Form and Cause in Goethe's Morphology

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Any modern reading of Goethe's morphological writings must struggle with the author's apparent satisfaction that his "morphology" (Goethe coined the term) was both a descriptive science and a causal one. This unlikely attitude is made all the more difficult by Goethe's suggestion that form — at least in the sense of "archetypal form" — is itself causal. That "form," which is normally thought to be the effect of causal process, may somehow be identified with its origin, is counterintuitive to our normal habits of thought. It is not surprising therefore that the identity of "form" and "law" in Goethe's writings is generally treated as an idealistic excess of *Naturphilosophie* which required no special effort to understand. Members of that school showed a tendency to reify ideas and had no misgivings about imposing such notions upon their observations. By the simple expedient of his inclusion in a homogeneous *Naturphilosophie* Goethe can be made unproblematic. It is an attractive solution, but an incorrect one.

I shall argue in this paper that Goethe's notion of archetypal form represents an important advance in the phenomenology of organic form, and that it does indeed have causal implications. I shall argue further that the confusion of Goethe's ideas with those of other figures, particularly the notion of an archetype as it is found in Oken and Owen, is attractive just because it requires no departure from our ordinary mental habits, and has led to a pervasive misreading of Goethe's work. If my argument holds, however, the efforts of Oken, Owen, and even some modern Darwinians, must be seen in a new light, for it would appear that these efforts fail in their intention to the degree that they depart from Goethe's approach. Archetypal form may be more central to morphological study than present attitudes allow, but until we recover Goethe's actual concept we have no way of deciding the question.

Introduction

Morphology is, as the term suggests, an account of form — an "account" that allows us a rational grasp of the perceived *morphe* by making its internal and external relations intelligible. I must ask my readers to focus, as they read the following pages, upon the implications that one form has for another, and not upon theorized processes that might give rise to such forms. These processes would concern us only when the relations between the forms were understood well enough to think about origins — that is, when the task of morphology had been completed. But before we reach this stage we must understand the manner in which distinct forms reveal a commonality through comparison, and the logic by which such comparison is articulated. The following discussion is an essay on the logic of form.

The Anatomy of Common Plan

Morphology studies the forms of organisms by juxtaposing them and evolving, from this juxtaposition, a standard of comparison. Since the work of Aristotle the most obvious standard of comparison has been that of *homology* (a term made popular by Owen) or standard part identity. Aristotle had noted, for example, that many animals seem to possess identical parts — heads, limbs, etc., and that groups of animals could be formed on the basis of common construction or common *Bauplan* as this was later termed in German (Russell, 1916). The possession of a common plan by a group of animals allows us to identify standard parts, giving them common names. Thus, with regard to any tetrapod, we may speak of the spine, the skull, the forelimb, or the upper bone in the forelimb, the *humerus*. These are all types of standard parts, the last being a single bone and the others complexes of several bones.

Of course, these elements may take on very different appearances in different animals (Aristotle's variation according to "excess or defect"), and our recognition of standard part identity, or homology, depends upon our recognition of identical position in the overall common plan, or identical structure in the complex of the part — that is, upon principles of position and composition.

Particular organs have been identified by such criteria since Geoffroy St. Hilaire (1818) formulated his "principle of connections" and "principle of composition." Geoffroy was particularly acute in his insistence that it was plan, rather than function, that identified both organisms and their parts, and his ideas of relation took their modern names at the hands of Richard Owen (1848) who termed functional similarity *analogy* and standard part identity *homology*. The former he defined as: "A part or organ in one animal which has the same function as another part in a different animal," and the latter was "The same organ in different animals under every variety of form and function." Neither Owen nor Geoffroy defined what they meant by "the same," but their meaning is easily recovered from the context of argument. Geoffroy had claimed that a particular organ might go through almost any transformation *except* transposition. Owen identified his homologies by their connections and composition. The identity preserved by the criteria applied is clearly one of position and structure, and one is thought to imply the other.

The same concepts form the basis of most modern work, although their significance is sometimes blurred by evolutionary explanations. Thus Remane's (1971) first and second criteria of homology are (1) the position of the organs within comparable systems and (2) direct agreement between organs with regard to numerous features — i.e. the "principle of composition."

Both of the above criteria are logical derivations of the concept of common structural plan (*Bauplan*). Homologous organs share the same position on the overall map of the organism, and *by extension of the same map,* share the same compositional structure. Structural comparison of organisms takes place by a conceptual reduction to schematic identity, and if we put aside functional studies, there is little more to modern morphology. Organisms are compared in terms of their similarity and differences, and similarity rests on schematic identity.

Of course, direct comparison of adult morphology is not the only manner of determining structural similarity, or homology, yet this does not alter the conclusion above. Two important additions are embryology and grouping, but both derive from common plan. This is relatively easy to see with regard to developmental evidence, for although such evidence will at times provide valuable information, comparison at this level must rest on the very same foundation as the mode of comparison discussed above. As Russell (1916) points out, the relations of embryonic structures "are still determined solely by relative positions and connections of parts, just as homologies are determined in the last of all stages of development, the adult state." Developmental evidence, which includes the entirety of ontogenesis as well as the adult form, provides richer comparative material both quantitatively (more forms to compare) and qualitatively (in the comparison, otherwise unavailable, of different stages of the same

organism). Yet in spite of the richer character of this evidence its application establishes homologies in exactly the same way as adult evidence — i.e. by clarifying position and composition.

The grouping of organisms does provide a further criterion of homology (besides position and composition), but not independently of common plan. Organisms sharing the same plan are for that reason grouped together, and within the overall plan (within the phylum) those sharing a particular variant of that plan form a sub-group. Thus, on the basis of shared and unshared variations, organisms within a plan are grouped in a hierarchical subordination of smaller groups within larger ones. Since any particular homology will be a particular variant of that standard part, which variant will either be unique or be shared by a certain number of species, each hypothetical postulation of homology carries grouping implications. In practice, the implications of a particular character (hypothesized homology) are compared with those of the other characters while constructing a hierarchy of groups. If the hypothetical homology is *congruent* with the aggregate of information (with the grouping implications of the majority of characters) it would seem to be correctly identified and passes the test. If it is not, it is judged mistaken — i.e. it is not a true homology (Nelson and Platnick, 1981; Patterson, 1982). Although this is not a criterion of position or composition, it is derived from the hierarchy of taxa that is itself derived from their ordering according to shared and unshared variations of a common plan. A group within such a hierarchy is defined by possession of a particular variant, or *morphotype* (since each variant of the overall plan is itself a particular plan). We have still but one concept of structural comparison.

