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THE ETERNAL LAWS OF FORM: MORPHOTYPES AND THE CONDITIONS OF EXISTENCE IN GOETHE'S BIOLOGICAL THOUGHT*

INTRODUCTION

In 1802 Gottfried Reinhold Treviranus announced the birth of a new scientific discipline. He called it "biology," the science whose aim was to determine the conditions and laws under which the different forms of life exist and their causes. Treviranus was not alone in forging the outlines of the new science of life. He was in fact consciously synthesizing discussions that had been going on for at least a decade in Germany involving such persons as Johann Friedrich Blumenbach, Karl Friedrich Kielmeyer, Heinrich Friedrich Link, and the von Humboldt brothers (Lenoir, 1981). But one of the most distinguished co-workers in this enterprise was the man whose scientific work we are celebrating in this volume; namely, Johann Wolfgang von Goethe.

In the decade marking the centenary of Darwin's death as well as the 150th anniversary of Goethe's death, it is tempting to treat the work of Goethe and his cohorts as the rudimentary beginnings of a scientific discipline which would acquire its firm foundations some sixty years later in the work of Darwin. This was in fact the strategy followed by Ernst Haeckel a century ago at a similar occasion when the sought to honor both men on the same program by casting Goethe as a precursor of the Darwinian theory of evolution (Haeckel, 1868, pp. 80—81). But such an ecumenical gesture would fail to appreciate the true significance of the movement initiated by Goethe, Treviranus and others. For the science of life they set out to found is not the one extrolled in textbooks today. In truth the works of Goethe and Darwin present us with two radically different conceptions of biological science, both capable in their own right of organizing the phenomena of life and serving as a basis for progressive empirical research. My aim in this paper is to discuss some of the special features of this grand conception of biological science that is found in Goethe's writings.

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THE PROBLEM CONTEXT OF GOETHE'S BIOLOGICAL THOUGHT: THE PROBLEM OF BIOCAUSALITY

Goethe summarized the essence of his approach to biology in a few lines in a poem entitled 'Die Metamorphose der Thiere,' written in 1819:

> Alle Glieder bilden sich aus nach ew'gen Gesetzen,
> Und die seltenste Form bewahrt im Geheimen das Urbild . . .
> Also bestimmt die Gestalt die Lebensweise des Thieres,
> Und die Weise zu leben, sie wirkt auf alle Gestalten
> Mächtig zurück. So zeiget sich fest die geordnete Bildung,
> Welche zum Wechsel sich neigt durch äusserlich wirkende Wesen.[1]

The major difference between the conception of biological science envisoned by Goethe in these lines and that developed by Darwin is that Goethe's biology is fundamentally and radically teleological in character. But Goethe's teleology is not that of a designing creator. To appreciate Goethe's teleology one must place it in the context of concerns that characterized biological thought in Germany in the 1790s.

Toward the end of the eighteenth century a number of persons were interested in placing the life sciences on a set of unified foundations. Their model was, naturally, Newton's theory of universal gravitation, but Newton's advocacy of applying the concept of 'force' to investigating chemical and electrical phenomena in the Queries to his *Opticks* also had a profound effect in shaping a 'Newtonian research program' for the life sciences. Albrecht von Haller was a leader of this movement, particularly in his attempt to explain organ function in terms of certain vital forces such as sensibility, irritability, and the force of secretion.[2]

This Newtonian strategy was plagued with difficulties as Caspar Friedrich Wolff and Johann Friedrich Blumenbach were quick to realize. These men called attention to certain features of organic bodies which resisted a strict Newtonian mechanistic strategy of explanation. Of special interest were the phenomena of development, growth and nutrition. These were clearly goal directed processes; and if they were indeed the effects of vital forces, they were not forces acting according to strictly mechanistic relations of cause and effect but causal relations in which means were subordinate to the end of organization.

