

Kant, Blumenbach, and Vital Materialism in German Biology

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ONE OF THE MOST INTERESTING and previously unexplored chapters in the history of German biology is the role of Immanuel Kant in helping to shape the theoretical foundations of the life sciences between 1790 and the late 1840s. There are numerous indications that the new physiology which emerged during this period was indebted to Kant for many of its central methodological insights. Indeed we learn from Helmholtz's correspondence that in order to understand Johannes Müller's lectures fully his spare moments had to be filled with reading Kant. In his work *Über den Materialismus der neuen deutschen Naturwissenschaft*, Schleiden pointed to the central importance for the new biology of the approach to vital phenomena advocated by Kant in the 1790s.¹ When we couple such remarks with recent studies which indicate that the traditional portrait of Johannes Müller as a vitalist must be re-evaluated, that Müller's vitalism, if it can be called that, was of a "materialist" sort not in any way to be considered as rooted in the idealism of the *Naturphilosophen*,² then the potential significance of Kant's philosophy of biology for early-nineteenth-century developments takes on important new dimensions.

The present study is based on the conviction that a reconstruction of the path through which Kant's methodological insights were first integrated in a systematic and concrete manner into the work of a biological theorist will shed important new light on the development of the life sciences in the period 1790–1850. The biological theorist I have in mind is Johann Friedrich Blumenbach (1752–1840), the Göttingen anthropologist and comparative anatomist. A detailed analysis will demonstrate that from the late 1780s to the late 1790s Blumenbach's ideas on natural history underwent a thorough revision in light of Kant's analysis of the conceptual foundations required for the construction of a scientific theory of organic form. Kant's treatment of the question of race in terms of a construct he called the *Stammrasse*, and the specific manner in which he attempted to ground that concept on Blumenbach's theory of the *Bildungstrieb*—conceived as an organic version of a Newtonian force, a mechanico-teleological drive operating materially within organic bodies to give rise to their determinate structures—led Blumenbach to realize the consequences that his own views, as modified by Kant, might hold for the construction of a general theory of natural history.

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¹Leo Königsberger, *Hermann von Helmholtz* (Braunschweig: Vieweg, 1902), Vol. I, pp. 29–30. Mathias Jacob Schleiden, *Über den Materialismus der neuen deutschen Naturwissenschaft: sein Wesen und seine Geschichte* (Leipzig: Engelmann, 1863), pp. 33–34.

²Brigitte Lohff, "Die Rezeption der Zellentheorie in Johannes Müllers Handbuch der Physiologie des Menschen," lecture delivered at the annual meeting of the Deutsche Gesellschaft für Geschichte der Medizin, Naturwissenschaft und Technik, Sept. 26, 1977.

Although the analysis offered here will deal chiefly with the relationship between Kant's philosophy of biology and the development of Blumenbach's theory of organic form, this careful treatment of the original problem context is intended to serve as preparation for understanding the dimensions of research to which these ideas gave rise in the works of others. For these ideas were not stillborn. In fact they provided a framework for the researches of Blumenbach's most illustrious students: Alexander von Humboldt, Karl Friedrich Kielmeyer, Heinrich Friedrich Link, Georg Reinhold Treviranus, and Christoph Girtanner. In the writings of those men we will find an amplification and further elaboration of the principal ideas set forth in the works of Kant and Blumenbach. Moreover, this theory, the spirit of which is best captured by the term "vital materialism," did not remain confined to the works of Blumenbach and his students. Although the basis for the claim can only be hinted at here, one of the main intentions of the present study is to suggest that vital materialism as illustrated in the works of Blumenbach, Kielmeyer, Humboldt, and others in the "Göttingen School" served to guide later empirical developments of the life sciences in early-nineteenth-century Germany. A brief discussion of its appearance in the writings of such significant figures as Karl Ernst von Baer and Hermann Lotze will provide ample evidence that vital materialism may have served as a significant unifying model for biological research in Germany in the first half of the century.

BLUMENBACH'S EARLY WORK: INTELLECTUAL CONTEXT, DEVELOPMENT, AND AFFINITIES WITH KANT

Two factors prompted Blumenbach to take deep notice of Kant's work: the aims of the two men in constructing a general theory of natural history as well as the means for achieving it were similar, and Blumenbach discovered in Kant's writings a way to resolve certain inconsistencies in his early approach to this problem. Kant's writings reveal only three direct references to Blumenbach, but they mark the close sympathy between their approaches to nature. In a footnote to his treatise "Über den Gebrauch teleologischer Prinzipien in der Philosophie" (1788),³ Kant praised Blumenbach's critique of the idea of a *Stufenfolge* of beings set forth in his *Handbuch der Naturgeschichte* (1779) as well as the theory of generation enunciated in the treatise *Über den Bildungstrieb* (1781). In the *Kritik der Urteilskraft* (1790) Kant argued that the theory of organic form must be based on an epigenetic theory of development and that no one had done more in the way of properly conceptualizing the theory of epigenesis than Blumenbach.⁴ In a letter to Blumenbach composed in August of 1790 Kant informed him explicitly about what he found so interesting in his works: "Your works have taught me a great many things; indeed your recent unification of the two principles, namely the physico-mechanical and the teleological—which everyone had otherwise thought to be incompatible—has a very close relation to the ideas that currently occupy me but which require just the sort of factual confirmation that you

³Immanuel Kant, "Über den Gebrauch teleologischer Prinzipien in der Philosophie," in *Kants gesammelte Schriften*, ed. Königlich Preussischen Akademie der Wissenschaften, Vol. VIII (Berlin: Georg Reimer, 1912), p. 180n. A complete reference for the relationship between Kant and Blumenbach is provided by Gottfried Martin, ed., *Allgemeiner Kantindex*, Personenindex, 2. Stufe, in *Kants gesammelte Schriften*, Vol. XXII (Berlin: De Gruyter, 1967), pp. B110–113.

⁴Immanuel Kant, *Kritik der Urteilskraft*, in *Kants gesammelte Schriften*, Vol. V, p. 424 [§81]. Unless noted otherwise, all translations of this work are taken from that of J. H. Bernard, *Critique of Judgment* (New York: Hafner, 1966).

provide."⁵ Indeed, in the *Critique of Judgment* the great philosopher from Königsberg had concerned himself with the problem of reconciling the mechanical and teleological modes of explanation and, as his *opus postumum* attests, this problem in its relation to physics continued to occupy him through his later years.

The letter of 1790 was written by Kant to acknowledge receipt of the second edition of the *Bildungstrieb* (1789). There were good reasons why Kant should have recognized a deep kinship between his own current interests and the ideas developed there by Blumenbach, for that particular edition marks the beginning of a reformulation of the theoretical foundations of his biological thought in light of Kant's writings. This reworking was inspired chiefly in response to three papers written by Kant between 1785 and 1788. They were "Die Bestimmung des Begriffes einer Menschenrasse," published in the *Berlinische Monatschrift*, November 1785; "Mutmasslicher Anfang der Menschengeschichte," *Berlinische Monatschrift*, January 1786; and "Über den Gebrauch teleologischer Prinzipien in der Philosophie," in the *Teutscher Merkur*, January and February, 1788. From these papers Blumenbach gained an idea for clarifying some of the central aspects of his own distinctive approach to natural history, prompting him to undertake revisions in several of his earlier works. These revisions resulted in new editions of the treatise on the *Bildungstrieb* (1789, 1791), the *Handbuch der Naturgeschichte* (1788, 1791), and his dissertation, *De generis humani varietate nativa* (1795).

To clarify why the insights Blumenbach gained from Kant's writings were so significant and how they led to a far-ranging formulation of a research program for natural history, it is worth describing Blumenbach's early work, especially his early attempts to work out problems for which Kant seemed to offer a solution. His difficulties and the development of his thought are revealed by shifts in theoretic formulation between successive editions of these early works.

Blumenbach's early work in natural history was motivated by a series of questions concerning the construction of the natural system and the theory of generation that had been of long-standing interest to Albrecht von Haller but which surfaced most visibly in the controversy surrounding Buffon's *Histoire naturelle*. Full analysis of the specific issues raised by Haller and others at Göttingen, such as Abraham Gotthelf Kästner, regarding Buffon's work is beyond the scope of the present study.⁶ In spite of serious reservations to the more speculative aspects of the *Histoire*, however, these men did support some of Buffon's aims for natural history which they found compatible with their own views. In particular, both Kästner and Haller supported Buffon's efforts toward constructing a natural system of classification. Nevertheless, while they sympathized with Buffon's critique of Linnaeus' reliance on single anatomical characters in establishing taxonomic classes, they did not follow Buffon in dismissing morphological criteria for distinguishing species. Rather they preferred a more robust Linnaean method based on correlations of multi-characters, the construction of the so-called *Totalhabitus*.⁷ Their reason for not following Buffon in this

⁵Immanuel Kant, *Werke*, ed. Ernst Cassirer (Berlin: B. Cassirer, 1922), Vol. X, p. 37.

⁶A full account of the various aspects of the controversy can be gathered from Phillip R. Sloan, "The Impact of Buffon's Taxonomic Philosophy in German Biology," *British Journal for the History of Science* (forthcoming); Timothy Lenoir, "Johann Friedrich Blumenbach's Research Program for Natural History and the Biological Thought of the Naturphilosophen," *Studies in the History of Biology*, 1981, 5 (forthcoming); James Larson, *Reason and Experience: The Representation of Natural Order in the Work of Carl von Linné* (Berkeley: University of California Press, 1971).

⁷This was an approach explored by Linnaeus himself in his *Genera plantarum* (1737) and the *Fragmenta methodo naturalis* in the *Classes plantarum* of 1738. Haller corresponded directly with Linnaeus on this

matter was that his approach seemed to require some mystical insight into the internal form, *die innerliche Form* or *moule interieur*, that gave rise to the external characteristics of the organism; and in their view proper scientific method had to remain content with the external, phenomenal characters of things.

Buffon's plan of constructing the natural system through historical lineages of genetically related ancestors met its strongest opposition from Haller and Kästner in the theory of generation. Buffon's causal approach to the natural system led him to insist upon an epigenetic theory of generation. Haller on the other hand (and Kästner followed) argued that the stability of both the physical and moral order required the fixity of species, while Buffon's theory advocated a transformation of species. Moreover, in Haller's view, Buffon's approach implied that an ultimate mechanical account could be given for organic form. Haller instinctively denied this possibility and insisted instead that the natural historian must take organization as a primary given incapable of further reduction, and this implied a *preformationist* theory of generation.⁸ Haller was later convinced that his own embryological researches provided irrefutable evidence for the preformationist theory.⁹

The ambience of views regarding the philosophy of organic form current in Göttingen scientific circles, which surfaced in the evaluation of Buffon's work, is reflected in the early writings of Johann Friedrich Blumenbach, who was a student of Kästner and Christian Gottlob Heyne, another close friend and former colleague of Haller. In his mature lectures on natural history Blumenbach told his students that the greatest thinkers on biological subjects had been Aristotle, Linnaeus, Haller, and Buffon. By nature an eclectic, from the very earliest stages of his career Blumenbach attempted to harmonize the diverse elements of the different perspectives embodied in the works of these great natural philosophers. As we shall see, Kant's writings suggested a means of effecting that synthesis.

Although Blumenbach's dissertation, *De generis humani varietate nativa* (1776), treated an anthropological theme, the underlying questions motivating the work were fundamentally those over which Buffon and Haller had disagreed. In fact the dissertation was a curious mix of ideas from Linnaeus, Buffon, and Haller that did not harmonize well, as Blumenbach was soon to discover. The aim of the dissertation was to prove that the main variations in human form were not representative of distinct human species, as many had presumed, but were races of one and the same species. The principal argument used in defending this thesis rested squarely on a morphological conception of species, a central element of Blumenbach's approach to natural history which was to remain unchanged throughout his later work. Of course the problem of deciding whether the varieties of man are races or distinct species could have been quickly dispatched if, instead of following Linnaeus, Blumenbach had adopted Buffon's breeding definition of species. Although nature, in his view,

problem before engaging Buffon, and he employed the method in question explicitly in his treatise *Enumeratio plantarum horti regii et agri* (Göttingen, 1753). For detailed discussion see Larson, *Reason and Experience*, pp. 62–63.

⁸Haller directly attacked the view that inorganic physical forces could account for processes of organic formation in his introduction to Buffon's theory of generation for the German translation of the *Histoire naturelle*. See Albrecht von Haller, "Vorrede über des Herrn von Buffons Lehre von der Erzeugung," in *Sammlung kleiner Hallischer Schriften* (Bern, 1772), Pt. 1, pp. 103 and 109.