Darwin (1859) thought so too, for the relations described above are exactly those "mutual affinities of organic beings" to which his thirteenth chapter refers. The patterns resulting from the study of these relations were to Darwin the standing patterns of natural history, which his theory proposed to explain by an evolutionary account. The common plan of the phylum was, in Darwin's treatment, the plan of the original progenitor of the line, preserved by heredity. Variation was introduced by descent, and channeled into particular lines of development by selective pressures. Since all variation preserved the same original plan, and each evolutionary novelty (each new variant or morphotype) could itself become a starting point for new departures (by being the common ancestral plan preserved within a group of lesser variations), the hierarchy of groups within groups was a record of descent, and classification became phylogenetic.

The key concepts of homology and *Bauplan* remained purely morphological, of course, for they describe relations that must first be known before they can be explained. Thus Darwin borrows them from pre-Darwinian morphology and simply provides a new name for the latter. In chapter thirteen of the *Origin* Darwin writes: "the ancient progenitor, the archetype as it may be called..."

The Problem of the Archetype

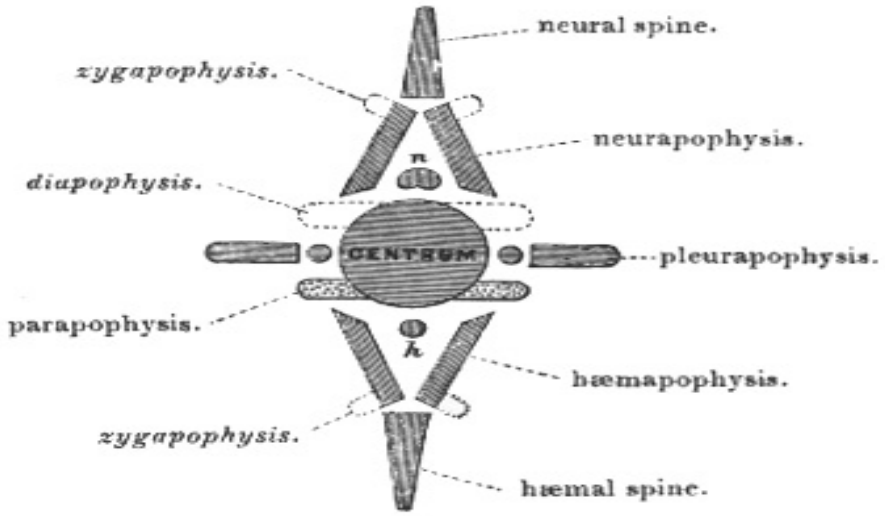
When Aristotle noted that animals within the same group possessed the same parts modified only "by excess or defect," he implied that the difference between these organisms was merely one of transformation — i.e. that some underlying identity was preserved through all the changes. The implication still holds, for it is obvious that the concept of homology postulates an identity of positional plan as well as an identity of organs (since the identity between the organs is often argued on the identity of their connections). Yet morphologists are not in the habit of giving that plan any definite form.

In actual taxonomic practice, although one *assumes* that all vertebrates are built upon a single schema, membership in the phylum is decided by possession, not of an entire plan, but of one very general character — the axial skeleton. Of course, the identification of this character implies the rest of the plan (as its context), but no attempt need be made to trace it out. The full plan, oddly enough, remains an object of speculation. (Darwin spoke of the "unknown progenitor" of the vertebrates, or of

any other phylum.)

When we compare fishes and tetrapods, for instance, the presumed homologies between fins and limbs are not clear. The conceptual problem is once again a standard of comparison — something that would act as a guide in our attempt to trace the transformation between fins and limbs. A good deal of morphological guesswork has been concentrated on this problem, but without better evidence — i.e. enough transitional forms between fins and limbs to make the positional relations clear — the answers must remain questionable. Of course, the more distant the forms, the more difficulty we have in following the transformation. A good (close) series of transitional forms would settle the matter, but lacking such evidence, we may elect to try another approach.

We could, for instance, imagine a form intermediate between fins and limbs, which form would then provide a hypothesis of relation. Or, in a related exercise, we could find a schema on which both fins and limbs could be mapped — i.e. a schema which generalizes on them both. Of course, the more distant the forms compared, the fewer particulars they have in common, and the more general a common schema will have to be. Thus, the progenitor of a phylum is usually conceived as a rather simple organism, and the "archetype" upon which the progenitor was modeled was constructed from a very simple form by repetition and transformation.



Ideal typical vertebra.

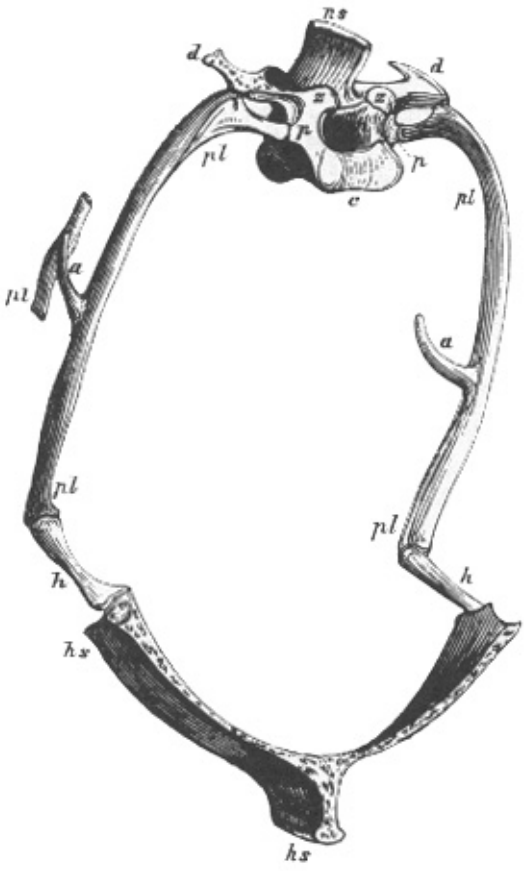
Figure 1

One of the latest and most influential versions of this notion of an archtype was produced by Richard Owen (1848), who may have been the last important representative of *Naturphilosophie* in Englind. Owen has absorbed a great deal from this German heritage, particularly the notion, found in Lorenz Oken (1807), that the plan of the vertebrate phylum was essentially a series of segments. Thus Owen begins by postulating a "typical vertebra" (Figure 1) — a schematic "map" generalizing on the vertebrae. He then projects each segment of the vertebrate skeleton on this map. Thus, the thorax of a bird (Figure 2) becomes an expanded vertebra. The section of the sternum shown becomes a "haemal spine," the sternal rib a "haemapophysis," and so on. Once he has mapped all elements of the skeleton on this same schema Owen is able to build that whole from vertebral sections by repetition and

transformation of parts.

Having reduced the varied structures of vertebrate skeletons to transformations of the underlying "typical vertebra," he constructs on this basis the "vertebrate archetype" (Figure 3). The latter is an animal with an axial skeleton that is minimally developed — i.e. is varied enough to support life but not so much that it cannot be seen as a series of transformations of vertebral sections. Even the skull is made into a series of expanded vertebrae, and the vertebral schema is the only irreducible element left.