These difficult and intricate problems relating to biocausality received clarification by Immanuel Kant. Kant had been following the work of Buffon, Haller, Blumenbach, Wolff and Georg Forster for several years — Kant himself had published on the question of races, varieties and species — and in 1790 in his *Kritik der Urteilskraft* Kant gave a definitive analysis and attempted resolution of the problems. Basically Kant concluded that while the goal of science must always be to press as far as possible in providing a mechanical explanation, mechanical explanations in biology must always stand under the higher guidance of a teleological framework (Löw, 1980; MacFarland, 1970). The essential difficulty, he argued, is that mechanical modes of explanation are inadequate to deal with many processes of the organic realm, where the relationship of cause to effect is completely different from that encountered in the inorganic realm. Although even in the inorganic realm there are reciprocal effects due to the dynamic interaction of matter, such phenomena nonetheless are capable of being analyzed in some fashion as a linear combination of causes and effects, $A \rightarrow B \rightarrow C$. This is not the case in the organic realm, however. Here cause and effect are so mutually interdependent that it is impossible to think of one without the other; so that, instead of a linear series, it is much more appropriate to think of a sort of reflexive series $A \rightarrow B \rightarrow C \rightarrow A$. This is a teleologic mode of explanation, for it involves the notion of a 'final cause.' In contrast to the mechanical mode where *A* can exist and have its effect independently of *C*, in the teleological mode *A* causes *C* but is not also capable of existing independently of *C*. The final cause is, logically speaking, the first cause. Because its form is similar to human intentionality or purpose, Kant called his form of causal explanation *Zweckmässigkeit*; and the objects that exhibit such patterns, namely organic bodies, he called *Naturzwecke:*

> The first principle required for the notion of an object conceived as a natural purpose is that the parts, with respect to both form and being, are only possible through their relationship to the whole .... Secondly, it is required that the parts bind themselves into the unity of a whole in such a way that they are mutually cause and effect of one another (Kant, 1908, p. 373; Kant, 1951, p. 219).

Clearly, Kant went on to argue, biological organisms qualify as *Naturzwecke.* The laws whereby organic forms grow and develop, he observed, are completely different from the mechanical laws of the inorganic realm. The matter absorbed by the growing organism is transformed into a basic organic matter by a process incapable of duplication by an artificial process not involving organic substances. This organic matter is then shaped into organs in such a way that each generated part is dependent on every other part for its continued preservation: the whole organism is both cause and effect of its parts. "To be exact, therefore, organic matter is in no way analogous to any sort of causality that we know . . . and is therefore not capable of being explicated in terms analogous to any sort of physical capacities at our disposal" (Kant, 1908, p. 375; Kant, 1951, pp. 221—222).

To be sure, there is, according to Kant, a certain analogy between the products of technology and the products of nature. But there is an essential difference. Organisms can in a certain sense be viewed as similar to clockworks. Thus Kant was willing to argue that the functional organization of birds, for example the air pockets in their bones, the shape and position of the wings and tail, etc., can all be understood in terms of mechanical principles, just as an *a priori* functional explanation of a clock can be given from the physical characteristics of its parts. But while in a clock each part is arranged with a view to its relationship to the whole, and thus satisfies the first condition to be fulfilled in a biological explanation as stated above, it is not the case — as it is in the organic realm — that each part is the *generative cause* of the other, as required by the second condition to be fulfilled by a biological explanation. The principles of mechanics are indeed applicable to the analysis of functional relations, but the teleological explanations demanded by biology require an active, productive principle such as the *Bildungstrieb* postulated by Blumenbach and others which transcends any form of natural-physical explanation available to human reason.

Kant's analysis demonstrated that the life sciences must rest upon a different set of assumptions and that a methodological strategy different from the physical sciences must be worked out if biology is to enter upon the royal road to science. One of the main conclusions of his analysis of causality was that biological organization could not be reduced to the laws of chemistry and physics, that at certain fundamental levels biological organization had to be assumed as given and beyond any further explanatory account. But whereas Kant's analysis had concluded the impossibility of constructing the forces of the biological realm from inorganic physico-chemical forces, he did nonetheless think it possible to go quite far in uncovering the framework of *laws* in terms of which the forces constitutive of the organic realm operate. If biological science were to be possible, it was because the biological realm no less than the inorganic realm was guided by a fundamental, unified framework of law. These bionomic laws were to be discovered through empirical research guided by reasonable hypotheses.

The practical implications of this analysis were illustrated by its application to animal systematics. Kant advocated the construction of morphotypes or organizational plans to be arrived at through comparative anatomy and physiology:

> 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 here (Kant, 1908, p. 418; Kant, 1951, pp. 267—268).