⁹The full exposition of Haller's theory of generation can be found in two sources: Albrecht von Haller, *De formatione pulli in ovo* (Lausanne, 1758), and in Vol. VIII of his epoch-making *Elementa physiologiae corporis humani* (Bern, 1766). For a recent discussion see Shirley A. Roe, "The Development of Albrecht von Haller's Views on Embryology," *Journal of the History of Biology*, 1975, 8:167–190.

tended to obstruct hybridization, Blumenbach allowed that closely allied species of the same genera could produce fertile hybrid offspring.¹⁰ Consequently an argument resting on the fertility of offspring resulting from mingling the different varieties of man could not constitute a sufficient condition for reducing these forms to the same species, and this problem inclined Blumenbach to turn to the unity of essential form as the surest means of identification.¹¹ Looking ahead to the great successes of Darwin, historians of biology tend to fault this myopia in appreciating one of the great unifying principles of biology, the biological species concept.¹² But, as we shall argue, Blumenbach's conservative morphological approach was later a key element in producing a revolutionary model for conceptualizing the natural system.

A salient feature of Blumenbach's dissertation and of his earliest work in the general area of natural history was his commitment to the preformation theory. Blumenbach explicitly acknowledged that in the theory of generation he followed the views of Haller in all details. Like Haller he asserted that "the embryo is contained in the maternal egg, and that the female provides the true stamina of the future foetus." The sole function of the sperm, he argued, is to awaken the germ from its eternal slumber "by the subtle odor of its parts which are particularly adapted for causing irritation."¹³

Implicit in this theory was the conclusion that the paternal contribution in generation is minuscule, merely setting in motion the development of structures already present in the egg, while the greater part of form in animals is derived from the mother. Although hybrids might be possible, because of the minor contribution of the male the offspring would return to the maternal stock after several generations. Consequently the preformationist model of generation led to the conclusion that "the offspring at last brought to light, . . . ought to go on forever like their first parents."

¹⁰Johann Friedrich Blumenbach, *De generis humani varietate nativa* (Göttingen, 1776) in *The Anthropological Treatises of Johann Friedrich Blumenbach*, trans. Thomas Bendyshe (London: Longman, Green, 1865), pp. 73 ff.

There are three cases in the discussion about hybridity which ought to be clearly distinguished. First, the mere copulation of different animals; secondly the birth of offspring from such copulation; and thirdly the fertility of such offspring and their capacity for propagation.

The latter case, although rare, (and that by the providence of the Supreme Being, lest new species should be multiplied indefinitely) I would admit of in beings closely allied.

. . . With respect to the union of dogs and apes, and the hybrids so born, I still remain in doubt. The animals seem too different; . . . And what makes me suspicious about these things is this especially that I have seen many apes of both sexes of different species constantly living for many years in the midst of dogs, also of different sexes, and yet never seen anything of the kind.

Basing his view on Haller's work on generation (*Elementa physiologia*, Vol. VIII, p. 9), Blumenbach traces the cause for the fruitless union of animals of different species to the following (pp. 75-76):

. . . I think that with very few, and those only very closely allied, is this actually successful, and in most cases the attempt is ineffectual. . . . Here let us consider the unequal proportions of the genital organs in many; which parts are providently and carefully adapted for copulation in either sex of the same species; but in distant genera render the whole thing impossible, or at all events very difficult, and certainly unfit for the purposes of conception. Besides I do not see according to what laws the offspring of this kind, coming from diverse parents, is to be formed in the womb, since in each species of animals there are certain and very definite periods for the gestation and pregnancy of the mother, the formation and development of the foetus.

¹¹Thus he writes (*De generis humani*, p. 98): "For on the first discovery of the Ethiopians, or the beardless inhabitants of America, it was much easier to pronounce them different species than to inquire into the structure of the human body, to consult the numerous anatomical authors. . . ."

¹²See, e.g., Ernst Mayr, "Species Concepts and Definitions," in E. Mayr, ed., *The Species Problem* (American Association for the Advancement of Science, Publication No. 50, 1957), pp. 1-22. Ernst Mayr, "Illiger and the Biological Species Concept," *J. Hist. Biol.*, 1968, 1:163-178. Sloan, "Impact of Buffon's Taxonomic Philosophy."

¹³Blumenbach, *De generis humani*, pp. 69, 70.

For the staunch defender of Haller's theory of development and organic form, then, the problem that leaped clearly to the fore, the problem which generated the substance of Blumenbach's dissertation, was to account for the manifestly varied forms of species, the human species in particular: "What is it which changes the course of generation and now produces a worse and now a better progeny, at all events widely different from its original progenitors?"¹⁴

In order to explain the origin of the races of man Blumenbach adopted a model employed widely by both epigeneticists such as Buffon and preformationists such as Bonnet. He argued that the various races were all degenerations of the Caucasian race, resulting from climatic variation produced by migration, changes in nutrition corresponding to the difference in the new habitat, and differences in the mode of upbringing due to cultural differences.

By the appearance of the first edition of the *Handbuch der Naturgeschichte* (1779) it is clear that Blumenbach had begun to feel uncomfortable with the synthesis of views he had worked out three years earlier in his dissertation. In particular he had come to recognize an incompatibility of the strict preformationist doctrine with his developing ideas on natural history. Although he continued to assert that Haller's preformationist theory was "mehr als bloss wahrscheinlich," he had come to think that the paternal contribution to the embryo was greater than Haller would admit, and he cited the production of hybrids and monstrosities, such as polydactyls, as the basis for his suspicions.¹⁵ Blumenbach did not develop this view further at this time, however, and he did not abandon his earlier commitment to preformationism.

All of this changed within a few months. In 1780 a paper of about twenty pages appeared in the *Göttingen Gelehrten Anzeigen* announcing a new epigenetic theory. It was followed in 1781 by a full treatise, *Über den Bildungstrieb und das Zeugungsgeschäfte*. Reflection on two problems led Blumenbach to abandon the preformation theory. The first was that the production of fertile varieties, such as mulattos, was completely inexplicable on Haller's model. In terms of a consistent application of the preformation theory, the mixture of two different races should not exhibit a blend or *Mittelschlag*. The second and decisive factor was Blumenbach's realization that Kölreuter's experiments absolutely refuted the preformationist scheme. Kölreuter had not only produced fertile hybrid offspring by crossing *nicotina rustica* with *nicotina paniculata*; more importantly, he had succeeded in reverting the hybrid offspring to the paternal form (*paniculata*) after several generations.¹⁶ This flatly contradicted Haller's preformationist theory, which held that the paternal contribution to form was negligible.

In spite of his decision to support the epigenetic theory, Blumenbach did not want to abandon what he considered to be desirable features in the preformationist account. In particular he wanted to retain the notion, fundamental to Haller's preformationism, that the fact of organization could not be accounted for in terms of

¹⁴*Ibid.*, pp. 70, 71.

¹⁵Johann Friedrich Blumenbach, *Handbuch der Naturgeschichte* (Göttingen: Dietrich, 1779), p. 18, writes: "Other famous men have . . . sought the fundamental basis of organization [*die Grundtheile der organisierten Körper*] in the female egg. Herr von Haller, in particular, has drawn conclusions from this hypothesis which make it more than merely probable." Two pages later, however, Blumenbach records the following doubts: "In our opinion, however, the contribution of the male semen to the structure [*Bildung*] of the embryo is probably greater than he [Haller] has expressly admitted. The production of bastards, the six-fingered families of Kalleja and Bilfinger, but especially the examples of so many species of animals in which both sexes display a completely different structure appear to strengthen our suspicion."

¹⁶Johann Friedrich Blumenbach, *Über den Bildungstrieb und das Zeugungsgeschäfte* (Göttingen: Dietrich, 1781; reprinted Stuttgart: Gustav Fisher Verlag, 1971), p. 61.

physico-mechanical causes but had to be treated as primary. Secondly he wanted to avoid the problems encountered by other epigeneticists, such as Buffon, in advocating a transformation or degeneration of species. In effecting these ends he selected a path modeled on the key concepts of Haller's own physiology, a path which also endeared him to Kant. He treated the agent responsible for organic structure as a Newtonian force, which he called the *Bildungstrieb*.

In the mature formulation of the theory, after he had begun to wrestle with Kant's philosophy of organic form, Blumenbach defined the *Bildungstrieb* as one among a class of *Lebenskräfte*, modeled on Haller's vital forces of sensibility and irritability. "By Lebenskraft," Blumenbach wrote, "the animal organization maintains its receptivity for receiving stimulating impressions and the ability of setting its organs in motion." Blumenbach stressed the importance of regarding these two aspects of the *Lebenskraft* as mutually supportive in order to render intelligible the "interaction of the parts for the purposive maintenance of the whole and vice versa."¹⁷

The basic model for the *Bildungstrieb* grew out of Blumenbach's experiments on the polyp. What was particularly striking about that organism was not only that it could regenerate amputated parts without noticeable modification of structure but that the regenerated parts were always *smaller* than their originals.¹⁸ Upon closer inspection this seemed to be characteristic of the reproduction of injured organic parts generally. In cases of serious flesh wounds, for example, the repaired region was never completely renewed but always retained somewhat of a depression. Such observations led to two conclusions:

[First] that in all living organisms, a special inborn *Trieb* exists which is active throughout the entire lifespan of the organism, by means of which they receive a determinate shape originally, then maintain it, and when it is destroyed repair it where possible. [Secondly] that all organized bodies have a *Trieb* which is to be distinguished from the general properties of the body as a whole as well as from the particular forces characteristic of that body. This *Trieb* appears to be the primary cause of all generation, reproduction, and nutrition. And in order to distinguish it from the other forces of nature, I call it the *Bildungstrieb*.¹⁹

The *Bildungstrieb* was not a blind mechanical force of expansion which produced structure by being opposed in some way; it was not a chemical force of "fermentation," nor was it a soul superimposed upon matter.²⁰ Rather the *Bildungstrieb* was conceived as a teleological agent which had its antecedents ultimately in the inorganic realm but which was an emergent vital force. It was this aspect of Blumenbach's work which was its distinguishing feature, and it was in terms of this extremely important idea that German philosophers of nature saw for the first time a means of uniting the teleological and mechanical systems of nature.²¹

¹⁷ Blumenbach, *Handbuch der Naturgeschichte* (4th ed., Göttingen: Dietrich, 1791), pp. 10, 11.

¹⁸ Blumenbach, *Über den Bildungstrieb*, p. 10.

¹⁹ *Ibid.*, pp. 12–13.

²⁰ *Ibid.*, p. 14. I must caution the reader that this force is not to be confused with the *vis plastica*, the *vis essentialis*, chemical fermentations, blind forces of expansion, or with any other mere mechanical forces which some have assumed in the exposition of the reproductive process.

²¹ Initiated by Kant's probing insights, the goal of uniting the teleological and mechanical frameworks of explanation was a topic of central importance in discussions on the philosophy of nature during the 1790s. The interest in this problem at Jena, the center of the budding *naturphilosophische* movement, can be gathered from Fichte's writings and the direction he encouraged his students to follow in unlocking the secrets of Kant's philosophy. Thus in describing Fichte's lectures to Hegel, Hölderlin, who studied with Fichte in 1795, wrote: "The manner in which he [Kant] unites mechanism with purposiveness of nature appears to contain the entire spirit of his system." Quoted from Johannes Hoffmeister, ed., *Briefe von und*

That the *Bildungstrieb* was conceived as intimately linked to a material basis can be seen from the manner in which Blumenbach claimed to have been led to the idea—that while the polyp always regenerates a lost part, the regenerated part is always smaller. Having lost a substantial portion of its primary generative substance, the force of the *Bildungstrieb* had been weakened. Though its force could be diminished, if it had sufficient strength it would always bring forth the whole structure associated with it:

. . . no small evidence in support of the [theory of the] *Bildungstrieb* consists in the fact that the shape and structure of organic bodies is much more determinate than either their size, length or other such qualities, . . . [not only in the case of waterplants] but also in the case of animals and even man, the size of many parts, even the most important tissues of the stomach and the brain and the length of the intestines, can vary enormously, while the variation in their structure and organization is seldom ever encountered.²²

Two features of Blumenbach's *Bildungstrieb* are extremely important to bear in mind. The first is that it could not be reduced to the chemical constituents of the generative fluid. Blumenbach repeatedly emphasized the immanent teleological character of his conception of the *Lebenskräfte*. The formative force existed in the organization of the *Zeugungssaft* as a whole: change any of its constituent elements and the organization of the whole was not just altered; it was completely destroyed. On the other hand, it is to be emphasized that this teleological agent was not to be considered a kind of soul superimposed on matter. This form of vitalism is what he found objectionable in Buffon's concept of the *moule interieur* and in Wolff's conception of the *vis essentialis*. For Blumenbach the *Bildungstrieb* did not exist apart from matter, but it could not be explained in terms of its constitutive elements. This is why in later, more mature formulations he portrayed the concept as an organic version of a Newtonian force:

. . . the term *Bildungstrieb* just like all other *Lebenskräfte* [such as sensibility and irritability] explains nothing itself, rather it is intended to designate a particular force whose constant effect is to be recognized from the phenomena of experience, but whose cause, just like the causes of all other universally recognized natural forces, remains for us an occult quality. That does not hinder us in any way whatsoever, however, from attempting to investigate the effects of this force through empirical observations and to bring them under general laws.²³

Fashioned in the language of the General Scholium to Newton's *Principia*, this passage revealed Blumenbach's goal of doing for organic bodies what Newton had accomplished for inert matter. For each class of organized beings there was a specific *Bildungstrieb* which gave rise to its determinate structure. And just as Newton had succeeded in finding the universal organizing force of inert matter by constructing a model which successfully unified Kepler's laws, Galileo's law, and a host of other "observed" regularities under a single plan, so it was the task of the naturalist to reconstruct the *Bildungstrieb* for each class of organism by unifying the regularities found in reproduction, generation, and nutrition under a general law.

an Hegel (3rd ed., Hamburg: Felix Meiner, 1969), Vol. I, p. 20 (Jan., 1795). The unification of the two frameworks is the central focus of Schelling's *Ideen zu einer Philosophie der Natur* (1797), as well as his *Von der Weltseele* (1800). Blumenbach's formulation of the problem is cited by Schelling as the starting point for his own conception: Friedrich Schelling, *Von der Weltseele* in Manfred Schröter, ed., *Schelling's Werke* (Munich: Beck, 1956), Vol. I, p. 590.

