.

Jahn, I. (1994). On the origins of romantic biology and its further development at the University of Jena between 1790 and 1850. In S. Poggi & M. Bossi (Eds.), *Romanticism in science* (pp. 75–89). Dordrecht/Boston/London: Kluwer.

Jardine, N. (1991). *The scenes of inquiry: On the reality of questions in the science*. Oxford: Clarendon Press.

Jardine, N. (1996). *Naturphilosophie* and the kingdoms of nature. In N. Jardine, J. Secord, & E. Spary (Eds.), *Cultures of natural history* (pp. 230–245). Cambridge: Cambridge University Press.

Kanz, K. T. (1994). *Philosophie des Organischen in der Goethezeit*. In *Studien zu Werk und Wirkung des Naturforschers Carl Friedrich Kielmeyer (1765–1844)*. Stuttgart: Franz Steiner Verlag.

Lakatos, I. (1978). *The methodology of scientific research programmes*. Cambridge: Cambridge University Press.

Larson, J. L. (1979). Vital forces: Regulative principles or constitutive agents? A strategy in German phisiology, 1786–1802. *Isis, 70*, 235–249.

Larson, J. L. (1994). *Interpreting nature: The science of living form from Linnaeus to Kant*. Baltimore: John Hopkins University Press.

Laurent, G. (2001). *La naissance du transformisme: Lamarck entre Linné et Darwin*. Paris: Vuibert et Adapt.

Lenhoff, S. G. (1986). *Hydra and the birth of experimental biology, 1744: Abraham Trembley's Mémoires concerning the polyps*. Pacific Grove: The Boxwood Press.

Lenoir, T. (1978). Generational factors in the origin of romantische naturphilosophie. *Journal of the History of Biology, 11*(1), 57–108.

Lenoir, T. (1980). Kant Blumenbach and the vital materialism in German biology. *Isis, 70*, 77–108.

Lenoir, T. (1981a). Teleology without regrets. The transformation of physiology in Germany: 1790–1847. *Studies in History and Philosophy of Science, Part A, 12*(4), 293–354.

Lenoir, T. (1981b). The Göttingen school and the development of transcendental naturphilosophie in the romantic era. *Studies in the History of Biology, 5*, 111–205.

Lenoir, T. (1982). *The strategy of life: Teleology and mechanics in nineteenth-century German biology*. Dordrecht: Reidel.

Löw, R. (1980). *Philosophie des Lebendigen: Der Begriff des Organischen bei Kant, sein Grund und seine Aktualität*. Frankfurt: Suhrkamp.

Marcucci, S. (1979). *Aspetti epistemologici della finalità in Kant*. Firenze: Le Monnier.

McLaughlin, P. (1982). Blumenbach und der Bildungstrieb: Zum Verhältnis von epigenetischer Embryologie und typologischen Artbegriff. *Medizinhistorisches Journal, 17*(4), 357–372.

McLaughlin, P. (1989). *Kants Kritik der teleologischen Urteilskraft*. Bonn: Bouvier.

McLaughlin, P. (1990). *Kant's critique of teleology in biological explanation: Antinomy and teleology*. New York: Mellem Lewinston.

McLaughlin, P. (2004). Naming biology. *Journal of the History of Biology, 35*(1), 1–4.

McLaughlin, P. (2007). Kant on Heredity and Adaptation. In S. Müller-Wille & H.-J. Rheinberger (Eds.), *Heredity produced: At the crossroads of biology, politics and culture 1500–1870* (pp. 277–291). Cambridge, MA: MIT Press.

Mensch, J. (2013). *Kant's organicism: Epigenesis and the development of critical philosophy*. Chicago: The University of Chicago Press.

Monti, M. T. (1990). *Congettura ed Esperienza nella Fisiologia di Haller: La Riforma dell'Anatomia Animata e il Sistema della Generazione*. Firenze: Olschki.

Nunziante, A. M. (2002). *Organismo come armonia: La genesi del concetto di organismo vivente in G.W. Leibniz*. Trento: Verifiche.