The fundamental plans referred to by Kant in this passage were the particular ways in which the forces constituting the organic world can be assembled into functional organs and systems of organs making up viable animals capable of surviving in the external world. The correctness of these hypothetical unities, Kant went on to point out, would have to be established through careful archaeological investigation.[3]

Goethe's Morphology

From his heavily annotated copies of Kant's *Critique of Judgement* we know that Goethe himself found these passages immensely stimulating. He later acknowledged that he owed a joyful period of his life to the ideas expressed by Kant herein (Goethe, 'Einwirkung der neuern Philosophie': *HA* 13, pp. 26—29). Indeed Kant's work fell on soil well prepared not only to appreciate but to further expand its more interesting features. For when he read Kant, Goethe was already well along in his own development of the notion of the morphotype (Bräuning-Oktavio, 1956; Gauss, 1970). In 1786 he had circulated his work on the intermaxillary bone in which the notion of a vertebrate skull morphotype is implicit; and in 1790, just a few weeks before the appearance of Kant's *Critique,* Goethe had published his work on the metamorphosis of plants in which the continuous transformation of an idealized primitive organ, the embryonic leaf, is used to establish homologies between the various structures of plants in different stages of development.

Goethe's early morphological work suggested a path toward realizing the program outlined by Kant of constructing a general science of form, and sometime in late 1794 and early 1795 Goethe set out to construct this general science. In his plant morphology Goethe had shown that all the advanced structure of the plant can be considered as a transformation of a single fundamental organ, and that the plant can be described as a continuous multiplication of similar parts. For more complex types of biological organization Goethe now advocated the hypothetical construction of a generalized morphotype consisting of a set of structures standing in definite relation to one another. Where he had earlier explored the unity of plant structure in terms of a single *Grundorgan,* Goethe now proposed a more general notion of the type based on a systematically interconnected set of fundamental organs. As one illustration of the richness of his approach Goethe concentrated on the construction of the osteological type, which he regarded as the most important expression of the forces determining life (Goethe, 'Erster Entwurf einer allgemeinen Einleitung in die vergleichende Anatomie': *HA* 13, p. 180).

The importance of comparative anatomy in arriving at the elements of the morphotype had been impressed upon Goethe by his earlier work on the intermaxillary bone. The apparent absence of the intermaxillary in adult humans had been a favorite argument of those, such as Camper and Blumenbach, who wished to argue that man is not related to the apes, which do exhibit a well defined intermaxillary. Goethe established that the intermaxillary is present in very young human skulls, and when its sutures are not fused, it can even be seen in adult skulls. Such considerations led Goethe to reject the practice of his eighteenth century predecessors of using a particular species, such as the human species, as the model for the rest (Goethe, *HA* 13, p. 172). The osteological type was to consist of all the structural skeletal elements common to the vertebrates, and it was to be arrived at through generalization based on careful comparative anatomies, not only of adult organisms but of organisms in different life-stages as well (Goethe, *HA* 13, p. 181).

Moreover, these researches revealed that a particular structure can appear quite differently in different animals, either part or all of it being elongated in one form while compressed in another, even to the point of being apparently absent. Hence Goethe introduced several important defining characteristics of the generalized elements constituting his morphotypes. Foremost among these is degree of complication [*Vollkommenheit*] (Uschmann, 1939). Structures that appear single in one form are shown to consist of several elements in another. Thus the seven cervical vertebrae, distinct in man and other mammals, are fused in the whale into a structure having the appearance of a single giant atlas with an appendage (Goethe, 'Erster Entwurf . . .': *WA* II.8, p. 43). In its most perfect or complex form an organ expresses its full potential for development, the entire complement of its component elements being present and fully articulated. The gill arches of the bony fishes, for instance, are the best representative of the archetype of the pharyngeal system. In different forms nature dissects, as it were, the structural components of the type, emphasizing now one, now another element. In addition to the number of elements, two further important defining characteristics of the type, according to Goethe, are position and arrangement.[4] The position of a structural element is its most constant feature, for position is defined in terms of the element's functional relationship to the organism as a whole. Thus, number of elements, their arrangement, position and degree of complication are all methodological tools for defining the morphotype, and it is in terms of these methodological requirements that organisms are to be established as related through homologlous variations on a ground plan [*Bauplan*].

In somewhat disparaging terms Goethe is frequently described as an essentialist and typologist (Mayr, 1963, p. 4; Mayr, 1957, 1—22; Mayr, 1968), and his conception of biology has been characterized as idealistic morphology (Russell, 1916, pp. 45—51; Uschmann, 1939; Riedl, 1978, p. 63). The implication is that he did not believe in the physical reality of his morphotypes. Now it certainly is true that Goethe himself referred to the types as 'pure ideas' of nature somewhat in Platonic fashion. But this is in part a result of the manner in which they were to be discovered. Morphotypes are necessarily hypothetical relations arrived at through what Goethe described as "der spekulative Geist." But they are not for that reason less really present in nature. In Goethe's view it is imperative to note that nature operates in terms of *forces* and *laws*. Both are present in nature, but in different senses.