²²Über den *Bildungstrieb*, pp. 25–26.

²³Blumenbach, *Handbuch der Naturgeschichte* (5th ed., Göttingen: Dietrich, 1797), p. 18. As I shall argue in the next section, this mature formulation resulted from his encounter with Kant's work.

It was in terms of this Newtonian conception of the *Bildungstrieb* that Blumenbach intended to preserve the conservative elements of the preformationist doctrine. Conceiving it as a force in Newton's sense implied that an account of the causal origins of organization was beyond the power of reason. Furthermore, the conceptualization of the *Bildungstrieb* as a teleological agent dependent upon the prior purposive organization of its parts enabled Blumenbach to avoid the problem of transforming species. According to the Newtonian force imagery underlying the model, the mixture of two parent stocks of widely differing species would cancel each other out: "the mixture of generational fluids of two completely different kinds normally smothers and destroys any disposition for the *Bildungstrieb* which would otherwise be excited. Consequently the possibility of hybridization is limited to a very few cases due to the confusion that would necessarily accompany it."²⁴ By permitting hybridization in cases only of closely allied species having near identical organizations, Blumenbach avoided the multiplication of species while providing a mechanism for understanding known cases of hybridization.

A second feature associated with the *Bildungstrieb* important to emphasize is its explicit commitment to the notion of functional adaptation. This was evident in the general definition of *Lebenskraft* which stressed the *receptivity* of the organism to external stimuli and the interconnected ability to set its organs in motion. It was this feature that enabled the *Bildungstrieb* to function as an explanatory concept for natural history. Although Blumenbach did not think that different species could produce fertile offspring, and this primarily from evidence based on the comparative anatomy of the generating organs as well as differences in the periods of fecundation for different species,²⁵ he did assign to the organism an ability to make slight modifications in its structure in order to adapt to its environment. There were severe limits placed on this adaptive power by the original organization of the *Bildungstrieb*, however. A variation in a single part entailed, according to what he termed the *law of homogeneity*, a correlative variation in other parts of the organism.²⁶ Such variations could not proceed beyond certain extremes without destroying the economy of the organism itself. In accordance with this adaptive ability of the organism, Blumenbach argued that the forces of the external environment, through gradual shifts in climate and nutrition, could produce variations in the formative force and that after many generations these variations could take root in the generative fluid itself, thus becoming a permanent structural feature of the organism.²⁷ In terms of this mechanism

²⁴ Blumenbach, *De generis humani*, pp. 75–76. Blumenbach stressed this point in all editions of his *Handbuch der Naturgeschichte*.

²⁵ Blumenbach, *Über den Bildungstrieb*, p. 62.

²⁶ While the variability of form within specified limits was central to the discussion of race in his dissertation, Blumenbach did not discuss this aspect of his model in the first edition of the *Bildungstrieb*. It appears explicitly first in his *Geschichte und Beschreibung der Knochen des menschlichen Körpers* (Göttingen: Dietrich, 1786). There in describing the effects of the variation of the *Bildungstrieb* he writes (pp. 84–86n):

The law of homogeneity, equally important for physiology and for the art of drawing and sculpting, is based on the exact congruence in the formation of the parts belonging to a particular structure. As variable as the strength or weakness in determination of the *Bildungstrieb* can be in individuals of the same species and the same age, just as homogeneous is its expression ordinarily in the particular parts of the same individual. . . . so that when I come across one or another part of a skeleton that is singularly well formed, I am certain to find the remaining parts formed in the same proportion and vice versa.

This principle would later occupy a central role in Blumenbach's seminal paleontological researches.

²⁷ *Über den Bildungstrieb*, pp. 62–63 ff.

Blumenbach accounted for races and varieties as degenerate forms produced by physical causes. In order to apply this causal theory to the construction of the system of nature, he urged the empirical investigation of the laws regulating the variations in the formative force through studies of teratology and the effects of climate and nutrition on generation.

The foundation of Blumenbach's approach to the *Bildungstrieb* was a conception of life understood in terms of functional adaptation. This same idea also permeated his approach to the problem of classification in every edition of the *Handbuch*. This primarily functionalist approach served as the basis for Blumenbach's rejection of the notion of a *Stufenfolge* of forms in nature:

Chains in nature, these we seek not in the graduated structure of organisms, namely in that one [link] is supposed to connect animals and plants while another is supposed to connect plants and minerals; but rather in the assigned functions [*Geschäften*] of the links of these chains, in the manner in which link after link interconnect, not in terms of their form, but in terms of their [*Bestimmungen*] interdeterminations.²⁸

Blumenbach's stated aim in the *Handbuch der Naturgeschichte* was to construct a natural system of classification. Like Buffon, he criticized the systems of Ray, Linnaeus, and Tournefort as being artificial, based on arbitrarily chosen single characteristics which resulted in a correspondingly arbitrary and often accidental grouping of forms. Linnaeus' reliance on differences in dentition as a distinguishing mark of mammals, for instance, had led him to divide the genus of bats into species belonging to three different orders, while the hedgehog and mole were grouped together in the same order as lions and tigers.

In order to construct the natural system there were two paths open to Blumenbach. He could follow Buffon's lead and insist on a genealogical system. Indeed he never denied that the natural system would in principle be genealogical. In the first edition of the *Handbuch*, for example, he stated: "Organized bodies are always produced by organisms of their own kind; their existence presupposes an interrupted series of identical forms all the way back to the first Creation."²⁹ While he certainly agreed that natural species are always capable of producing fertile offspring, he did not feel that the breeding criterion was a sufficient condition for distinguishing species. In every edition of his *Handbuch* he emphasized the impracticality of employing the criterion because of a number of factors, including difficulties such as those of mating the Asian and African elephants as well as the inadequacy of information existing on truly fertile hybrids. But Blumenbach always insisted that if two species are really distinct, they will have different morphologies. Thus in response to numerous accounts of fruitful matings of mules and horses Blumenbach argued that these accounts must be fabulous, because the differences between the structure of the larynx in the two forms were so great that it was impossible to imagine they were of the same species.³⁰

In order to apply this morphological criterion in a manner consistent with his functionalist approach, Blumenbach defined his orders in terms of interrelated multi-characters, the so-called *Totalhabitus*: "We have attempted to construct a natural system whereby we have looked . . . not to individual abstracted characteristics, but

²⁸ *Handbuch der Naturgeschichte* (1779), pp. 13–14.

²⁹ *Ibid.*, p. 4.

³⁰ See, e.g., *ibid.* (1802), p. 25.

rather to all external characters at once; that is, upon the entire habitus of the animal. Accordingly, animals that agree in nineteen parts while differing in the twentieth are nonetheless grouped together whether that twentieth be teeth, claws or any other part."³¹ In terms of his functionalist approach to classification, animals that demonstrated the greatest number of commonly interrelated parts constituted a natural group in terms of the total economy of nature.

THE REVISION OF BLUMENBACH'S THEORY IN THE 1790s: THE INFLUENCE OF KANT

Blumenbach's views remained substantially unchanged throughout the early and mid-1780s. Both the second edition of the *Handbuch* (1782) and the second edition of the treatise on man (1781) registered his shift to an epigenetic theory of development, and the *Bildungstrieb* supplied the mechanism for the variation and adaptation of species in these and all his subsequent works. But the difficulties Blumenbach had in insisting on the functional and teleological aspects of his views without espousing an outmoded vitalism, and in stressing the mechanical features of his model without espousing a reductionist philosophy of organic form, were not resolved in these early versions of his theory. It was Kant who resolved both of these issues neatly and thus opened the way for the formulation of what proved to be an extremely fruitful theory of biological organization.

In the later sections of the *Kritik der reinen Vernunft* (1781; 2nd ed., 1787) as well as in the *Kritik der Urteilskraft* (1790) Kant emphasized the necessity of employing teleological principles as regulative aids in the employment of reason:

I must always reflect upon them [all events in material nature] according to the principle of the mere mechanism of nature, and consequently investigate this as far as I can, because unless this lies at the basis of investigation, there can be no proper knowledge of nature at all. But this does not prevent us, if opportunity offers, in the case of certain natural forms from following out the production of material things according to final causes, which is quite different from explaining them according to the mechanism of nature. Reflexion in accordance with mechanical causation is thus not removed; on the contrary we are told to follow it as far as we can. Nor is it said that these forms would not be possible in accordance with the mechanism of nature. It is only asserted that *human reason* could never find the least ground for that which constitutes the specific character of a natural purpose, although it would increase its knowledge of natural laws.³²

Kant stressed that the regulative use of the concept of teleological (*zweckmässige*) agents was imperative in the investigation of organized bodies; that the naturalist should use the concept as a *guiding thread* for conducting empirical investigation without inquiring into the first origins of organization, which lie beyond the purview of a mechanical conception of cause.³³ In Kant's view the aim of natural philosophy should always be to provide a mechanical explanation, but in actuality there are limits to the possibility of succeeding in this. It is at this juncture, at the highest level of scientific understanding, that reason must take recourse to teleological principles as regulative guides to inquiry.

This teleological approach to organic phenomena is reflected in Kant's reasons for preferring a modified version of the epigenetic theory similar to that described by

³¹*Ibid.* (1779), pp. 56–57.

³²Kant, *Kritik der Urteilskraft*, Bernard trans., p. 234 [§70]. The numbers in brackets refer to the corresponding section of Kant's original German text.

³³*Ibid.*, p. 237 [§72].

Blumenbach: "The system which regards generation as a product is entitled the system of *epigenesis*. This latter may also be entitled the system of generic preformation, because the productive faculty of the generator, and consequently the specific form, would be *virtually* preformed according to the inner purposive capacities [*Anlagen*] which are part of its stock [*Stamm*]." ³⁴ Kant applied this notion in a manner similar to that found in Blumenbach's early writings. He pointed out that, consistent with this view of development, the variation encountered in certain individuals of organized genera can become hereditary if they take root over many generations in the generative fluid. He was careful to state, however, that this gradual shift in the form of these individuals is rightly to be regarded as the development and utilization of the "purposive capacities [*zweckmässige Anlagen*] originally present in the species, with a view to the preservation of the race." ³⁵ As in Blumenbach's treatment of the same problem, nothing could be taken up into the generative fluid that did not contribute to the functional adaptation of the organism, and this adaptation was viewed as the result of mechanical action on a preexistent functional organization.

In light of the close parallels between his own view of organic phenomena and that developed in the writings of Kant in the late 1780s and early 1790s, it is not surprising that Blumenbach began to introduce Kantian formulations of his own philosophy of biology into the new editions of his increasingly popular *Handbuch der Naturgeschichte*, the dissertation *De generis humani*, and the treatise on the *Bildungstrieb*. In fact, in pointing to the relationship between mechanism and teleology in his own work and in explicating the proper manner of viewing that relationship, Kant had provided language for clarifying issues at the heart of Blumenbach's work. In particular, Blumenbach had constantly striven to insist on the functional and teleological aspects of his views without espousing vitalism. At the same time, however, he had wanted to insist on the mechanical features of his model without adopting a reductionist philosophy of organic form. Kant resolved both of these issues:

In all physical explanations of these formations Herr Hofrat Blumenbach starts from organized matter. That crude matter should have originally formed itself according to mechanical laws, that life should have sprung from the nature of what is lifeless, that matter should have been able to dispose itself into the form of a self-maintaining purposiveness—this he rightly declares to be contradictory to reason. But at the same time he leaves to natural mechanism, under this to us indispensable principle of an original *organisation*, an undeterminable and yet unmistakable element, in reference to which the faculty of matter is an organized body called a *formative force* in contrast to and yet standing under the higher guidance and direction of that merely mechanical power universally resident in matter. ³⁶

³⁴*Ibid.*, p. 272 [§81].

³⁵*Ibid.*, p. 269 [§80].