Philonenko, A. (1982). Kant et la philosophie biologique. In *L'heritage de Kant: Melanges philosophiques offerts au P. Marcel Regnier* (pp. 63–79). Paris: Beauchesne.
Poggi, S. (2000). *Il genio e l'unità della natura. La scienza nella Germania romantica*. Bologna: Il Mulino.
Ratcliff, M. (2004). Abraham Trembley's strategy of generosity and the scope of celebrity in the mid-eighteenth century. *Isis, 95*, 555–575.
Rehbock, P. F. (1990). *Transcendental anatomy*. In A. Cunningham & N. Jardine (Eds.), *Romanticism and the sciences*. Cambridge: Cambridge University Press.
Reill, H. P. (2005). *Vitalizing nature in the enlightenment*. Berkeley: California University Press.
Rey, R. (2000). *Naissance et développement du vitalisme en France de la deuxième moitié du 18e siècle à la fin du Premier Empire*. Oxford: Voltaire Foundation.
Richards, R. J. (1992). *The meaning of evolution: The morphological construction and ideological reconstruction of Darwin's theory*. Chicago: University of Chicago Press.
Richards, R. J. (2000). Kant and Blumenbach on the *Bildungstrieb*: A historical misunderstanding. *Studies in History and Philosophy of Biological and Biomedical Sciences, 31*(1), 11–32.
Richards, R. J. (2002). *The romantic conception of life. Science and philosophy in the age of Goethe*. Chicago: University of Chicago Press.
Roe, S. A. (1975). The development of Albrecht von Haller's views on embryology. *Journal of the History of Biology, 8*, 167–190.
Roe, S. A. (1981). *Matter, Life, generation: eighteenth-century embryology and the Haller-Wolff debate*. Cambridge: Cambridge University Press.
Roger, J. (1963). *Les sciences de la vie dans la pensée française du XVIII siècle. La génération des animaux de Descartes à l'Encyclopédie*. Paris: Armand Colin.
Russell, E. W. (1916). *Form and function: A contribution to the history of animal morphology*. London: John Murray.
Sartenaer, O. (2017). Disentangling the vitalism-emergentism knot. *Journal for General Philosophy of Science, 48*, 1–16.
Schmitt, S. (2004). *Les parties répétées. Histoire d'une question anatomique*. Paris: Éditions du Muséum National d'Histoire Naturelle.
Schmitt, S. (2006). *Les forces vitales et leur distribution dans la nature: Un essai de « systématique physiologique »*, texte de C. F. Kielmeyer (1765–1844), H. F. Link (1767–1851) et L. Oken (1779–1851) rassemblés, introduits et annotés par S. Schmitt, Turnhout: Brepols.
Schmitt, S. (2007). Succession of functions and classification in post-Kantian naturphilosophie around 1800. In *Understanding purpose. Kant and the philosophy of biology*, *North American Kant society studies in philosophy, 8* (pp. 123–136). Rochester: University of Rochester Press.
Schmitt, S. (2009). Comparative anatomy and Vicq d'Azyr plan reform for life sciences and medicine. *Science in Context, 22*(2), 145–193.
Sloan, P. (1976). The Linnaeus-Buffon controversy. *Isis, 67*(3), 356–375.
Sloan, P. (1979). Buffon, German biology and the historical interpretation of biological species. *The British Journal for the History of Science, 12*(2), 109–153.
Sloan, P. (1992). On the edge of evolution. In R. Owen (Ed.), *Hunterian lectures in comparative anatomy, May-June, 1837*. Chicago: University of Chicago Press.
Sloan, P. (2002). Preforming the categories: Eighteenth-century generation theory and the biological roots of Kant's a priori. *Journal of the History of Biology, 40*(2), 229–253.
Sloan, P. (2006). Kant on the history of nature: The ambiguous heritage of the critical philosophy for natural history. *Studies in History and Philosophy of Biological and Biomedical Sciences, 37*(4), 627–648.
Sloan, P. (2007). Kant and the British bioscience. In P. Huneman (Ed.), *Understanding purpose. Kant and the philosophy of biology*, *North American Kant society studies in philosophy, 8* (pp. 149–171). Rochester: University of Rochester Press.
Smith, J. E. H. (2003). *Divine machines: Leibniz and the sciences of life*. Princeton: Princeton University Press.