The reduction to simplicity here is extreme, for Owen must unify such distant structures, but the strategy is not unusual. Owen termed the relation "in which a part or series of parts stands to the fundamental type" *general homology* (which relation was thereby distinguished from what he termed *special homology* — the relation between identical organs in different organisms described in the preceding section). Of course, the general homology of several distinct elements with the type indicates as well their homology with each other, but the crucial point seems to be that their relation to each other could not be discovered without the mediation of the type concept.

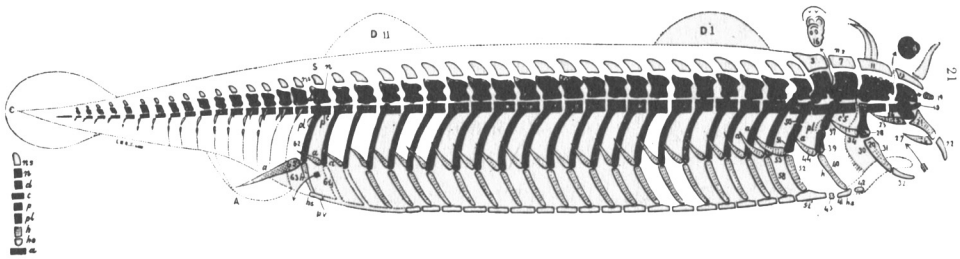


Natural typical vertebra: thorax of a bird.

Figure 2

Owen's analysis of the limb, for instance, homologized the entire structure with a single element in the "typical vertebra." Owen dismissed the obvious differences — the multiplicity of elements in the limb, which is a compound organ — by stating that the single bone of the schema had become "teleologically compound," presumably for the purpose of locomotion. Owen could affirm the homology of fins and limbs in this manner, since both would be transformation of the same vertebral element, but his approach is more legislation that discovery. The real problem is not the extreme degree to which Owen pushed his strategy, but the strategy itself. He is not alone in this mistake, however, and we will be better able to examine the nature of his error in a modern example.

When the positional data is fairly clear, as is the case when the distance between forms is not great, homology is traced by direct matching of connections and composition. When these are somewhat ambiguous, however, the morphologist may still determine homology through the implications of grouping information (see preceding section). When the empirical data is too impoverished to clarify groups, the investigator may still form a hypothesis or relation by proposing a form or schema which generalizes upon the forms under examination. This can be done in two ways — either by constructing a hypothetical intermediate between forms, or by constructing a schema simple enough that it could serve as a common map. Either approach allows one to hypothesize agreement between the forms compared on the basis of the agreement of each with the mediating form, or their "general homology." But this strategy confuses evidence and theory. If we follow out its present-day career we shall see why this is so.



Ideal archetype skeleton

Figure 3

Patterson (1982) reviews the Owen version of an archetype and notes that the real problem is the notion of general homology, by which "an idealization" is homologized with actual features through "abstract transformations." He then argues that the same strategy can be found in the contemporary practice of homologizing dissimilar organs on the basis of the homology of each with the primitive version of the organ in a hypothesized progenitor. Due to the use of such a strategy in contemporary works, Patterson concludes that "archetypes are by no means extinct," but live on in the form of speculative progenitors. These modern versions are Darwinian, of course, but however far they appear to be from Owen's idealistic schema, they result in the same difficulties.

Empirical determination of homologies is always by comparison, either a direct comparison between two forms or a wider comparison between all members of a hypothetical group. But if comparison is our method of handling the empirical data, it would seem only logical that the items compared be the empirical forms. When we construct an intermediate form to trace the positional relations between two organs, however, we begin to compare empirical forms with invented forms. The procedure treats the invention as if it were an empirical discovery, and results in the determinations that would follow from such a discovery. Of course, if the grouping information were more complete, we could have determined the homologies in questions, and if we now make it more complete by adding an imaginary taxon, a determination will result. But the approach is quite arbitrary. The fact that we *can* invent such forms means nothing, for when the relations are unclear we can invent many — *all* possible intermediates — but none actually found in nature. There can be no profit in the strategy.

A similar problem arises with regard to the hypothetical ancestor, for this invention is equally without empirical foundation, and occupies a space in our reflections that should be reserved for actual observation. If we can invent one ancestral form, we can invent many, and lacking the evidence for which they substitute, there is no way to determine which form, if any, is correct.

We must remember, while reviewing these problems, that the mediating form was hypothesized because the data was inconclusive without it. It becomes, therefore, an interpretive tool by which the data can be given definition. The known forms are now interpreted by the hypothesized ancestor (or intermediate), and what the existent organisms do or do not possess will now depend upon what the hypothesized ancestor (or intermediate) says they possess. If the empirical forms must submit to interpretation *by* the hypothesis, they cannot be used to *test* that hypothesis. For these reasons Patterson calls general homology "vacuous," and I must concur. Speculative construction of general forms and the paths of transformation that they suggest may hold a certain fascination for the imagination, but the practice is merely guesswork and can tell us nothing about the actual paths of

transformation. "General homology" is not actual homology.

Patterson's critique of general homology shows us both how widespread and how bankrupt the practice is, but it does not dissolve the problem of the archetype. What Patterson has actually targeted is the practice of legislating paths of transformation in order to interpret data. Admittedly, most archetypal schemes did just this. But the problem to which they were addresses is innocent of the response.

From the inception of this discussion the comparison of organic forms has led to postulations of underlying unity, which unity is often conveniently expressed in a schematic plan of positions (connections). It seems but an extension of this practice to suppose that if forms which appear distant to the eye are yet thought to be transforms of one another, that transformation may be made intelligible by discovering the positional schema that is common to both and therefore unchanging in the transformation. Geoffroy's principles imply no less, for if organic structure can pass through any transformation *except* transposition, the unity which remains constant through these transformations must be a positional schema. And unless we want to suppose that the vertebrae of fish and those of tetrapods are not the same thing, such a schema would underlie both fins and limbs.

Goethe

At first glance it seems obvious that Goethe must have exerted an influence on Owen, at least in so far as the latter figure looked to *Naturphilosophie* for his notion of an underlying unity represented by every part of an organic whole. This idea had been prominent in German thought since Herder, and Goethe developed it in such a manner that Owen may well have thought of Goethe's work as a precursor to his own. Yet the notion of an archetypal schema that underlies the parts of an organism is really older than Goethe, and his own contribution, developed mainly in botany, rests on a different principle. Before I clarify that statement however, let me point out the *appearance* of similarity that has led most commentators to make a parallel reading.

We are privileged, in Goethe's case, to watch his botanical notions as they grow. The basis of his *Metamorphosis of Plants* (published in 1790; English translation, 1946) was worked through during Goethe's journey to Italy (1786-87) and reflected in his letters (collected and published as the *Italian Journey*: Goethe, 1968). The following excerpts bear directly on the emerging idea of an archetypal or primal plant [*Urpflanze*].