Even as concerns the variation to which certain individuals of organized genera are accidentally subjected, if we find that the character so changed is hereditary and is taken up into the generative power, then we cannot pertinently judge the variation to be anything else than an occasional development of purposive capacities originally present in the species, with a view to the preservation of the race. For in the complete inner purposiveness of an organized being, the generation of its like is closely bound up with the condition of taking nothing up into the generative power which does not belong, in such a system of purposes, to one of its undeveloped original capacities. Indeed, if we depart from this principle, we cannot know with certainty whether several parts of the form which is now apparent in a species have not a contingent and unpurposive origin; and the principle of teleology: to judge nothing in an unorganized being as unpurposive which maintains it in its propagation, would be very unreliable in its application and would be reliable solely for the original stock (of which we have no further knowledge).

³⁶*Ibid.*, p. 274 [§81].

Kant had made this same point regarding Blumenbach's work in his paper "Über den Gebrauch teleologischer Prinzipien in der Philosophie" of 1788.³⁷

Seizing the opportunity to clarify his own work, Blumenbach issued a new edition of the *Bildungstrieb*. The substance was identical to the first edition, only now in defining the formative force Blumenbach was careful to choose language emphasizing the mechanical aspects of the model and to eliminate all grounds for a possible vitalistic interpretation that had remained in the definition of the *Bildungstrieb* in the first edition. In subsequent editions of the *Handbuch der Naturgeschichte* (1791, 3rd ed. and following), Blumenbach added a note pointing out this change in emphasis and informing the reader that he did not want this revised definition of the *Bildungstrieb* to be confused with that in his earlier "unreiferen Abhandlung."³⁸ Moreover, the new editions of the *Handbuch* underwent revisions reflecting the clarifications introduced by Kant. In the sections on the *Bildungstrieb*, Blumenbach simply replaced his earlier account with that of Kant, which depicted it as a purposive [*zweckmässige*] organization that unites teleological and mechanical forms of explanation. This is particularly evident in the fifth edition, published in 1797 and afterward.³⁹ Blumenbach also adopted Kant's definition of an organized body as "one in which every part is reciprocally end and means,"⁴⁰ in explication of which Kant had noted: "For a thing to be a natural purpose . . . it is requisite that its parts (as regards the presence of their form) are only possible through their reference to the whole. . . . It is requisite secondly, that its parts should so combine in the unity of a whole that they are reciprocally cause and effect of each other's form."⁴¹

These aspects of Kant's works were readily absorbed by Blumenbach, for they expressed well the essential spirit of his own biological thought and were easily introduced into his works without modifying the basic structure of his ideas. There were other aspects of Kant's biological writings, however, that did not fit so easily into Blumenbach's approach. They were ideas that were nonetheless consistent with everything he had done in natural history and in the analysis of the physiological foundations of organic form, and their adoption would vastly increase the explanatory power of Blumenbach's theory. The introduction of these ideas brought with them a revolution in his whole manner of thinking about the phenomena of natural history, however. Accepted only haltingly and with severe reservations after his first

³⁷"Über den Gebrauch teleologischer Prinzipien," *Kants gesammelte Schriften*, Vol. VIII, pp. 180–182.

³⁸Blumenbach, *Handbuch der Naturgeschichte* (1791), p. 18: "I have explained all of this [the reproductive powers of the *Bildungstrieb*] in my book *Über den Bildungstrieb* (Göttingen, 1789), which I ask not to be confused with the immature treatment of the subject that appeared under a similar title in 1781."

³⁹The improved exposition that Blumenbach perceived in his approach to organic form in Kant's work is evident in the definition of *Lebenskraft*, adopted directly from Kant in the 1791 edition of the *Handbuch*, p. 10 (see notes 15 and 16 above). That Blumenbach continued to make improvements in the exposition of his views in light of Kant's works is indicated by a comparison of the following passage, altered from the 1791 edition. Thus Blumenbach, *Handbuch der Naturgeschichte* (1791), pp. 13–14, writes: "The cause of the *Bildungstrieb* is no more capable of explanation than attraction or gravity or any other generally recognized natural forces. It suffices that it is an independent force whose undeniable existence and extensive effects manifest themselves through experience of the entire organized creation and whose constant phenomena give an easier and brighter insight into development and several other important facets of life than any other theory." In 1797 (5th ed.), p. 18, we read: "The word '*Bildungstreib*', like the designation of all forms of *Lebenskräften*, explains nothing in itself; rather it is intended to designate a particular force (*namely that which unites in itself the mechanical with that which is capable of purposive modification*), whose constant effect is recognized in experience, but the cause of which is no more capable of explanation than the cause of all other generally recognized forces of nature which remain for us in normal discourse, *qualitas occulta*." The same point is stressed on pp. 17 and 16n, where Kant's *Kritik der Urteilskraft* is cited.

⁴⁰Blumenbach, *Handbuch der Naturgeschichte* (1797), p. 12. Again Kant's *Kritik*, [§66] is directly cited.

⁴¹Kant, *Kritik der Urteilskraft*, pp. 219–220 [§65].

encounter with Kant's work in the late 1780s, these ideas only came to be embraced fully by Blumenbach in the period between 1795 and 1797. The potentially revolutionary ideas I am referring to were Kant's ideas on race published in 1785 and elaborated in 1788.

Kant's paper of 1785, "Die Bestimmung des Begriffs einer Menschenrasse," harnessed ingeniously the notion of generic preformationism mentioned earlier with a breeding definition of species in order to solve the riddle of races. The rule for identifying races is according to Kant:

When differently formed Men are placed in conditions such that they are capable of intercourse, there is a strong suspicion that they belong to different races if the offspring is intermediate [*halbschlächtig*]; if however the product of the intermingling is *always* intermediate, so will this suspicion become certainty. On the other hand, if only a single offspring demonstrates no hybrid trait [*Mittelschlag*], one can be certain that both parents, no matter how different they might appear, belong to one and the same race of the same species.⁴²

Kant goes on to use this rule in distinguishing different classificatory levels based on the transmission of hybrid characteristics.

In order to account for the remarkably different appearance of the races of man while still recognizing their ability to produce fertile hybrid offspring, Kant argued that it was necessary to assume a single generative stock, or *Stamm*, in which all the seeds (*Keime*) for the specific characteristics of the different classes were present along with adaptive capacities (*Anlagen*) of certain combinations of these seeds: "What can the cause [of races] be other than that they must have lain in the *Keimen* of an original *Stamm* of the human species, which is unknown to us, as certain natural capacities [*Naturanlagen*] which necessarily contributed to the preservation [*Erhaltung*] of the species, at least in the earliest periods of their propagation, and therefore come forth infallibly in following generations?"⁴³ In Kant's view races are not "degenerations" of the *Stamm*. The *Stamm* consists of certain specific characteristics (*Keime*) and adaptive mechanisms (*Anlagen*) for the preservation of the species. When placed in a particularly appropriate environment certain *Keime* and *Anlagen* are manifested while others remain dormant. If a population of individuals of the same *Stamm* were to be transported to another environment, a different set of *Keime* and *Anlagen* would be manifest. If, however, the members of the species in question were to remain for numerous generations in this habitat, then, Kant argued, the dormant *Keime* and *Anlagen* would be extinguished altogether and a single set would be passed on to future generations. If transplanted to another environment, the offspring of these organisms would not generate the *Keime* and *Anlagen* appropriate to that new habitat (assuming that such had been present in the original *Stamm*). In this situation the race could face possible extinction. Hence the origin of races: "The *Keime* which were laid in the *Stamm* of the human species for the production of races must have developed in the earliest times according to the requirements of the habitat if the stay was sufficiently long. And after these *Anlagen* had developed in a particular race [*Volk*], the remaining ones were completely extinguished." According to this model, then, the *Stamm* need not be encountered as existing in nature. On the one hand, since it consisted of various *Keime* and *Anlagen* from which all the possible adaptive varieties of its underlying form were derivative, it might never appear in

⁴²"Die Bestimmung des Begriffs einer Menschenrasse," in *Kants gesammelte Schriften*, Vol. VIII, p. 100.

⁴³*Ibid.*, p. 98.

nature as such. On the other hand, if sufficient time had transpired in order to permit the establishment of races, thus extinguishing some of the *Keime* and *Anlagen*, the original *Stamm* could never be reconstructed. Once a race has taken root, "one cannot assume that an intermingling of different races will permit the reconstitution of the *Stamm*. . . . How the form of the original *Menschenstamm* might have been constituted is, therefore, impossible to unravel; even the character of the white race is only the development of the original *Anlagen* which along with the others were to be encountered in the *Stamm*."⁴⁴

In spite of the deep kinship between Kant's functionalist approach to organic form and Blumenbach's conception of the formative force, several aspects of Kant's treatment of race could not be easily absorbed into Blumenbach's work. A central problem was that according to Kant the *Stamm* of the human species was not identical to any of its phenomenal manifestations as race; Blumenbach, however, had argued that the varieties of man were all degenerations of the Caucasian race. The issue at stake for natural history was the notion that a common generative stock of *Keime* and *Anlagen* could underlie each of the phenomenal manifestations of a class of organisms without ever appearing in any single one of them.

Whatever misgivings he may have had with this idea, Blumenbach recognized that it was completely consistent with his own conception of the *Bildungstrieb*. The *Stamm* described by Kant was the source of all the structural characteristics of the organism, and as we have seen, it also contained *Anlagen* which permitted it a certain degree of adaptive variation. Both of these were features of the *Bildungstrieb*. Blumenbach spoke of a formative force specific to each class of organisms. Like Kant's *Stamm* this resided in the organization of the constituents of the generative fluid, and it was responsible for producing, maintaining, and transmitting structure. Built into Blumenbach's model also was the notion that certain slight modifications could be "absorbed" into the organization of the formative force without totally disrupting the whole. It was in terms of this second aspect that Blumenbach attempted to account for the functional adaptation of organisms to different habitats, and it was ultimately the foundation of all his ideas on race.

If for all practical purposes the *Stamm* and the *Bildungstrieb* were identical, Blumenbach had difficulties nonetheless with accepting the *Stamm* fully. Two problems stood out, the first being the language in which Kant expressed the idea. For all practical purposes the *Stamm*, with its complement of *Keime* and *Anlagen*, was a preformationist theory; the language in which Haller expressed his theory, for instance, was in terms of a *Keim* actually present, although invisible, in the maternal egg. Now Blumenbach had expended a considerable amount of intellectual energy in his early years freeing himself from the strict preformationist theory, however, and Kant's choice of words threatened to undo that.⁴⁵ More important, it was possible that critics might mistake the new theory for its preformationist predecessor and dismiss it without an understanding of its genuine merits. Nevertheless Kant's formulation of the notion of generic preformationism was an exact, if unhappy, expression of the fundamental idea behind Blumenbach's *Bildungstrieb*.

⁴⁴ *Ibid.*, p. 105.

⁴⁵ Thus while building upon Kant's formulation of the concept of organic form in the 1797 edition of the *Handbuch*, Blumenbach goes on to note in the very same context (p. 13n): "When on the other hand, in order to unify the preformationist hypothesis [*Evolutionshypothese*] with the theory of gradual development, some moderns admit that the generative fluid is not preformed but at the same time maintain that it contains nonetheless a *Keim*, which is something different from a formless generative fluid, these are indeterminate, empty expressions."

The second difficulty in accepting Kant's version of the *Stamm* was more serious, for it centered on a fundamental conceptual issue. For Kant the task of natural history is to trace genealogies of organisms: "To my conception of natural history belongs the derivation of inheritable characteristics of organic beings of one and the same natural species (*species naturalis*), insofar as they originate from the same *Stamm* and are connected through their reproductive capacities [*Zeugungsvermögen*]."46 Kant's whole approach to natural history turned around employing a breeding criterion as a means for grouping individuals into classes, whereas Blumenbach advocated, as we have seen, a morphological approach. From the earliest stages of his career Blumenbach had objected to the breeding criterion as a means for grouping organisms; he always insisted that animals that belong to truly distinct species are also distinct morphologically.

Although the two approaches to natural history were based on different principles, there was a way of reconciling them. While Kant's definition of species rested on reproductive capacity, the *Stamm* which united individuals was really a generative source of structure. There was in Kant's view a genuine *structural* difference between races. The races of man differ only in skin color, but this difference is the external sign of a difference in the organization of the flesh. The flesh of Negroes, for example, is according to Kant specially organized to remove phlogiston from the blood. This is an arrangement designed to enable the species to adapt to tropical environs where thick woods and marshes produce an atmosphere rich in phlogiston.⁴⁷

The reason why this character [skin color] is an appropriate basis for a class distinction . . . is that the expulsion of wastes by means of sweating is the most important bit of concern exercised by nature insofar as the creature—which is affected quite differently by exposure to all sorts of different climates—is supposed to be preserved with the least amount of recourse to artificial means. Accordingly the flesh, considered the organ of that expulsion, carries in it the traces of that difference in natural character, which justifies the division of the human species into different classes.⁴⁸

Thus even races are morphologically distinct, a difference in structure leaving the ability to produce fertile offspring unaffected. Species, however, are morphologically distinct in degrees that eliminate the possibility of leaving progeny at all. Viewed in this light, Kant's notion of the *Stamm* was a concept that Blumenbach could integrate into his own approach, even if he did not implement its implied methodology.