Steigerwald, J. (2002a). Goethe's morphology: *Urphänomene* and aesthetic appraisal. *Journal of the History of Biology, 35*, 291–328.
Steigerwald, J. (2002b). Instruments of Judgment: Inscribing organic processes in late eighteenth-century Germany. *Studies in History and Philosophy of Biological and Biomedical Sciences, 33*, 79–131.
Steigerwald, J. (2006). Kant's concept of natural purpose and the reflective power of judgment. *Special Issue of Studies in History and Philosophy of the Biological and Biomedical Sciences, 37*(4), 712–734.
Steigerwald, J. (2010). Natural purposes and the reflecting power of judgment: The problem of the organism in Kant's critical philosophy. *European Romantic Review, 21*(3), 291–308.
Steigerwald, J. (2013). Rethinking organic vitality in Germany at the turn of the nineteenth century. In *Vitalism and the scientific image in post-enlightenment life science, 1800–2010*. Dordrecht: Springer.
Steigerwald, J. (2014). Treviranus' *biology*: Generation, degeneration and the boundaries of life. In *Gender, race, and reproduction: Philosophy and the early life sciences in context*. New York: SUNY Press.
Steinke, H. (2005). *Irritating experiments: Haller's concept and the European controversy on irritability and sensibility, 1750–90*. Amsterdam/New York: Rudopi.
Toepfer, G. (2010). *Historisches Wörterbuch der Biologie: Geschichte und Theorie der biologischen Grundbegriffe*. Stuttgart/Weimar: Metzler.
Van den Berg, H. (2009). Kant on vital forces: Metaphysical concerns versus scientific practice. In *Kants Philosophie der Natur: Ihre Entwicklung im Opus Postumum und ihre Wirkung* (pp. 115–136). Berlin/New York: De Gruyter.
Van den Berg, H. (2014). *Kant on proper science: Biology in the critical philosophy and the Opus Postumum*. Dordrecht: Springer.
Watkins, E. (2001). *Kant and the sciences*. Oxford: Oxford University Press.
Wellmann, J. (2001). Pariser Wallfahrten: Deutsch-französischer Wissenschaftstransfer am Beispiel Lorenz Okens und Étienne Geoffroy Saint-Hilaire. *Francia, 27*, 25–48.
Williams, E. A. (2003). *A cultural history of enlightenment vitalism in montpellier*. Farnham: Ashgate.
Witt, E. (2008). Form – A matter of generation: The relation of generation, form, and function in the epigenetic theory of Caspar F. Wolff. *Science in Context, 21*(4), 649–664.
Wolfe, C. T. (Ed.). (2008). *Vitalism without metaphysics? Medical vitalism in the enlightenment*. Cambridge: Cambridge University Press.
Wolfe, C. T. (2013). Teleomechanism redux? Functional physiology and hybrid models of life in early modern natural philosophy. *Gesnerus – Revue Suisse d'Histoire de la Médicine et des Sciences, special issue, Entre mécanisme et téléologie: Anatomie, physiologie et philosophie des fonctions (16e – 18e siècles).*
Wolfe, C. T. (2014). On Newtonian analogies in eighteenth-century life science: Vitalism and provisionally inexplicable explicative devices. In *Newton and empiricism* (pp. 223–261). Oxford: Oxford University Press.
Wolfe, C. T., & Normadin, S. (Eds.). (2013). *Vitalism and the scientific image in post-enlightenment life sciences, 1800–2010*. Dordrecht: Springer.
Wolfe, C. T., & Terada, M. (2008). The animal economy as object and program in Montpellier vitalism. *Science in Context, 21*(4), 537–579.
Zammito, J. (1992). *The genesis of Kant's critique of judgment*. Chicago: University of Chicago Press.
Zammito, J. (2002). *Kant, Herder and the birth of anthropology*. Chicago: University of Chicago Press.
Zammito, J. (2003). This inscrutable principle of an original organization: Epigenesis and looseness of fit in Kant's philosophy of science. *Studies in History and Philosophy of Science, 34*(1), 73–109.

Zammito, J. (2006). Teleology then and now: The question of Kant's relevance for contemporary controversies over functions in biology. *Studies in History of Biological and Biomedical Sciences, 37*(4), 748–770.

Zammito, J. (2007). Kant's persistent ambivalence toward epigenesis 1764–90. In P. Huneman (Ed.), *Understanding purpose: Kant and the philosophy of biology*, *North American Kant society studies in philosophy, 8* (pp. 51–74). Rochester: University of Rochester Press.

Zammito, J. (2012). The Lonoir Thesis revisited: Blumenbach and Kant. *Studies in History and Philosophy of Science, Part C: Biological and Biomedical Sciences, 43*(1), 120–132.

Zittel, M. (2001). Lorenz Oken und Goethe: Die Geschichte einer heillosen Beziehung. In O. Breidbach, H. J. Fliedner, & K. Ries (Eds.), *Lorenz Oken (1779–1851): Ein politischer Naturphilosoph*. Herman Böhlhaus: Weimar.

Zuckert, R. (2007). *Kant on beauty and biology: An interpretation of the critique of judgement*. Cambridge: Cambridge University Press.

Zumbach, C. (1984). *The transcendent science*. In *Kant's conception of biological methodology*. The Hague: Nijhoff.