Padua Botanical Gardens
September 27, 1786

> To wander about among vegetation which is new to one is pleasant and instructive. It is the same with plants as it is with other familiar objects; in the end we cease to think about them at all. But what is seeing without thinking? Here where I am confounded with a great variety of plants, my hypothesis that it might be possible to derive all plant forms from one original plant becomes clear to me and more exciting. Only when we have accepted this idea will it be possible to determine genera and species exactly. So far this has, I believe, been done in a very arbitrary way. At this state of my botanical philosophy, I have reached an impasse, and I do not see how to get out of it. The whole subject seems to me to be profound and of far-reaching consequence.

Botanical Gardens, Palermo, Sicily
April 17, 1787

> Here, where, instead of being grown in pots under glass as they are with us, plants are allowed to grow freely in the open fresh air and fulfill their natural destiny, they become more intelligible. Seeing such a variety of new and renewed forms, my old fancy suddenly came back to mind: among this multitude might I not discover the Primal Plant [*Urpflanze*]? There certainly must be one. Otherwise, how could I recognize that this or that form *was* a plant if all were not built on the same basic model?
>
> I tried to discover how all these divergent forms differed from one another, and I always found that they were more alike than unlike. But when I applied my botanical nomenclature, I got along all right to begin with, but then I got stuck, which annoyed me without stimulating me.

Naples
May 17, 1787

> I must also tell you confidently that I am very close to the reproduction and organization of plants, and that it is the simplest thing imaginable. This climate offers the best possible conditions for making observations. To the main question — where the germ is hidden — I am quite certain I have found the answer; to the others I already see a general solution, and only a few points have still to be formulated more precisely. The Primal Plant is going to be the strangest creature in the world, which Nature herself shall envy me. With this model and the key to it, it will be possible to go on forever inventing plants and know that their existence is logical; that is to say, if they do not actually exist, they could, for they are not the shadow phantoms of vain imagination, but possess an inner necessity and truth. The same law will be applicable to all other living organisms.

Rome; second visit
July 31, 1787

> While walking in the Public Gardens of Palermo, it came to me in a flash that in the organ of the plant which we are accustomed to call the *leaf* lies the true Proteus who can hide or reveal himself in vegetal forms. From first to last, the plant is nothing but leaf, which is so inseparable from the future germ that one cannot think of one without the other.

As other commentators have noticed (Arber, 1950; Cassirer, 1950; Steiner, 1962), Goethe begins by speaking of his *Urpflanze* as if it were an ancestral form. His later references to it make clear, however, that it is something abstracted from the empirical particulars. It seems unlikely that this indicates an alternation in his approach, for when he speaks of discovering the *Urpflanze* "among this multitude" he probably does not mean actually *finding* it among the plants of the Palermo garden but *seeing* it through their mediation. After all, Goethe boasts, a month later, that "Nature herself" would envy him the *Urpflanze*, clearly indicating that it was not a natural product. Unless he went through a very rapid conversion, the *Urpflanze* was probably a general plan — rather than an ancestral species — from its inception.

In keeping with his notion of an archetypal plan, Goethe proposes the general identity of all appendicular organs of the plant, or as it has usually been interpreted, the homology of cotyledons, foliage leaves, sepals, petals, pistils, stamens, etc. The germ of this idea is found as early as Theophrastes, and related notions are developed by both Grew and Malpighi. Wolff worked out a parallel idea based on common embryonic forms nineteen years before Goethe's letter, but Goethe

seems to have been ignorant of these predecessors and thought he had none. Earlier work is therefore without interpretive value for Goethe's text (Arber, 1950).

Against the background of *Naturphilosophie* and the predilection of its adherents to emphasize the repetition of parts in the *vertebrate* skeleton to the point at which the whole becomes only vertebrae, Goethe seems to be postulating: (1) the "general homology" of all appendicular organs of the shoot; (2) a generalized plan for the underlying organ; (3) by repetition and transformation of the underlying organ, a generalized plan for the whole shoot. Interpreted in this manner, Goethe's work finds a parallel in both Oken (1807) and Owen (1849, 1866), and too many figures have interpreted Goethe in this fashion to list them here. (A few commentators — such as Arber, Cassirer and Steiner — resist this reading, but they have not influenced the majority.) This mistake is perhaps quite natural given the context in which Goethe would be read, but it remains a mistake. The identity that Goethe postulates between organs is not that of "general homology," nor does his "leaf" [*Blatt*] perform the same function as Owen's typical "vertebra." Nor, for the matter, can his *Urpflanze* be an Owenian archetype. Goethe attempted to define another solution to the problem of the archetype, but the more influential work of such known biologists as Owen has effectively prevented historians from making a decent reading of his text (see for example: Russell, 1916; Nordenskiold, 1928; Singer, 1959). If we pay close attention to certain details in Goethe's argument, however, the differences between his notion and that of "general homology" will become clear.

The point of "general homology" is the homology of each element with the type, but this notion of type is hardly distinct from ancestral form. When Owen used the generalized plan of a vertebra for his type, it was obvious that the "typical vertebra" was most directly represented by actual vertebrae, and Owen was imagining something like an actual transformation from vertebra to ribs, limbs, etc. Of course, since the vertebral form is the common one, it remains primary. The transformations described move *from* vertebrate to other forms, almost in the manner that we imagine the transformation from an original progenitor to its descendents. In a certain sense, in fact, Owen's notion contributed to Darwin's idea.

In the thirteenth chapter of the *Origin of Species* (section on morphology, 1859), Darwin suggests that the progenitor — "the archetype as it may be called" — provides an explanation for the homologies that obtain between various parts of the same organism. He then goes on to read Goethe (he does not mention the name, but the text is clear in its implications) in these terms. Noting that "in a flower the relative position of the sepals, petals, stamens, and pistils, as well as their intimate structure, are intelligible on the view that they consist of metamorphosed leaves, arranged in a spire," and that parallel relations of homology are found in the vertebrata and the articulata, Darwin concludes: "An indefinite repetition of the same part or organ is a common characteristic (as Owen has observed) of all low or little modified forms; therefore we may readily believe that the unknown progenitor of the vertebrata possessed many vertebrae; the unknown progenitor or the articulata, many segments; and the unknown progenitor of the flowering plants, many spiral whorls of leaves." Read in terms of Owen's general homology, Goethe's work seems to suggest that the foliage leaf is the original form from which all other appendicular organs were derived.

But this is actually a step which Goethe refuses to take. In the *Summary* of his *Metamorphosis of Plants* (1946) we find a warning against just this interpretation:

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> Just as we have now sought to explain the protean organs of the vegetating and flowering plant all from a single organ, *the leaf*, which commonly unfolds itself at each node; so we have also attempted to refer to leaf-form those fruits which closely cover their seeds.