The changes in the formulation of the theory of the formative force introduced in the 1791 edition of the *Bildungstrieb*, a copy of which he had personally sent to Kant, and in subsequent editions of the *Handbuch* indicate that at least from early 1790 Blumenbach had begun to come to grips seriously with Kant's philosophy of organic form. There are indications that he had also grappled deeply with Kant's ideas on race, particularly the idea of a genealogical system. In the *Vorrede* to the 1788 edition of the *Handbuch*, he defined "species" [*Gattung*] in terms of the ability to interbreed [*sich gatten*] with the possibility of leaving fertile progeny. By 1797 the consequences of this definition of species were highlighted explicitly in the *Vorrede*: "Species are created by nature: The systematist brings them under genres in terms of common similarities."⁴⁹

Blumenbach did not immediately embrace the full consequences of this conception

⁴⁶Kant, "Über den Gebrauch teleologischer Prinzipien," p. 178.

⁴⁷*Ibid.*, pp. 169–170n.

⁴⁸Kant, "Bestimmung des Begriffs einer Menschenrasse," p. 93. See also pp. 102–103.

⁴⁹Blumenbach, *Handbuch der Naturgeschichte* (1797), p. ix.

and the attendant theory of race, however. In the 1795 edition of the treatise on man, he concludes, after discussing various opinions and the evidence in support of them, that the principle of copulation is not sufficient to distinguish genuine species from varieties.⁵⁰ And while he follows Kant, whom he cites directly, in tracing the cause of racial difference to differences in the interrelated structures of the corium, reticulum malphigi, and the lymphatic vessels, which he describes as the great purifier and chemical laboratory of the human machine,⁵¹ Blumenbach relies totally on morphological rather than breeding criteria in identifying the races and varieties of man. Two years later, however, at the end of the period which I am claiming as critical for the mature formulation of his views, Blumenbach was prepared to accept without reservation Kant's theory of race as a theoretical principle for natural history, even though he continued to object to the impracticality of its employment in all cases. Thus in the section of the *Handbuch* devoted to variations in the *Bildungstrieb*, he writes: "'Race' in an exact sense, however, signifies a characteristic arisen through degeneration which is transmitted necessarily and infallibly through reproduction."⁵² In a note to this section Blumenbach acknowledges his debt to Kant's paper on race, and he recommends the work of his student Christoph Girtanner, *Über das Kantische Prinzip für die Naturgeschichte* (1796) for a thorough exposition of the theory.⁵³ Finally, an appendix to the German translation of the *De generis humani*, published in 1798, points explicitly to the fact that in the definition of genus, species, races, and varieties, Blumenbach had agreed to adopt Kant's model.⁵⁴

If by 1797 Blumenbach was prepared to accept a breeding definition of species and Kant's related treatment of race as *theoretical* principles for the construction of the natural system, problems still remained in working out the full implications of a Kantian genealogical approach and the methodology for exploring it. Chief among these was that of providing a generalized interpretation of the *Stamm*. When coupled with Blumenbach's morphological approach to natural history, the notion of a common generative stock contained exciting, possibly revolutionary consequences. Only one difficulty prevented Kant's treatment of race from serving as a model for an entire natural system. While Blumenbach was inclined to treat only species as real natural divisions, Kant had pointed out that genera too might be considered natural groupings: "The designations of 'classes' and 'orders' are clearly expressions of mere logical categorization which reason uses among its concepts for the sake of making a comparison. 'Species' and 'genera' can, however, signify a physical categorization as well, which nature itself makes among its creatures in light of reproduction [*Erzeugung*]."⁵⁵ Clearly such a conception ran counter to the Linnaean approach fundamental to Blumenbach's early writings; and in light of Kant's insistence, with which he was in agreement, that only members of the same species are capable of interbreeding, the ideas behind this passage must have seemed contradictory. The only real sense to be made of treating the generic linkages between groups of organisms in

⁵⁰ Blumenbach, *De generis humani* (1795), pp. 188–190.

⁵¹ *Ibid.*, pp. 207–208.

⁵² Blumenbach, *Handbuch der Naturgeschichte* (1797), p. 24.

⁵³ Girtanner's work will be treated in the next section.

⁵⁴ Blumenbach, *Über die natürlichen Verschiedenheiten im Menschengeschlechte* (Leipzig, 1798), trans. Johann Gott. Gruber, pp. 259–261. Although this appendix was written by Gruber, he makes it clear that its contents were discussed with Blumenbach and that Blumenbach approved the identification of his views with those of Kant. Cf. pp. 227 and xii. Moreover, the notes make it clear that Gruber had to have taken the substance of the appendix from Blumenbach himself, for he writes that Kant's papers on race as well as Girtanner's *Kantische Prinzip* were not available to him.

⁵⁵ Kant, "Über den Gebrauch teleologischer Prinzipien," pp. 163–164n.

terms of reproductive relations was that the assemblage of separate existing forms to be grouped under a common genus were at some time in the past pressed together into a common, “generic” ancestral form. If the *Stammrasse* was the set of *Keime* and *Anlagen* that provided the foundation for the emergence of the different races, perhaps there were *Stämme* of higher orders that contained the generative stock for the emergence of the various species of a particular genus or order. Changes in the geology and climate of large regions of the earth might produce the conditions appropriate for the emergence of new species, or *Gattungen*. According to this interpretation the appearance of new species would be the adaptive response of the organism to its changing environment, the specific form of the “response” being guided by the *Keime* and *Anlagen* of the *Stammgattung*. Species in this scheme would not be infinitely plastic, being constrained by the limits of structural variation concordant with their primitive ancestral organization; but in order to account for the present reproductive isolation among species of the same genus, it would have to be assumed that the *Bildungstrieb* had suffered a fundamental alteration.

This was a highly speculative application of the model derived from the synthesis of his own work and the ideas of Kant, but it was a hypothesis that Blumenbach did not immediately dismiss as preposterous.⁵⁶ In fact it offered a means of unifying the study of natural history as well as suggesting a plan for research. Although Kant hinted at the idea only to leave it unexplored, Blumenbach pursued its potential for research in a paper entitled “Beyträge zur Naturgeschichte der Vorwelt,” published in Voigt and Lichtenberg’s *Magasin für das Neueste aus der Physik und Naturgeschichte* (1789, 6:1–17), and more extensively in the first edition of his *Beyträge zur Naturgeschichte* (1790).

In the first edition of the *Handbuch der Naturgeschichte* Blumenbach had observed that while fossil evidence indicates that whole classes of organisms such as the ammonites seem to have been destroyed through revolutions of the globe, he left open the question whether living descendants of fossil forms could be discovered in the yet unexplored regions of the earth and the ocean depths.⁵⁷ A decade later he had decided this question: “Almost every paving stone in Göttingen bears witness to the fact that species—even entire genres—of animals must have perished. . . . The structures of an enormous number of fossils in our vicinity are so divergent from all present forms that hopefully no one will seriously attempt any longer to search for

⁵⁶ Indeed it was an application of the model that occurred to Kant himself, as indicated by the following extremely suggestive passage from the *Kritik der Urteilskraft* (p. 418), (my translation):

The agreement of so many species of animals in a particular common schema, which appears to be grounded not only in their skeletal structure but also in the organization of other parts, whereby a multiplicity of species may be generated by an amazing simplicity of a fundamental plan, through the suppressed development of one part and the greater articulation of another, the lengthening of now this part accompanied by the shortening of another, gives at least a glimmer of hope that the principle of mechanism, without which no science of nature is possible, may be in a position to accomplish something even here [in the treatment of organic phenomena].

⁵⁷ Blumenbach, *Handbuch der Naturgeschichte* (1779), pp. 43–44:

Since we know so many animals that exist only in fossil form, several famous men have concluded that many species and even entire genres may have perished. On the one hand it can be objected that a large portion of the earth remains unexplored and that we cannot know what might lie on the ocean floor, in the reaches of Africa and elsewhere, where natural history has yet to strike a path. On the other hand it remains suspicious that among such large genera of fossils like the ammonites not a single original has been discovered: and since from all indications we see that our Earth has already undergone numerous large catastrophes, it is at least possible that species of animals could have perished which were only suited to that primeval world and were dispensable for the Earth in its transformed state [*der revolvirten Erde entbehrlich gewesen wären*].

them among present forms of life.”⁵⁸ Blumenbach distinguished between three different types of fossil remains: forms similar to currently existing organisms, forms differing from present types but apparently related in structure, and forms, such as the ammonites, completely unlike anything presently known. Forms of the first type, he observed, were to be found in only the most recent strata; but even in these cases the organisms in the geological strata often did not resemble the present fauna in the same locale. Although not exotic, most frequently they resembled fauna that could not be connected directly to the present fauna in that level but were more easily related to forms in other parts of the globe, particularly the tropical zone.

The forms in the second class were by far the most interesting. If one looks at the fossilized forms in almost all strata, he tells us, one finds structures that *appear* to be identical to present forms. Upon closer examination, however, these forms frequently demonstrate remarkable variations from their existing analogues. A noteworthy example is the sea snail: currently existing species of *murex despectus*, for example, are coiled in a clockwise direction; the analogous fossil in almost every detail is coiled counterclockwise. “The explanation for such phenomena can scarcely be anything other than a modified direction of the *Bildungstrieb*,” he said. Through changes in the environment gradual modifications in the formative force were effected, leaving the general form of the type intact and thereby producing a similarity in structure to ancestral forms: “By these transformations organisms in part of similar type to those in the *Vorwelt* are reproduced, but the majority by far are necessarily replaced with forms which are better adapted [*zweckmässiger*] to the new order of things, since they are [produced] by the modified laws of the *Bildungstrieb*.”⁵⁹

Two features of Blumenbach’s picture of the mechanism responsible for the apparent history of species are worth emphasizing. The first is that in his approach the interrelation of organisms to one another and to the physical environment is a determinant of form. Shifts in the environment or the extinction of several species could have an effect on the organization of present forms resulting in a specific *modification* of the *Bildungstrieb*. The second noteworthy feature is that the modification in the *Bildungstrieb* was not a form of degeneration. Blumenbach emphasized this point explicitly.⁶⁰ The modifying influences of climate and nutrition can frequently cancel each other out, he noted. On the other hand, it is extremely important to bear in mind that Blumenbach did not speak of a transformation of species by means of the acquisition of *new* characters. This was impossible within the Kantian model, which denied any form of an evolutionary “chain of being.” To what then did he assign the cause of the major modifications in the direction of the *Bildungstrieb*? He could come to no other conclusion than the one which must strike every comparative anatomist: natural organisms have an innate tendency to vary. “Admittedly no explanation of this phenomenon can be given. Suffice it to say that the phenomenon itself is the unmistakable consequence of the inherent changeability [*Veränderlichkeit*] of nature.”⁶¹

Having explored the full implications of his model of the *Bildungstrieb* through the stimulus provided by Kant’s work, and having duly incorporated the ideas into his

⁵⁸ Blumenbach, *Beyträge zur Naturgeschichte* (Göttingen: Dietrich, 1790), pp. 6–8.

⁵⁹ *Ibid.*, pp. 22, 20n.

⁶⁰ *Ibid.*, p. 23: “Such a fact cannot be a consequence of degeneration [*Ausartung*], rather [it must be attributed to] transformation [*Umschafung*] through an altered direction of the *Bildungstrieb*.”

⁶¹ *Ibid.*, p. 31.

theory of the natural system in the 1797 edition of the *Handbuch*,⁶² Blumenbach had begun to set forth the outlines of a concrete program for future research. The construction of the natural system would come when research into embryology and heredity had revealed the laws governing the inherent variability of nature and when paleontological and geological researches had indicated the developmental path taken by the *Bildungstrieb*.

THE SYSTEMATIC ELABORATION OF VITAL MATERIALISM IN THE EARLY NINETEENTH CENTURY

Perhaps because he was educated never to allow speculative theory to overwhelm the evidential basis upon which it must ultimately be grounded, Blumenbach hesitated to set forth a full-blown scheme that might be rejected as fiction and never made a systematic exposition of the theory of natural history implicit in his generalization of Kant's ideas on race. He did continue to explore aspects of his model as he had in the *Beyträge zur Naturgeschichte*;⁶³ his continuing interest is evident in his treatise "De anomalis et vitiosis quibusdam nisus formativi aberrationibus" (1812), which explored the variations of the *Bildungstrieb*, and in a work entitled "Specimen archaeologiae telluris terrarumque imprimis Hannoveranarum" (1801), in which he recorded his investigation of the relation between geological strata and organisms specific to them. His own reluctance, however, did not prevent those in close personal contact with him from pursuing the implications of his vital materialism for natural history. Several students who worked under his guidance during his most productive period, the late 1780s and early to mid-1790s, developed his theories in their works, the most notable being Girtanner, Kiemeier, Humboldt, Link, and Treviranus.