For Goethe, morphotypes are laws that guide and delimit what he, like Blumenbach, Wolff and Kant, called the *Bildungstrieb,* the organic forces giving rise to nutrition, growth and reproduction (Lenoir, 1981; Lenoir, 1980). They are similar to what Buffon described as the "moule interieur." In the "Paralipomena" to the plan for a general morphology written in 1795 Goethe provides us with a clue to his conceptualization of this issue. He writes that the type has associated with it a domain of forces. The total quantity of available force is limited for a specific organizational plan, such as the vertebrates. But a very important law, the law of compensation, controls the distribution and expenditure of this total reservoir of force. An organism, in response to external factors defining the conditions of its existence, can expend more of this 'force' on developing certain structures, making them more complex and efficient for the ends life; but at the same time this can only be accomplished at the expense of other systems, which must compensate by becoming less complex (Goethe, *WA* II.8, p. 316). The morphotypes provide — in a phrase used by Goethe — the *Bauprincipien* in terms of which the forces of the organic world are to operate.

In his *Metamorphosis of Plants* in 1790 Goethe specifically advocated the attempt to construct a physiology based on improved understanding of the physico-chemical basis of life. But he immediately went on to point out that while life makes use of physico-chemical forces in achieving its ends, the fact of the matter is that it cannot be *reduced* to these forces pure and simple (Goethe, 'Betrachtung über Morphologie': *HA* 13, pp. 124—125). If one could indulge in an anachronistic analogy, Goethe's view is that biological organization can be analyzed in terms of 'levels' similar to a computer. The computer makes use of physico-chemical laws and processes in carrying out its program, but the *program* itself is not a set of physico-chemical laws, nor can it be reduced to them. Goethe's morphotypes are like that. They are the biological laws, the programs, guiding the *Bildungstrieb* in its production, of, in Goethe's phrase, "little worlds closed within themselves" (Goethe, 'Erster Entwurf . . .':*HA* 13, p. 176). Morphology is the scientific study of those internal laws of biological organization.

The Conditions of Existence

I have spoken up to now of Goethe's concern with internal laws of organization. But internal structure was inseparably correlated with the external conditions of existence in Goethe's view. Morphology was just one side of a more comprehensive science which Goethe called *Zoonomie* and which Treviranus called *Biologie* (Goethe, 'Erster Entwurf. . .': *HA* 13, p. 126).

Goethe had already demonstrated a concern for the external conditions of existence in his earliest morphological work on the intermaxillary bone. There is, in Goethe's view, a natural order among the stuctures one chooses to focus upon in morphology. The morphologist is not guided by an arbitrary choice of structures but rather focuses upon whose which have some special significance for the life of the animal, and in particular, with its contact with the external environment. Viewed in this context, the intermaxillary bone is of considerable importance, for as Goethe notes, it is by means of this structure that the animal is first in contact with its food; and, as Goethe also pointed out, the structure of the intermaxillary bone varies in accordance with the type of food for which the animal is adapted.[5] Generalizing upon this type of consideration, Goethe wrote:

> If one inquires into the causes that bring such a manifold of determinations to light, then we answer above all: the animal is formed by external conditions for external conditions; thus its inner perfection and its external purposiveness ('Erster Entwurf . . .': *HA* 13, p. 177).

Although Goethe did not follow up this idea in his own researches, its implications were clearly spelled out by him. Once the internal laws of organization as revealed by the science of morphology had been delineated, Goethe viewed the task of *Zoonomie* to investigate the law-like relationships in the external environment that condition the transformation of structure:

> First the Type should be investigated with respect to the effect upon it of the different elementary natural forces, and how to a certain degree it must conform to general external law ('Erster Entwurf': *HA* 13, p. 178).

Such variables as the role of the climate, temperature, moisture, and altitude were all to be taken into consideration. Examples of the sorts of 'laws' Goethe envisioned here were provided by Humboldt in his *Ansichten der Natur* and later in his *Kosmos* when he investigated the variation of forms within a class of animals by relating them to a biogeographical grid determined by isothermal lines. This approach was explored in somewhat different terms in the 1840s by the Göttingen physiologist Carl Bergmann leading to 'Bergmann's Law,' which relates variation in size to the temperature of the animal's environment (Coleman, 1979).