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It goes without saying that we must have a general term to indicate this variously metamorphosed organ, and to use in comparing the manifestations of its form; we have hence adopted the word *leaf*. But when we use this, it must be with the reservation that we accustom ourselves to relate the phenomena to one another *in both directions*. For we can just as well say that the stamen is a contracted petal, as we can say of the petal that it is a stamen in a state of expansion. And we can just as well say that a sepal is a contracted stem-leaf, approaching a certain degree of refinement, as that a stem-leaf is a sepal, expanded through an intrusion of cruder saps.

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In the same way it may be said of the stem that it is an expanded flowering and fruiting phase, just as we have predicated of the latter that it is a contracted stem.

Goethe's warning that the transformations must be run i*n both directions* makes it quite clear that the foliage leaf cannot be taken as more general than other forms or "primitive" rather than "derived." Goethe's choice of the term *Blatt* (leaf) for the general organ has confused some commentators, but as Arber noted (1950), it must be understood as an entirely general organ, while each of the actual organs of the plant are particularized.

One might suppose, upon first reading, that if Goethe affirmed the homology of foliage leaves, sepals, petals, stamens, etc., he must have had some common schema in mind. Since a schema is itself a form, however, Goethe must provide a form which is not only a possible starting point for all plant appendages, but is also equally distant from each and therefore specially related to none. This would be a formidable task if accepted, but Goethe did not accept it. He did not produce a schema for his *leaf*, nor did he trace the identity of the organs mentioned by means of position and composition. To call this identity "homology" may in fact be misleading, since that term has come to mean "identity of position and composition." Goethe used other criteria.

The various organs of the flowering plant are usually identified by common recognition rather than any formula, for the foliage leaf, petal, stamen, etc., all seem obvious. We may recognize something like positional information here, in that one expects each organ to occupy the same place in the topography of the stem — the sepals will come between the foliar members and the petals, for instance — but this is hardly a criterion of recognition. Tulips move directly from leaves to petals, omitting the sepal stage entirely, but no one wants to call its petals sepals for that reason. But just because it is not a criterion of recognition, positional information can be used in another manner.

If we take the "node" as a point at which some appendicular organ appears, then we find that these nodal points are multivalent. In the "normal" progression of any particular flowering species, we are able to predict what sort of organ will arise at which node. But in an "abnormal" progression the same node may give rise to something other than the expected form. In the case of "doubled" flowers, for example, we find that the group of nodes that would usually produce stamens give petals instead. In a more extreme reversal of the ordinary progression, the whorl of nodes that usually produce the corolla may go vegetative and produce foliage leaves instead. Due to such violations of the usual progression we learn that a single nodal position may be capable of giving rise to several different forms, which fact suggests, upon reflection, that these forms may share an underlying identity.

This suggestion is strengthened when we find, in the same flower, not only petals and stamens but forms intermediate between the two, often moving so gradually from the petal-like to the stamen-like that they form a smoothly graded series. Here we actually seem to "see" the metamorphosis of petal to stamen, or back again, for the intermediate series gives the appearance of "snapshots" of a continuous transformation. Such intermediates are also found between petal and pistil, stem-leaf and sepal, sepal and petal, etc. Through his consideration of these apparent transformations, plus the multivalence of

the node, Goethe concluded that whether the plant produces foliar, floral, or other members — "it is still the same organs which, with different destinies and under protean shapes, fulfill the part prescribed by Nature."

But if this is homology, it is neither "special" nor "general" homology, for it makes no use of their criteria. Goethe's common organ, or *leaf*, is not a simplification of foliar members. All empirical forms are, for him, equally particularized, and his general organ can be general only by lacking such particularity. His *leaf* accomplishes this requirement *by having no form at all*. To say that these organs are "the same" means here only that they can occupy the same nodal position and that transitional forms may be found between them — or at least those are the empirical criteria used. Clearly, this is not the identity by position or composition that Owen, and most other biologists, were thinking of when they postulated homology. Nor can we use this sort of identity as the basic unit in a schematic "archetype," for it is not capable of taking on schematic form. But if the immediate differences between Goethe's approach and that summarized by Owen (and Darwin, for that matter) are now visible, the import of these differences remains obscure. Before we can pentrate to the real content of the Goethean method we must review another point of contrast.

Formation, Transformation, and the Graded Series

If Goethe did not construct an ideal schema, the "one model" [*Muster*] upon which all plants were built might seem rather problematic. What could he have had in mind? Given the tendency of biologists, then and now, to conceive of any plan as a construction of fixed parts or positions, it would be difficult to read his "one model" in any other way. Goethe evidently worried about the tendency himself. In 1817 he decided to add an introduction to his botanical writings which would point the reader in the right direction. The piece was titled *Formation and Transformation (Bildung und Umbildung:* Goethe, 1963), and the opening paragraphs of the second section — "The Intention Introduced" — follow:

> If we become attentive to natural objects, particularly living ones, in such a manner as to desire to achieve an insight into the correlation of their nature and activity, we believe ourselves best able to come to such a comprehension through a division of the parts, and this method is suitable to take us very far. With but a word one may remind the friends of science of what chemistry and anatomy have contributed to an intensive and extensive view of Nature.
>
> But these analytic efforts, continued indefinitely, produce many disadvantages. The living may indeed be separated into its elements, but one cannot put these back together and revive them. This is true even of inorganic bodies, not to mention organic ones.
>
> For this reason, the urge to cognize living forms as such, to grasp their outwardly visible and tangible parts contextually, to take them as intimations of that which is inward, and so master, to some degree, the whole in an intuition, has always arisen in men of science. How closely this scientific demand is tied to the artistic and imitative impulses need not be worked out in detail.
>
> One finds, therefore, numerous attempts in the course of art, learning, and science, to found and develop a study which we call morphology. The varied forms in which these attempts appear will be discussed in the historical section.
>
> The German has the word *Gestalt* for the complex of existence of an actual being. He abstracts, with this expression, from the moving, and assumes a congruous whole to be determined, completed, and fixed in its character.
>
> But if we consider *Gestalts* generally, especially organic ones, we find that independence,

> rest, or termination nowhere appear, but everything fluctuates rather in continuous motion. Our
>
> speech is therefore accustomed to use the word *Bildung* pertaining to both what has been brought forth and the process of bringing-forth.
>
> If we would introduce a morphology, we ought not to speak of the *Gestalt*, or if we do use the word, should think thereby only of an abstraction — a notion of something held fast in experience but for an instant.
>
> What has been formed is immediately tranformed again, and if we would succeed, to some degree, to a living view of Nature, we must attempt to remain as active and as plastic as the example she sets for us.

Cassirer (1950) is exemplary in his grasp of the principles set forward in this introduction. Pointing out that the notion of "type" is fundamental to all the important figures of the day, he then proceeds to distinguish Goethe's version from the rest:

> To Cuvier or Candolle "type" was an expression of definite and basic constant relationships in the structure of living things that are fixed and unalterable and upon which all knowledge of them depends. They follow rules no less inviolable than the purely ideal figures of geometry. Candolle insisted that the disposition of the parts was the most important factor for the establishment of the plan of symmetry of a plant. Likewise K. Ernst von Baer explained the type as the "positional relationship of the inherent elements and the organs." But this view was not Goethe's. He did not think geometrically or statically, but dynamically throughout. He did not reject permanence, but he recognized no other kind than that which displays itself in the midst of change, which alone can discover it to us.