The most systematic statement of the theory of natural history resulting from the synthesis of the *Bildungstrieb* with Kant's notion of the *Stamm* was set forth by Christoph Girtanner in his treatise *Über das Kantische Prinzip für die Naturgeschichte* (1796). Girtanner was a student of Blumenbach's from 1780 to 1782, and persistent themes in Girtanner's works apart from his interests in antiphlogistic chemistry are aspects of theories developed by his mentor. In 1790, for example, he published a paper in *Roziers Journal* on irritability as the vital principle and its relation to oxygen; and his work of 1796, *Über das Kantische Prinzip*, which was dedicated to Blumenbach, built explicitly upon the theory of the *Bildungstrieb*.

⁶²In the *Handbuch der Naturgeschichte* (1797), p. 3n, after explaining that all organized bodies presuppose for their existence an uninterrupted series of beings of the same species up to the first creation, Blumenbach notes: "Or at least to their first *Stammältern*. For I have presented facts in the first part of my *Beyträge zur Naturgeschichte*, which make it more than merely probable that even in the present creation new species of organized bodies are emerging and will likewise be later transformed."

⁶³According to K. F. H. Marx, who was Blumenbach's colleague from 1822 on and later his personal physician, Blumenbach worked long at a history of natural history and he planned a work on the philosophy of natural history, both of which were never published. If the present reconstruction of the development of his views is correct, the philosophy of organic form developed there would have been deeply Kantian. See K. F. H. Marx, "Zum Andenken an Johann Friedrich Blumenbach" (Göttingen, 1840), in Bendysche, trans., *The Anthropological Treatises of Johann Friedrich Blumenbach*, p. 10n.

Blumenbach was not the only natural philosopher at Göttingen interested in the implication of Kant's ideas for science. A similar interest motivated his close friend and colleague Georg Christoph Lichtenberg. Thus in Lichtenberg's correspondence we read: "I am currently writing a complete compendium of the sciences, and I intend to follow Kant completely in its general outlines. For the past twenty years I have read the works of this extraordinary man and I have been amazed by them. . . . There are incredible things in his philosophy, and those parts of it that I understand are more satisfying to me than anything else I know." See Wolfgang Promies, ed., *Georg Christoph Lichtenberg: Schriften und Briefe* (Munich: Hanser, 1967-1971), Vol. IV, pp. 712-713.

Girtanner had closer indirect personal ties to Kant than any of Blumenbach's other students. In 1787 Girtanner sought out guidance from Karl Reinhold in the finer points of Kant's philosophy of nature.⁶⁴ While in Edinburgh during 1788–1789 he roomed with Johann Jachmann, another of Kant's disciples, and the two subsequently travelled together in France, witnessing the tumultuous events of the revolution in Paris. In 1790 Jachmann came to Göttingen, where he stayed with Lichtenberg and discussed Kant's views with what he described as an eager audience.⁶⁵

The aim of Girtanner's treatise is twofold: first he wants to explain the theory behind the construction of the natural system resulting from uniting Kant's notion of the *Stamm* with Blumenbach's theory of the *Bildungstrieb* and his ideas on classification; and secondly he wants to marshal evidence then available to support the claim that the approach will succeed in revealing the natural system in its full extent. As evidence supporting the universality of Kant's model for race he cites data from breeding experiments for species in three different orders (mammals, birds, plants) as defined by Blumenbach; namely man, dogs, finches, tobacco plants, and carnations. Central to Kant's model of the *Stammrasse* was that races of the same species, no matter how apparently divergent morphologically, always produce fertile hybrid offspring, and that successive crossbreeds between hybrid and parental stocks ultimately result in the extinction of the hybrid form, whereas true racial lines continue infallibly once they are established. Citing various sources, Girtanner argued that after the fifth successive cross-fertilization of Caucasian and mulatto stocks, the offspring demonstrate none of the negroid characteristics of their hybrid origin.⁶⁶ Kölreuter's experiments on tobacco plants demonstrated that *nicotina rustica* and *nicotina paniculata* produce fertile hybrids, indicating, according to the "Kantian principle," that they are races of the same species. After five successive cross-fertilizations of the hybrid stock with *paniculata*, no traces of *rustica* traits in the hybrid stock remain. The analogy with the races of man, writes Girtanner, is complete.⁶⁷ Although he mistakenly includes the fox as a canine race, he follows the same genetic principle in classifying dogs and horses.

The merits of Kant's causal explanation of the relationship between races of a given species in terms of the *Keime* and *Anlagen* present in an original *Stammrasse* had been debated in Blumenbach's circle of colleagues and students, and aspects of the model had been explored in Blumenbach's own writings of the 1790s as means for constructing a general system of organized nature. Girtanner made this more explicit in his own work. Applying the Kantian model for races to species, Girtanner wrote: "Natural history teaches us (or at least attempts to teach us) how the original form of each and every *Stammgattung* of animals and plants was constructed, and how species [*Gattungen*] have gradually been derived from their *Stammgattung*."⁶⁸ For the sake of reconstructing these stem relations it did not matter whether the original

⁶⁴Biographical information on Girtanner is provided in Carl Weglin, "Dr. med. Christoph Girtanner (1760–1800)," *Gesnerus*, 1957, 14: 141–163.

⁶⁵See the letter from Jachmann to Kant of Oct. 1790 in Kant, *Werke*, ed. Cassirer, Vol. X, pp. 47–54. Jachmann mentions that Blumenbach is sending a copy of the *Beyträge zur Naturgeschichte* with him for Kant. Lichtenberg also discusses Jachmann's enthusiastic reception in Göttingen in a letter to Kant dated Oct. 1791 (pp. 103–105). I am indebted to Prof. Phillip R. Sloan for calling my attention to the relation between Girtanner and Jachmann.

⁶⁶Christoph Girtanner, *Über das Kantische Prinzip für die Naturgeschichte* (Göttingen: Vandenhoeck and Ruprecht, 1796), p. 394.

⁶⁷*Ibid.*, pp. 391–394.

⁶⁸*Ibid.*, p. 2.

Stamm was a single pair or a group of individuals. The task of natural history in its empirical aspect was to reconstruct the set of *Keime* and *Anlagen* present in this original *Stamm*, and establish the physical conditions under which certain of them became active while others remained dormant, thus giving rise to different but historically related species.

In elaborating upon the difference between the approach he advocated and what he termed the “descriptive” approach (*Naturbeschreibung*) of earlier systematists, Girtanner noted that in the Linnaean system organisms were grouped into classes, orders, genera, and species merely according to structural similarity or analogy. Natural history, which aims at finding the real relations among organisms, however, groups them according to *Stämme* of breeding relations: “In this manner a natural system arises for the understanding [*Verstand*], a grouping of organisms according to laws, and chiefly according to the laws of the *Bildungstrieb*.⁶⁹

The assembly of all the experiments and correlation of data needed to determine the laws of the *Bildungstrieb* “will probably take centuries,” he surmised. In the meantime artificial systems could serve as an aid, “but only until the laws of generation are made sufficiently evident. Then, however, a new grouping of the organic kingdom into classes, orders, species, races, sports [*Spielarten*], and varieties in terms of generative relations must be undertaken.”⁷⁰ By insisting that the natural system would only be revealed through an understanding of the laws of heredity, development, and reproduction controlled by the *Bildungstrieb*, Girtanner was emphasizing the synthesis of physiology and taxonomy, of form and function at the heart of Blumenbach’s program.

A central element of both Blumenbach and Kant’s approach had been the rejection of chance variation induced by external forces as a causal agent in organic change. For Blumenbach the mechanico-teleological framework entailed on the one hand that any divergence in kind among related organisms be a morphological difference contained in the purposive, responsive capacities of the *Keime* and *Anlagen* of a common generative stock. Girtanner emphasized the power of this model in depicting races of a species: “In warmblooded animals the different races of a single *Stamm* are distinguished chiefly through the different organization of the flesh; that is, through the difference in its structure, color, hair or feathers—through that part which is subject to the greatest influence of the climate.”⁷¹ Following Blumenbach, he assigned the importance of the structural difference to the necessity of a mechanism for regulating the carbon and oxygen content of the blood in order to insure the preservation of the species in different environments.

While this model functioned well for the species-race relation, certain obvious problems stood in the way of its application to higher taxonomic groupings; for as Girtanner emphasized, such structural differences did not affect the reproductive capacities of the organisms in question. But the goal of finding the proper grouping of species related in a common genus or *Stammgattung* according to reproductive capacities could not proceed similarly: species were identified according to the model in terms of the ability to leave fertile progeny. Hence the *Bildungstrieb* of different species necessarily contained *Keime* and *Anlagen* affecting reproduction.

No solution of this problem was attempted by Girtanner. Entailing the construc-

⁶⁹*Ibid.*, pp. 3–4.

⁷⁰*Ibid.*, p. 54.

⁷¹*Ibid.*, pp. 41–42. In elaborating this point Girtanner indicated that his explanation for racial difference was taken directly from Blumenbach.

tion of a causal morphology, its solution remained the central goal of the research program of Blumenbach's school. Although he did not explore the idea, at least one interesting possibility for future inquiry presents itself in his work. Central to the theory of organic form at the heart of Blumenbach's views was the limited functional adaptation of the organism to its environment. This manifested itself in the triggering of certain *Keime* and *Anlagen* and the permanent extinction of others; that is to say, through a limited alteration of the *Zeugungskraft* that left the capacity for interracial union unaffected. Girtanner pointed out, however, that even racial characteristics are not completely independent of altered breeding capacities. Commenting on the results of Kölreuter's experiments, he writes: "From these experiments it is evident that . . . *nicotina* (and probably all plants) *prefer* the pollen of their own race to that of all others, and only in cases of deficiency will they mingle with the pollen of another race of the same species."⁷² Perhaps long isolation in sufficiently powerful environmental circumstances could affect these "preferences" so as to make fertile hybrid cross-breeding impossible. Whatever the mechanism, Girtanner, like Blumenbach, emphasized that the solution of the relationship between species in terms of reproductive capacities necessarily involved an alteration in the direction of the *Bildungstrieb*; and the laws of these relationships would not emerge until empirical research had unlocked the conditions leading to variations in the formative force: "When, finally, further advance in the construction of natural history is permitted us, and the laws are revealed according to which the organization of bodies is altered . . . only then will we be able to demonstrate how organic nature has come to be in the condition in which we now find it."⁷³

Other students of Blumenbach worked on the pressing theoretical problem of determining the laws of variation of the *Bildungstrieb* and the mechanism for "unpacking" the organizational contents of the *Stammgattung*. Outstanding among these students are Carl Friedrich Kielmeyer, Alexander von Humboldt, and Heinrich Friedrich Link.

Having begun his education at the famous Hohen-Karlsschule in Stuttgart, Kielmeyer moved on to Göttingen, where he studied from 1786 to 1788, chiefly with Blumenbach, Lichtenberg, and Gmelin. No doubt his interest in exploring aspects of the new system of nature then forming in Blumenbach's mind was encouraged through participation in the lively discussions in the Physikalische Privat Gesellschaft formed by Blumenbach in 1787.⁷⁴ In his *Lebenslauf* Kielmeyer cited Blumenbach as a major influence on his personal development. These personal ties to his mentor were further strengthened when Kielmeyer returned to Göttingen for several months in 1794, after having taught at the Karlsschule for three years.⁷⁵ It was probably exposure to the intense interest in Kant's work in Blumenbach and Lichtenberg's circle during this period that aided the formation of Kielmeyer's view, later expressed in 1807 to Cuvier, that Kant's philosophical views had provided the best foundation for an empirical study of organic form.⁷⁶

⁷²*Ibid.*, p. 390.

⁷³*Ibid.*, p. 55.

⁷⁴Information on Blumenbach's Gesellschaft comes from two sources: Johann Stephen Pütter, *Versuch einer akademischen Gelehrten—Geschichte an der Georg-Augustus Universität zu Göttingen* (Göttingen: Vandenhoeck and Ruprecht, 1778–1838), Vol. II (1788), pp. 368–371; Hans Plischke, "Johann Friedrich Blumenbach's Einfluss auf die Entdeckungsreisenden seiner Zeit," *Abhandlungen der Gesellschaft der Wissenschaften zu Göttingen*, Philologisch-Historische Klasse, 1937, p. 57.

⁷⁵Carl Friedrich Kielmeyer, *Gesammelte Schriften*, ed. F. H. Holler (Berlin: Keiper, 1938), p. 11.

⁷⁶Kielmeyer, "Über Kant und die Deutsche Naturphilosophie, 1807," in *Gesammelte Schriften*, pp. 250 ff.