The extent to which Goethe was prepared to incorporate his ideas on morphology into a more general theory of systematics is demonstrated in a discussion of rodents which appears in the second part of his *Morphologie* of 1824. In reviewing D'Alton's widely influential tables on the skeletal structure of the rodents Goethe concluded that the entire class seemed to be based on a fundamental set of *Anlagen* capable of being diversified in numerous directions; but while the class seemed to be generically determined by these internal laws of organization, external conditions of life have brought about determinate specification of the forms in the class through structural transformation. In Goethe's view the class of rodents are all related through a common set of biological laws governing structure:

If, however, we want to form a basic judgement of this change of form and understand its actual cause, then we must admit, in good old fashion, the special influence of the four elements (Goethe, 'Die Skelette der Nagethiere': *HA* 13, p. 214; Goethe, 'Erster Entwurf. . .': *HA* 13, p. 178).

This apparent adaptation of the basic rodent *Bauplan* to a variety of habitats led Goethe to the hypothesis that:

An internal and original community lies at the basis of all organization; the difference of forms on the other hand arises out of the necessary relationships to the external world, and it may be justified therefore to assume an original simultaneous difference and [at the same time] a continuous progressive transformation in order to understand the constant as well as the divergent phenomena ('Die Skelette. . .': *HA* 13, p. 218).

Conclusion

Goethe's conception of biology was that of a functional morphologist, and, accordingly, whatever similarities persons like Haeckel have sought to detect between Goethe's views and Darwin's theory of evolution are purely superficial. Goethe shared the viewpoint of his contemporaries such as Kant, that a specific discipline is possible only in so far as it designates the domain of applicability of a set of necessary laws. For Goethe, even though it is not possible to reduce life to strict mechanistic laws, a *science* of life is possible nonetheless because there are internal laws of biological organization. These laws are expressed phenomenologically as morphotypes and *Baupläne,* and they are the essential core of the animal. For Darwin, on the other hand, morphotypes are not the manifestation of biological laws at all; they are simply the effects of natural selection operating on the descendants of a common ancestral form. The search for internal laws of organization turn out to be an illusion in Darwin's view. By invoking community of descent to explain commonality of form the 'biological laws' of the morphologist are simply dismissed by Darwin.

Nor can Goethe's conception of biology be turned into Darwin's by simply redefining Goethe's morphotype as Darwin's ancestor. Goethe's conception of life is fundamentally teleological. The morphotype is a set of means organized for the purpose of adapting to the conditions of life. Surprisingly, in spite of language like the "struggle for existence," for Darwin, organisms are far more passive and less tenacious in their grip on life: they simply vary — spontaneously. Natural selection does all the work of adapting populations of descendants to their changing circumstances. Not so for Goethe. Not only does the *Bauplan* of an organism provide the material for adaptation but the organism is controlled by internal laws, such as the law of compensation, which adjust means to ends in order to produce a functional whole organism. Goethe's universe is based on the rational relationship of ends to means. To argue that the principal source of change in organic nature is ultimately dependent on chance is, in Goethe's view, to surrender the goal of achieving a scientific treatment of biological organization.

NOTES

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[1] *WA* II.8, p. 59. This poem dates back to a sketch written in 1806. See *WA* II.8, "Lesearten," 279—280.

[2] Haller was no vitalist, at least not in the ordinary sense of someone who advocates the imposition of a soul or designing agency upon organic forces. Rather, Haller's vital forces were assumed to be rooted in the material constitution of muscle, nervous and mucous tissue but incapable of further mechanistic reduction (cf. Roe, 1981).

[3] "The archaeologist can let the great womb of nature, which emerges from the original chaos as a great animal, give birth first to creatures of less purposive form, those in turn to others which are better adapted to their birthplace and to their inter-relations with one another; until this womb has petrified, fossilized and limited its progeny to determinate species incapable of further modification, and this manifold of forms remain just as it emerged at the end of the operation of that fruitful formative force. But

in the end, he must attribute the imposition of the original purposive organization to each of these creatures to the Mother herself" (Kant, 1908, p. 419; Kant, 1951, p. 268).

[4] Goethe, *WA* II.8, p. 39—41; see also expaned version of the Entwurf of 1796, *WA* II.8, p. 86 and elsewhere.

[5] See Goethe, 'Dem Menschen wie den Thieren ist ein Zwischenknochen oder obern Kinnlade Zuzuschreiben' (*HA* 13, p. 185).

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