We can bring this opposition into clearer focus by considering two different ways of treating the graded series, or as it was sometimes called, "serial homology." During his argument against Owen's general homologies of the vertebrate skull, Huxley (1858) offered a plausible reconstruction of the mental steps by which Owen came to his "typical vertebra." The tendency to abstract an idealized plan was only normal, he suggested, for "a community of plan is discernible amidst the manifold diversities of organic structure."

> The tyro in comparative anatomy cannot fail to be struck with the resemblances between the leg and the jaw of a crustacean; between the parts of the mouth of a beetle and those of a bee; between the wing of a bird and the forelimb of the mammal. Everywhere he finds unity of plan, diversity of execution.
>
> Or again, how can the intelligent student of the human frame consider the backbone, with all its numerous joints or vertebrae, and consider the gradual modification which these undergo downwards to the sacrum and coccyx, and upwards into the atlas and axis, without the notion of the vertebra in abstract, as it were, gradually dawning in his mind: the conception of an ideal something which shall be a sort of mean between these actual forms, each of which may then be conceived as a modification of the abstract or typical vertebra?
>
> Such an idea, once clearly apprehended, will hardly permit the mind which it informs to rest at this point....What can be more natural than to take another step — to conceive the skull as a portion of the vertebral column still more altered than the sacrum or the coccyx...?

I have quoted Huxley's account because I find it a good example of the approach usually made to the "theme and variations" problem, as well as the way in which such a theme, once detected, seems to suggest further applications — i.e. to suggest the general homology of other elements with the same

schema. As long as we understand the "theme" as a fixed form which underlies all variations, Huxley's rhetoric seems utterly lucid, and we should be surprised if the "vertebra in abstract" did not "dawn" in the mind of a serious student. But there is another way to grasp the "gradual modification" of the series.

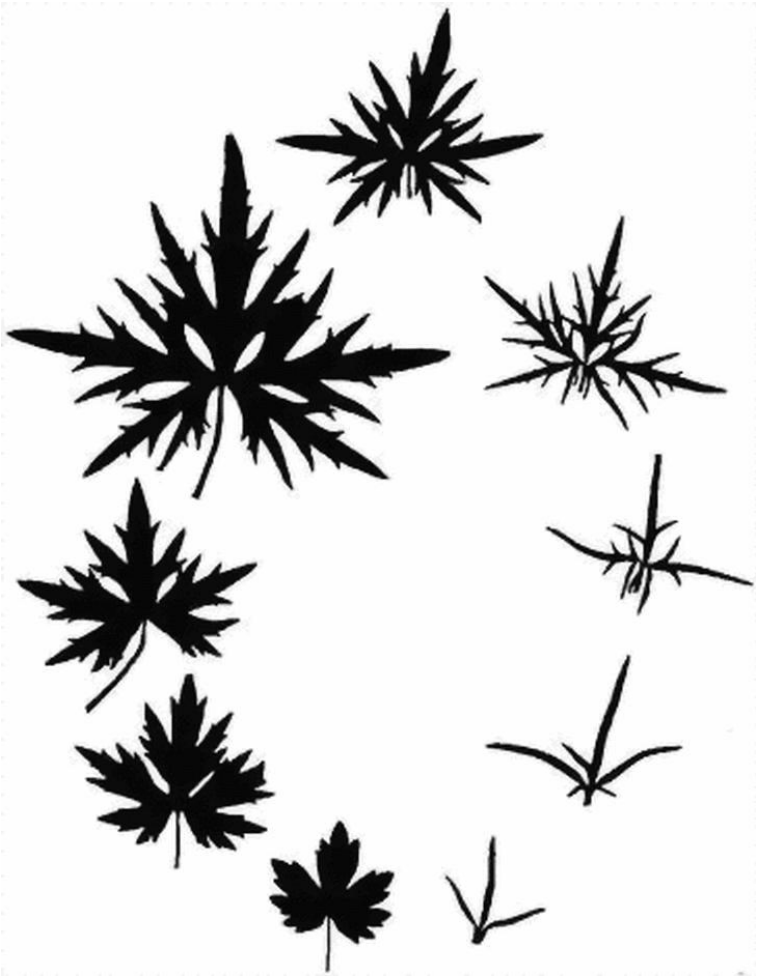

Figure 4

In order to make the second possibility apparent, let us substitute the series of foliage leaves presented by the field buttercup — *Ranunculus acris* (Figure 4; shown in ascending order from bottom left to bottom right) for the vertebral series that Huxley used. The series covers an extensive range and is gradual enough to create the impression of overall unity. Should we attempt to assign an underlying schema to the series, however, we shall run into difficulty. What form shall we choose? The simplest schema, patterned after the three-part leaf at the lower right, is preserved by the whole series but tells us almost nothing about the complex forms. The reverse procedure, beginning from the most complex form, gives a schema which can map the other forms only by deletion. And neither can tell us anything about the progression itself. The information content of this approach is trivial unless we use the schema we pick to extend the transformation into as yet unrelated forms, as Owen did when he worked out the general homology of the skull in Huxley's accout above. But as I argued earlier, such a step may represent nothing more than an arbitrary legislation.

On the other hand; were we to begin our study of the series *from the progression itself* rather than from a single form, we will obtain a very different result. Let the reader imagine, for a moment, how one could decide whether an additional form, not included in the series as yet, could be placed within it. By what criterion could the judgement be made? (Since I have performed the experiment with luckless classrooms of students — mostly ignorant of biology — I can report that the solution is almost immediate for most observers.) The forms of a graded series have the peculiar property of appearing to be arrested stages — we might call them "shapshots" — of continuous "movement." If we begin with the first leaf on the stalk (lower left) and follow the transformation to the last (lower right), we have the sense that we are in fact watching the form on the lower left turn into the form on the lower right. Because we "see" the series in the context of this imagined or "intended" movement (to use the phenomenological term), an adequate criterion for accepting or rejecting a new member is near at hand.

We must reflect that the "movement" of the forms becomes more apparent in the actual phenomena to the degree that the "missing pictures" — the forms transitional between the shapes we have — are supplied. The movement we are *thinking* would, if entirely phenomenal, be entirely continuous, leaving no gaps. Thus as gaps narrow the impression of movement is strengthened, and the technique by which a new form can be judged consists in placing that form within one of the gaps or at either end of the series and observing the result. When the movement is strengthened or made smoother the new form may be left in place. But if the impression of movement is weakened or interrupted, the new form must be rejected. Thus the context of movement is itself a criterion by which we accept or reject new forms.