Insight into Kiemeyer's plan for constructing a causal morphology, which he called a *Physik des Tierreichs*, is set forth schematically in his lecture notes for a course on comparative zoology given at the Karlsschule between 1790 and 1793. In addition to the *Totalhabitus*, including the chemical constitution of the organism, Kiemeyer recommended the use of developmental histories as a key to grouping organisms, a technique that came to play a central role in vital materialism, especially in the works of von Baer and Johannes Müller. General physiology, he wrote, should examine the development or metamorphosis of organisms:

. . . *historically* through description of changes occurring at significant moments and the determination of their temporal relations, duration, succession, and co-existence with one another and with respect to external conditions insofar as these can be determined for the organisms and their classes. *Theoretically* through the determination of the internal and external more or less general conditions of change in the significant individual moments; through determination of their laws; through reduction of the variations themselves to classes valid for the different classes of organisms.⁷⁷

By linking the external conditions of change with the corresponding developmental stages, Kiemeyer's goal was "a determination of causes and effects, insofar as they can be determined for developmental phenomena in general as well as for their differences according to classes of organism." Among the factors listed that would aid in the construction of these developmental histories was a comparative study of "permanent inborn, accidental variations of the individuals of species." These variations included: "(a) misbirths, malformations, bastards. Variations with respect to geographical zones and other circumstances. Inheritable degenerations and permanent climatic and geographical variations. Universality of variation and structure [*Bildung*]. (b) variations in capacities and their excitability. Temperament, individual natures and idiosyncracies."⁷⁸

In addition to these factors Kiemeyer's *Physik des Tierreichs* also advocated the careful examination of the geographical distribution of animals and the determination of "laws of the differences in populations [*Haufen*]." Also to be considered was the gradation of forms among animals and the "affinities among them generally and with respect to populations." Finally, he advocated the examination of "changes which the animal kingdom and its populations [*Haufen*] suffer and have suffered in the past. *The developmental history of the animal kingdom* in relation to the epochs of the earth and the solar-system."⁷⁹ All of these various undertakings were, in Kiemeyer's scheme, designed to represent the series of animal forms and organization generally as a series of successful attempts by nature ". . . to set forth the phenomena of life and organization in all its forms, combinations, mixtures, sizes, etc.; to unfold it, dissect it as it were as a sum of fractions which only through summation gives the whole, the integral of life [*das Integral des Lebens*]."⁸⁰

Kiemeyer's idea of undertaking population studies and geological researches in order to uncover the historical *Stamm*-lineages of species was explicitly taken up by other students of Blumenbach—Humboldt, Treviranus, and Link. A common feature of the works of these three is the notion that large groups of organisms are united by common *Grundformen* and that the action of physical agents in the environment as well as the interaction of populations of individuals has acted to divide these forms

⁷⁷Kiemeyer, "Entwurf zu einer vergleichenden Zoologie, 1790–93," in *Gesammelte Schriften*, p. 22.

⁷⁸*Ibid.*, pp. 25, 27.

⁷⁹*Ibid.*, pp. 28, 29.

⁸⁰*Ibid.*, p. 27.

into known species. In his "Ideen zu einer Physiognomik der Gewächse," Humboldt writes: "If one grasps in a single vision all the different phanerogamic species of plants . . . one recognizes in this amazing multitude certain key forms [*Hauptformen*] to which all the others can be reduced. . . . Sixteen plant types determine the physiognomy of nature."⁸¹

In order to investigate the physical forces which caused these *Grundformen* to vary, Humboldt embarked on studies of the variation of species along the same isothermal lines, as well as the geographical variation of the same species and the number of species of the same family.⁸² He decided ultimately that in addition to thermal and other climatic factors, the distribution of species depended on "geological forces" which required further research.⁸³ These reflections led him to the following interesting conclusion:

My researches concerning the numerical laws of the distribution of forms will someday be applicable to the various classes of vertebrates. . . . They explain how in a given location the individuals of one class of plants or animals mutually limit the numbers of each other, and how after struggle [*Kampf*] and long fluctuations a condition of equilibrium establishes itself through the requirements of sustenance and the manner of life [*Lebensart*]; but the causes which have spatially limited not just the number of individuals of one form but rather the forms themselves and which have laid the basis of their characteristic differences lie beneath the impenetrable mist which still obscures our vision and touches ultimately on the origins of things and the first appearance of life itself.⁸⁴

Like Kiemeyer, Link and Treviranus looked to developmental histories and functional relations between groups of organs for a clue to dissolving the impenetrable mists mentioned by Humboldt in the preceding passage. Thus in language similar to that found in Kiemeyer's lecture notes on comparative zoology in which he described the forms of nature as united in the "integral of life," Link speaks of a single *Bildungstrieb* dominating all of nature:

All forms are interconnected through a multiplicity of transitional and intermediate forms. This multiplicity of form can best be represented as a net. *Thus one form differs from another only in that it has not received the same degree of development or is retarded in its development*, hence . . . the possibility arises of transforming one form into another [*alle in einander zu verwandeln*]. In this perspective we assume only a single universal *Bildungstrieb*, which when fully awakened, developed, or unhampered by external forces would give rise to a single extremely perfect structure; *now however, it is presented as limited to numerous stages in its development: in one stage awakened earlier in another stage awakened later.*⁸⁵

Link argued that malformed fetuses and various forms of degeneration provide evidence for this mechanism of transformation.

Elaborating upon a different aspect of the same mechanism, Treviranus argued that experience reveals that every organism has numerous contacts with the external environment, each point of contact corresponding to a particular organ. Experience,

⁸¹Alexander von Humboldt, "Ideen zu einer Physiognomik der Gewächse," in *Ansichten der Natur* (reprint of 3rd ed., 1849, Stuttgart: Cotta, 1871), Vol. II, pp. 21–23 (1st ed. 1807).

⁸²*Ibid.*, pp. 122–124.

⁸³*Ibid.*, p. 134.

⁸⁴*Ibid.*, pp. 138–139. Similar ideas were developed by Blumenbach in his paper "De anim. colon. sive sponte migr., sive casu aut studio ab nom. aliors transl.," in the *Götting. Comment. Rec.*, 1817, 5:101–116.

⁸⁵Heinrich Friedrich Link, *Natur und Philosophie* (Leipzig/Rostock: Stiller, 1811), pp. 307–308. Italics added.

he said, also teaches that variations in the effects of external forces can cause alterations in the structure of the corresponding organ, leaving the rest of the body unaffected. Finally, he said, "Experience teaches that these variations often become inheritable, and by a continued anomalistic effect of that power they even become permanent. . . . People say that such anomalistic influences may bring forth varieties, but never species and genera; but they assert it without proof."⁸⁶ Like Humboldt, Treviranus regarded climatic factors as well as the struggle between populations of individuals as providing the stimulus for such variation.⁸⁷

Like his fellow Göttingen alumni, Treviranus followed Blumenbach in asserting the need for investigation of the *Totalhabitus* in establishing a natural classification. He also postulated certain *Grundformen*, the analogues of Kant's *Keime* and *Anlagen*, from which all other forms have been derived: "Only a certain number of species were constructed out of the elemental forms, while all the remaining ones are degenerations from their originals."⁸⁸

In addition to developmental histories and the use of teratology, Blumenbach's *Beyträge zur Naturgeschichte* had pointed to a second source of information for reconstructing *Stämme* and their phylogeny—the geological record.⁸⁹ A concern with the fossil record was also a persistent theme in the works of his students, all of whom followed Blumenbach in supporting a uniformitarian geology. To Kiemeyer, for example, the picture emerging from geology is that of an *Entwicklungsbahn* for the total machine of the organic world.⁹⁰ Link argued, similarly to Blumenbach, that the fossil record reveals species related to present forms only in the broadest *class* distinctions.⁹¹ Humboldt, who had also studied with Werner at the Bergakademie, speaks in a similar vein of geological strata revealing traces of an almost completely destroyed creation and of a series of forms which have replaced one another in entire groups [*Gruppenweise*].⁹² The viewpoint of Blumenbach's entire school concerning the results to be expected from paleontology can best be summarized in the words of Treviranus:

We believe that the encrinities, pentacrinities and zoophytes of the prehistoric world [*Vorwelt*] are the original forms from which all the organisms of the higher classes have come into being through gradual evolution [*Entwicklung*]. . . . And it appears to us to follow that, contrary to what is commonly said, the animals of the prehistoric world were not destroyed by great catastrophes; rather many of these forms have survived, but they have disappeared from nature because the species to which they belong have been transformed into other species [*in andere Gattungen übergegangen sind*].⁹³

⁸⁶Georg Reinhold Treviranus, *Biologie: oder Philosophie der lebenden Natur*, 6 vols. (Göttingen: Röwer, 1802–1822), Vol. III (1805), pp. 163–164.

⁸⁷*Ibid.*, p. 18.

⁸⁸*Ibid.*, Vol. I (1802), pp. 162, 500.

⁸⁹Karl Ernst von Hoff is quoted by Marx to have written: "Amongst naturalists Blumenbach is the first who assigned to a knowledge of petrifications its true position in the foundation of Geology. He considered them as the most necessary helps to that study. He asserted with determination, that from a knowledge of petrifications, and especially from an acquaintance with the different position of fossils, the most important results for the cosmogenical part of mineralogy might be expected" (*The Anthropological Treatises of Johann Friedrich Blumenbach*, p. 11, n. 3). Von Hoff, a uniformitarian, was awarded the prize for his work on the question proposed by Blumenbach in 1817 to the Königliche Gesellschaft der Wissenschaften zu Göttingen: "on the changes in the Earth's surface that can be established in history, and the application which can be made of this information in the investigation of the revolutions of the Earth that lie beyond the domain of history."

⁹⁰Kiemeyer, *Gesammelte Schriften*, p. 62.

⁹¹Link, *Natur und Philosophie*, p. 338.

⁹²Alexander von Humboldt, *Kosmos* (Stuttgart/Tübingen: Cotta, 1845–1862), Vol. I, p. 44.

⁹³Treviranus, *Biologie*, Vol. III, pp. 225–226.

In the writings of Blumenbach and his students the framework for a general theory of animal organization and a plan for carrying it out in terms of empirical research are clearly visible. According to this theory the laws of organization can only be discovered by viewing the animal from several different perspectives. One side of animal organization has no immediate relation to the elements in which the animal lives. This level, the deep structure of animal organization, operates in terms of strictly biological laws independent of external influences. Another side of animal organization, however, has direct reference to the external world. To construct a theory of organic form is to understand the gradation of interaction between these two extremes and the laws of their interaction. The discovery of these laws demands a repertoire of methods designed to reveal different levels of organization. Comparative anatomy, comparative physiology, and comparative embryology reveal the internal, essential principles of organization, the highest of which is the type or *Grundform*. Paleontology, studies of geographical variation, and teratology together reveal the "variations on the theme" laid down by the type, the manner in which natural groupings of forms are pressed together into comprehensive generative stocks. Finally the principles at work shaping the surface structure of the organism were to be grasped from methods for examining the relationship of the organism to its environment. Among these were ecological and geographical studies as well as behavioral studies.⁹⁴ The various levels of organization revealed by these methods would provide the framework for a natural classification.

It is rewarding to explore the presence of vital materialism in the writings of other figures in this period. From the work of his early years in Königsberg it is evident that Karl Ernst von Baer had assimilated the principles of vital materialism into his view of organic nature and that his own embryological researches were an integral part of that framework. In three unpublished lectures delivered in Königsberg in 1822 and 1825 entitled "Vorlesung über die Zeugung" (1822), "Über die Entwicklung des Lebens auf die Erde" (1822), and "Über die Verwandtschaften der Tiere" (1825), as well as in his last lecture delivered in Königsberg in 1834 which he later included in his *Reden* under the title "Das allgemeinste Gesetz der Natur in aller Entwicklung," von Baer adopts the same theory of animal organization we have reconstructed from the works of Blumenbach and the "Göttingen School." Thus in the lecture on generation he argues that

... it appears that at the moment of fertilization the new being must arise as if through an electrical shock or some sort of magical artifice. But no matter how exacting the choice of microscope, no matter how one strains the eye, one sees nothing immediately after fertilization that was not previously visible. Only sometime later is the new plant or animal recognizable and then it is already caught up in growth. The thought must, therefore, impress itself upon us that the beginnings do not at all coincide with fertilization, but that the fruit lies already formed in the parents and has now entered into relations in which it can develop more quickly.⁹⁵

⁹⁴The fact that Kiemeyer, Humboldt, and many others, such as Louis Agassiz, stressed the importance of behavioral studies as one of the key elements in determining species has been totally overlooked in the secondary literature. These men as well as Johannes Müller, among others, stressed the importance of comparative anatomy of the vocal apparatus and the organs of generation as keys to species determination. In addition to Kiemeyer see Louis Agassiz, *Contributions to the Natural History of North America* (Boston: Little and Brown, 1857), pp. 58–59. Johannes Müller, *Über die bisher unbekannten typischen Verschiedenheiten der Stimmorgane der Passerinen* (Berlin: Akademie der Wissenschaften, 1845).

⁹⁵The principal source of these lectures is B. E. Raikov, *Karl Ernst von Baer 1792–1876: sein Leben und sein Werk* (Leipzig: Barth, 1968). In his biography Raikov includes long, invaluable citations from these works, which have not appeared in print elsewhere. The excerpt cited here was taken from Raikov, pp. 60–61.