The movement of such an extensive series does not preserve any particular schema but the trivial form on the lower right, for *connections are themselves transformed during the course of the series*. The only general element besides the trifoliate schema is the movement itself, which is also the element by which membership may be determined. Huxley's remarks indicate that he was quite cognizant of the dynamic aspect of a graded series, since his statement that the vertebrae — which are fixed particulars — are seen to undergo "gradual modification" can only refer to the sort of "seeing" that intends the movement of the series. Yet Huxley's habits of mind, in which he is hardly alone, led him to miss the obvious analysis. The impression of "gradual modification" cannot depend any more on what each form has in common with its neighbors than upon what it *does not share* with them. Change demands difference, and continuous change, continuous difference. We can take the continuity of the series as an indication of a common underlying schema only by a sort of mental laziness — we do not care to undertake the problem of how things may be united by *difference*, prefering the empty alternative that they were not really different at all — that is, they are united by sameness.

Having recognized the function of the *intended* movement, we are in a position to admit what Huxley could not. We are able to "see" such movement between the forms only by a distribution of sameness and difference between them. We intend the dynamic context because *by it the lawful relation between the forms is made manifest*. All this usually happens tacitly, as an unnoticed aspect of ordinary perception, but the fact that it is normally unnoticed does not hinder our analysis of it now. And it is at this point in the anlysis that we shall begin to recover Goethe's meaning.

Notice that in order to take the forms as parts of a continuity, we must cancel their independence. If we intend a continuous movement, we cannot recognize the stasis of the empirical particulars in such a manner as to contradict the movement. We compromise with the sensible conditions by taking each individual form as an arrested stage of the transformation, akin to a series of photographs which break a continuous movement into a series of "shots," which then become transparent to the movement they portray. For the purpose of our intention, the arrested stage, or *Gestalt*, is an abstraction. It is held in arrest by our sensible experience, but when we attempt to detect the relation between stages, we must dissolve that condition in the mind. We move our intentional focus from text to context, from the individual particulars to the unifying movement.

I have already remarked that Huxley is not unusual in supposing that the continuity of the series is

due to the mediation of a single underlying form. Were someone to remark, when viewing such a series, that "they are all the same thing," the meaning of the statement would seem immediately apparent. But no single schema can generalize upon the series, for each schema, being itself a type of *Gestalt*, will be closer to one stage of the series than it is to the others. This is very apparent with the leaves, but it holds true of the vertebrae as well. Yet the notion of a "single form" may still be correct, for "form" may be a more subtle matter than *Gestalt*.

Compare, for example, the *Gestalts* of two leaves extracted from differing zones in the series (Figure 5). Compared in isolation from the rest of the series, they are quite unlike.

Figure 5

But let the observer work through the series, as Goethe claimed that he did, both forward and backward, until it becomes a continuous movement, and then glance again at the extracted forms. If these can be placed within the context of the movement of the whole series they will no longer seem unlike. They will, in fact, bear a distinct resemblance to each other, and bear it so strongly when the trick is learned that the impression arises that they are somehow *the same form*. Here is the intuited "single form" of the series, but it cannot be equated with anything static.

Form as Movement

When we compare the information content of these two strategies — i.e. the idealized schema and the overall movement — the contrast becomes particularly pointed. The series of Figure 4 *could* be mapped upon a common schema, but this unvarying element would tell us nothing about the differential that runs throughout. The movement, on the other hand, specifies that differential, and by so doing, specifies the forms possible to the series. The latter approach, it would seem, does succeed in generalizing upon the series while the former does not.

The movement of the series cannot, of course, demand that any particular potential will be realized, but it does give the range of potential forms — those which would become actual were the imagined continuous transformation to become actual. Whether an actual leaf will realize this or that potential is determined by something else, but it is the movement which defines the potential forms. Of course, this is why it serves as a standard of inclusion or exclusion with regard to the introduction of new members, but this is not to say that the new forms must empirically exist. Since all potentials are specified by the movement, it can also *generate* those intermediates which we do not actually find in nature. After all, the movement is perfectly continuous, and capable of giving rise to any number of discontinuous *Gestalts* for that reason. The movement specifies forms, it would seem, by generating them.

It might seem counter-intuitive to speak of movement, rather than an object making the movement, as generative, but between the forms and their movement there is only one possibility. We must remember that no single *Gestalt, qua Gestalt*, can generate a movement between forms. We detect the movement through the differential between forms, but no one form can give us this. The movement, on the other hand, is a continuity which must contain, in order to be continuous, multiple *Gestalts*. Thus the movement is not itself a product of the forms from which it is detected, but rather the unity of those forms, from which unity any form belonging to the series can be generated. Individual forms are in this sense "governed" by the movement of the series in which they are found — their shape and position in that series are both functions of the overall transformation.

At this point in the argument, the project of description must permanently shift from static to mobile form, for the latter generalizes upon the former. But can the sort of movement that I have been following itself be thematized? If we resurrect the problem of underlying unity at this level, can we find a basic element or elements from which the complexities of plant metamorphosis are built up? The answer seems to be yes.

The movement of the stem-leaf series depicted in Figure 4 is detected *a posteriori* — i.e. by comparing the range of forms on the stem — and of course, this exact movement belongs only to the plant from which the leaves were taken. But when we compare this group of forms with those produced by other plants of the same species, it becomes obvious that all share a common transformation. All members of this species begin from a relatively small and "filled-in" version of the leaf and progress first by an expansion in size and an articulation though division (i.e., through the division of the plane of the leaf into separate branches), and then by a shrinking and a simplification of the branch pattern. Given a reasonable sample of individual plants within the species, the mind quickly seizes upon the transformation *characteristic* to all. It is this characteristic transformation that is co-extensive with the species. (It is also this transformation that we tend to pick out of Figure 4, for it is far easier to recognize a characteristic transformation than the unique one.) Of course, by my tactic of describing the movement of the entire sequence in terms of two transitions, I have already suggested the possibility of further generalization.

If the metamorphic series of this species is compared to those produced by other species, some will answer to the same description and some will differ, but the differences will be describable in terms of general transitional relations — i.e. the movement from the filled-in to the articulated, or that from the articulated to the simplified, or the reverse of these, or in fact, the transition from any characteristic condition of development to any other. Since I have already argued that it is not the static condition that is important here but the movement that leads to or away from this condition (thus unifying it with other conditions), the movement of metamorphic foliar series might be describable in terms of several transitional "gestures" that generalize upon all such series.