Having adopted the generic performance scheme central to vital materialism, von Baer goes on to draw a conclusion which is one of the characteristic features of the theory: "Just as we nowhere observe an absolute beginning, so must the different forms which we call species have been gradually developed out of one another without having been originally constructed in all their present diversity."⁹⁶

In August of the same year von Baer developed this idea further through an examination of the evidence provided by recent paleontological research. Here in the lecture, "Über die Entwicklung des Lebens auf der Erde," he set forth the thesis that the development of the earth and its forms of life are deeply interdependent. The fossil record reveals three classes of remains: species for which even class and order are difficult to determine in terms of present forms; others which seem to belong to current genera but which have no representations among current species; and finally those which seem to be identical to current forms. The extinct species are in layers of the earth which according to geological evidence must have been formed earlier, while those demonstrating characteristics more closely resembling current forms appear in the most recent strata. In order to explain this phenomenon von Baer proposed a model based on the interdependence of animal organization, means of subsistence, and climate: "Some mosses of the European Alps are similar to mosses in the Andes. Even if slight differences between them can be detected, this does not contradict our theory, for there are slight climatic differences as well. . . . Similar climatic conditions produce similar animals and plants."⁹⁷

In order to see the scope von Baer was willing to accord these transformationist ideas it is useful to consider the lecture from 1834. Here he brought together elements of his more youthful writings in addressing the question of the origin of the diversity of form. He rejects the idea that new forms can be generated through the fruitful mating of different species, for nature erects too many barriers for hybridization to be an effective mechanism. Instead he prefers the process generated by the relationship of the organism to its environment in the manner proposed first by Blumenbach:

On the other hand every type of variation in the growth of the individual is transmitted through reproduction, and we see here the most evident confirmation of the principle . . . that generation is only a continuation of growth. If, therefore, external influences change the manner of sustenance, it will have an effect on the process of reproduction, and the longer this same influence is continuously active on numerous generations, the more pronounced will its effect be on later generations even after the influence has subsided.⁹⁸

As positive evidence for this claim von Baer cited the apparent transformation of the American guinea pig. This animal had not been known to European taxonomists before the sixteenth century, when it was introduced into Europe as a household pet. While the wild guinea pig is grey-brown, the tame animal is variously colored brown, black, and white. It prefers a different habitat from the original stock; it reproduces three times rather than once a year; the bones of its skull have received a different shape; and it will not mate with the wild stock. "This animal is, therefore, according to zoological principles actually a new species. This much has been produced in three

⁹⁶*Ibid.*, p. 63.

⁹⁷*Ibid.*, pp. 64–65, 66.

⁹⁸Karl Ernst von Baer, "Das allgemeinste Gesetz der Natur in aller Entwicklung," *Reden gehalten in wissenschaftlichen Versammlungen und kleinere Aufsätze vermischten Inhalts* (St. Petersburg: Schmitzdorff, 1864), p. 52.

centuries.”⁹⁹ Von Baer went on to note that all species of apes, of which he knew 150, were probably of common origin. He urged a similar thesis for the wild sheep, goats, and cattle.

While he defended a transformationist view of species in these early writings, von Baer did not attribute a common origin to all species. Like the vital materialists, von Baer argued that the transformation of species must be contained within definite limits. “We must conclude that as far as observation has enabled us to determine, a transformation of certain original forms of animals in the course of the generations has with great probability taken place, but only to a *limited degree*; that the complete destruction of many types has occurred and at the same time they only gradually emerged.”¹⁰⁰ Here von Baer was expressing one of the central doctrines of vital materialism which distinguished it from a true evolutionary theory. In von Baer’s view animals in responding to their environment *do not acquire new characters*. This is inconsistent with the fundamentally teleological conception of zoology he shared with the vital materialists. Kant had made the essential point: organization can never be understood without presupposing an original state of organization. Similarly, more complex forms cannot be generated from less complex forms. If groups of species are to be considered as descendants of a single ancestral form, the *Keime* and *Anlagen* for those later forms had to be present *in potentia* in the original stock. They represent the capacity for adaptation of an original state of systematic organization.

An examination of the works of other major contributors to early-nineteenth-century German biology strengthens the claim that the postulates of vital materialism came to serve as a unifying framework for the life sciences. For instance, Hermann Lotze provides the clearest statement ever given of the conceptual core of vital materialism. This appears in the article “Lebenskraft” in Rudolph Wagner’s *Handwörterbuch der Physiologie*, one of the foundational works of the “new physiology.” Wagner, who was Blumenbach’s successor at Göttingen, planned this work as a compendium of theoretical and empirical contributions which laid the basis for the new science of vital phenomena. Although Lotze’s article had been scheduled for a later volume, Wagner decided to use it as the introduction, for “this article deserves the careful attention of all who are concerned with a truly scientific standpoint, . . . and the principal questions of the organic sciences.”¹⁰¹

The aim of Lotze’s article is to clarify the meaning of *Kraft* in its application to vital phenomena and to demonstrate the proper role of teleological reasoning in biology. He argues that although such able biologists as Müller, Henle, and others (among whom Kiemeier and Humboldt are clearly implicated) had properly applied the methodological principles of vital materialism, they had frequently used language leading to a false and inconsistent impression of the term *Lebenskraft* at the core of their views. To avoid this, we have seen, was one of the motivating factors behind Blumenbach’s careful reflection on Kant’s formulation of the mechanico-teleological framework of the life sciences. Others, however, had considered organic forces as though they were directive agents independent of a material substrate. This confusion about first principles leads to a false conception of force, which ought to signify the same thing in the organic sciences as it does in the inorganic sciences.

⁹⁹*Ibid.*, pp. 53–54.

¹⁰⁰*Ibid.*, p. 60.

¹⁰¹Rudolph Wagner, *Handwörterbuch der Physiologie mit Rücksicht auf die pathologische Anatomie* (Göttingen: Vieweg, 1842), Vol. I, p. v.

To grasp the proper significance of force, Lotze argued, it is necessary to understand the role of teleological reasoning in the life sciences. That organic bodies are constructed in a purposeful manner is not to be desired. But *Zweck* in biological explanations can never substitute as a cause; it is rather an order manifest in a particular arrangement of the parts, from whose interrelations a result eventually emerges:

The fulfillment of purpose is, therefore, . . . only possible if all the means from which it will be effected are so arranged that the form of the predetermined result follows from them necessarily according to universal laws. Purpose obtains thereby control over the course of events only insofar as it was already present as a *Keim* in the disposition and order of the causes. . . .¹⁰²

Like Kant, Lotze argued that the only basis for a scientific explanation is one grounded on the principles of physics, ultimately the laws of matter and motion. "Forces" are not material objects; they are "contributions of thought." "Things do not act because they have forces, rather they have apparent forces because they act on something else." Nevertheless, Lotze emphasized the impossibility of providing a mechanical explanation for biological organization: "the pantheistic error is to be avoided; as though it were the case that organization could ever be a product emerging automatically out of matter coming together accidentally." That order and organization could ever emerge from disorder and chaos is inconceivable.¹⁰³ This unification of mechanical reasoning within a teleological framework led to a definition of biological organization as:

. . . nothing other than a particular direction and combination of pure mechanical processes corresponding to a natural purpose. The study of organized bodies can thus only consist in the effort to trace the particular ways in which nature combines those processes and how, at the basis of organization unlike artificial mechanical contrivances, she lays numerous divergent series of combined processes united into complex atomic events [*Atome des Geschehens*].¹⁰⁴

Kant, we have seen, called these "complex atomic events" *Keime* and *Anlagen*.

Lotze discussed the application of this vital materialist framework to the definition of species and the treatment of embryological development. Just as each chemical element is an aggregate capable of appearing in different states without being transformed into another element, so the organic realm was to be conceived as "a system of masses which pass through different developmental stages, without ever transgressing the continuity of motions generated by the species."¹⁰⁵ A certain "disposition of the material particles and forces" in the germ must form the basis for the development of the embryo, and the embryo must result from the interaction of these particles "according to the laws of mechanics." The primary function of such particles and dispositions is to provide a regulative framework within which a mechanical explanation of function can be constructed:

¹⁰²Hermann Lotze, "Lebenskraft" in *ibid.*, p. xv.

¹⁰³*Ibid.*, p. xxiv. Lotze drew from this the conclusion that the teleological-mechanical framework must even be a guiding thread for the physical sciences. How elements were first constructed to have the properties we now observe and why there were 56 (then) known elements could never be the object of a strictly mechanical explanation. Cf. pp. xxvii–xxviii.

¹⁰⁴*Ibid.*, p. xxii.

¹⁰⁵*Ibid.*, p. xxvii.

It need not be expected that these primitive dispositions which we presuppose in the germ will ever be an object of experience; rather—if it is permissible to express our expectation of the results of research not yet begun—it will turn out here just as in the new structure of the theory of light: a good hypothesis will generate a comparison of general morphological characteristics, and the acceptance of the hypothesis will follow from its ability to account for the phenomena.¹⁰⁶

CONCLUSION

One of the most vexing areas in the history of biology has been the development of the life sciences in Germany from 1790 to the late 1840s. Although no detailed study of the entire period has yet been undertaken,¹⁰⁷ most discussions have assumed that so many complex factors played a role that no unified account is possible. The problem goes beyond the fact that no generally accepted approach to a scientific treatment of the biological realm had been proposed—that biological science had not yet found its Newton. Religious factors, political convictions, popular movements, and the general tumult of events following the Napoleonic wars and leading up to German unification under Prussia so fragmented intellectual life that no single tradition could hope to flourish. There were, accordingly, nearly as many approaches to natural philosophy as there were thinkers on the subject, and similarly there were as many approaches to biological phenomena as researchers.

In this paper a scheme has been proposed for the history of the life sciences in early-nineteenth-century Germany which denies these assumptions. Instead I have offered the hypothesis that a model for organizing the biological sciences first sketched in the works of Kant and Blumenbach and then explored more systematically by a small group of closely related individuals guided subsequent development in several key areas of biological research for at least three decades, leading to the major achievements of German zoology and physiology in the early nineteenth century. At the basis of this argument is the claim that viewing the development of the life sciences in terms of the exploration and systematic articulation of this model will clarify the sources for the construction of the mechanistic—but not, as it is frequently assumed, reductionistic—approach to biological phenomena that emerged in the late 1840s. After describing the elements of the model through careful analysis of its problem context in the works of Kant and Blumenbach, I have attempted to provide evidence which suggests that it served as a unifying framework within which later biological research was conducted: first by showing that it was developed by Blumenbach's students, some of the most distinguished zoologists and physiologists of the early years of the nineteenth century; and secondly by showing that the model was adopted by a major theorist of the late 1820s and 1830s, Karl Ernst von Baer, as well as an acknowledged major contributor to the developments of the 1840s, Hermann Lotze. It has long been known that both von Baer and Johannes Müller flatly rejected the theoretical viewpoint offered by *Naturphilosophie*. Was it necessary for them to fashion their own new theory of organization? Or was there an alternative theoretical viewpoint? I suggest there was, and that it was vital materialism. Indeed Müller's theory of specific sense energies—the notion that the specialized response of each sense organ is a function of the particular manner of organization of the organic

¹⁰⁶ *Ibid.*, p. xlvii.

¹⁰⁷ The groundwork for such a study has been laid by E. S. Russell, *Form and Function* (London: Murray, 1916) and K. E. Rothschild, *Physiologie. Der Wandel ihrer Konzepte, Probleme und Methoden vom 16. bis 19. Jahrhundert* (Munich: Karl Alber, 1968).

materials constituting it—is a consistent application of the vital materialist framework to sensory physiology.

Before the scheme proposed here can be shown to be a truly useful framework for viewing early-nineteenth-century zoology and physiology several questions must be answered: How was vital materialism transmitted? Did it develop independently in different institutions or did it spread principally from Gottingen? We know, for example, that while he published virtually nothing, Kiemeyer's manuscripts on "Vergleichende Zoologie" and "Allgemeine Zoologie" (1806) circulated.¹⁰⁸ On the other hand, we know that although Ignaz Döllinger was enamored with Schelling's ideas, he was an ardent enthusiast of Kant's biological writings.¹⁰⁹ Here were at least two major potential sources for the dissemination of the theory. Equally important, of course, the question of the relationship of *Naturphilosophie* to vital materialism must be addressed; for if the scheme proposed here is correct, vital materialism and hence the development of the new physiology was completely independent of the conceptual structure of *Naturphilosophie*. Finally, if the advances in embryology and the cell theory are to be seen as the most fruitful concrete contributions of vital materialism, how did these developments take place? The answers to these and related questions must await a further exploration of vital materialism in early-nineteenth-century German biology.

¹⁰⁸See "Schreiben an Windischmann, 25 November 1804," in Kiemeyer, *Gesammelte Schriften*, pp. 206–207, ff.

¹⁰⁹See Guenter B. Risse, "Ignaz Döllinger," *Dictionary of Scientific Biography*, Vol. IV (New York: Scribner's, 1971), pp. 146–147. See also K. E. von Baer, *Nachrichten über Leben und Schriften des Herrn Geheimrathes Dr. Karl Ernst von Baer, mitgeteilt von ihm selbst* (St. Petersburg: Akademie der Wissenschaften, 1865), p. 171.