When we begin to follow out this last line of thought we are travelling Goethe's own path of investigation. The turn from *Gestalt* to *Bildung* is shift of focus from the static product to the transformation which leads to and from the product, and thus eventually to a consideration, not of the products, but of the generative field of movement. This turn has been carried through in a very promising manner by Bockemühl (1982), who describes certain "transformations" [*Bildebewegungen*] within the development of individual leaves and argues that these constitute the basic formative "gestures" of the plant. Bockemühl speaks of four such "gestures," which he names as "shooting," "articulating," "spreading," and "stemming" [*Spriessen, Gliedern, Spreiten, Stielen*]. "Shooting" is apical growth which extends the leaf tip outward, and "articulating" is a continuation of this through the development of multiple apices. "Spreading" is the filling-in of the leaf plane; "stemming" is growth at the base of the leaf which extends it from the main stem (and thus forms a secondary stem on the leaf). These same "gestures" are found as well in the sequential movement of stem leaves, and are, by Bockemühl's argument, adequate to describe, and generalize upon, all such series. The "gestures" by which leaves grow are evidently fundamental to the transformations between them.

I cannot proceed with this account in the present discussion, for from this point onward the actual investigation must be an empirical one. The nature and possibility of such an investigation should now be clear, however, even if the concept of movement as a *form-making* principle leads the exposition into difficulties of expression. Such difficulties are to be expected when a new subject must be communicated. (In this respect Bockemühl seems to possess an exemplary sensitivity to the difficulties of portraying form in the context of movement, and his own language as well as his comments on Goethe's locutions provide an illuminating interpretation of Goethe's botanical writings. A partial bibliography of Bockemühl's publications may be found in the references, and I refer the reader who wishes to read Goethe to these articles as well. I have found them invaluable.) How movement can be a "making" principle rather than a "thing made" and can be spoken of in language that implies causal efficacy, however, is not a linguistic problem but a conceptual one. If we are unable to move beyond the usual notion of causality such treatment must remain merely a figure of speech. The next section, therefore, will attempt to clarify the concept by which the topic must be approached.

Form and Potency

Although I have spoken of *form-making* movement, implying a causal aspect, it is possible to understand the account I have produced thus far as the discovery of a descriptive differential (or differentials) which could be expressed mathematically as well. If we take this approach, the dynamic aspect of the forms becomes little more than an artifact of perception, and should we choose to call it generative, in that it specifies all forms potential to the series, there would seem less reason to suppose it causal. After all, a mathematical differential, however predictive of future forms, is not a productive *power* but a specification of relations. It shows us how the finished product is structured, but not how it was caused.

Let me try to clarify the distinction. Were we able to isolate a single differential within a metamorphic series, we could then point to it as the relation held constant through all changes. But if this would give us the formal parameters governing the transformation, it does not in itself demand that there *be* a transformation — i.e. that any one form be superseded by any other. *If* there is a supersession, the differential predicts its form, but *does not explain its necessity*. The fact that we may describe the forms of the plant in terms of "transformations" is evidence that we may perceptually detect a general relation between the forms (i.e. the mathematical differential), but not that we are able to perceive the making *power* by which this regularity is effected.

If the argument above follows from the given assumption (i.e. that the movement reduces to a mathematical differential), the assumption itself is somewhat problematic. The differential properly exists only between *Gestalts*. At the moment that we detect the continuity of the series, the empirical experience is dynamic rather than static, and the forms are seen within the context of movement. It would seem to follow that the empirical forms, *at this stage*, are something other than *Gestalts*.

Form, in morphological study, is never entirely static. Morphology proceeds by comparison, and the interest of the morphologist is focused upon what is revealed by the juxtaposition of forms. As our familiarity with transformation sequences increases, however, so does the capacity of a single form to bring other forms to mind, or of two forms to build a connecting bridge between them. The morphologist not only "sees" that two distinct configurations are still "the same," but is made aware, by the same faculty, of nascent potentials that seem to arise from every juxtaposition. This peculiar potency of organic form has acted as a constant spur to thought, and a fair amount of theory — including speculations on "vital force" and "final cause" — has responded to it. As we have seen, however, neither Owen's foray into *Naturphilosophie* nor Huxley's hardheaded analysis produced a satisfactory account of the mediating element between the members of a transformation. But both

Owen and Huxley, as well as the mathematical approach above, take it for granted that *form* means Gestalt, neglecting just that aspect which gives organic form its peculiar character. Goethe's own investigation produces a different sense of form and a unique notion of cause.

Goethe began from the "potency" of organic form described above, but he knew better than to attempt any reduction to a schema. He had learned that a static form could not generalize upon botanical transformations by the time he wrote his *Metamorphosis*. That text is structured upon his notion of *Bildung*, and attempts to follow the transformations that lead to and from each organ of the plant, remaining, as he remarks later, "as active and as plastic as the example she [Nature] sets for us." His attempt to achieve a "spiritual participation" in the operation of plant metamorphosis led him to exercises of imagination — or as we might now say, intentionality — by which he attempted to follow the movement between forms. The goal of these investigations was to observe the manner in which the law — "the eternal" — entered into "the transitory," something which he expected to trace through his own intentional activity (which activity constituted his "participation" in the activity of nature). It was through these exercises that he became conscious of the difficulty that had stopped others at this juncture.

In a note of 1818 entitled *Indecision and Resignation (Bedenken und Ergebung*: 1963), Goethe considered the Kantian argument that the "ideas of reason" cannot be sensibly portrayed or analytically grasped, and admits that there seems to be "an inherent difficulty, which does not always enter clearly into consciousness":

> The difficulty of uniting idea and experience appears very troublesome in all scientific research, for an idea is independent of space and time but research is confined to them. In an idea, the simultaneous and the successive are intimately bound together, whereas in experience they are always separated, and an action of Nature which we are obliged to think in conformity to the idea — i.e., as both simultaneous and successive — seems to drive us to a species of madness. The understanding cannot think united what sensibility transmits to it divided, and so the conflict between what is sensibly grasped and what is thought through the idea remains forever unresolved.

(The point of the last, rather untranslatable sentence, is the opposition between the Kantian *Verstand* and *Vernunft* — "understanding" and "reason" in the customary translations. *Verstand* works in "concepts," is analytic, and duplicates the separations forced upon us by sensible conditions. *Vernunft* deals in "ideas," which are synthetic, and capable of unifying elements that must be separate for *Verstand*. Kant supposed that although the "ideas of reason" provide a framework for investigation, they could never constitute scientific knowledge, for unlike the "concepts of understanding," they cannot be "filled-in" by perception. He argued in *The Critique of Judgement* that we are simply fated, by our mode of thought (which is dependent upon sense-perception and the analytic approach of *Verstand*), to represent the organic in a manner that we would never fully comprehend, since it was *by intention* beyond analysis — i.e. a whole that creates its own parts.)

The "action of nature" which we must think in conformity to the idea is organic metamorphosis, for here we have presumably a law by which the plant produces its multiplicity of forms, a whole which designs its own parts. The comprehension of such a whole would oblige thinking to move from the whole to the parts, rather than the other way around (the manner in which thinking approaches analytic wholes). We cannot picture nor even think — in our usual analytic mode — the unity that generates multiple potentials. Yet we intend such a unity when we perceive the movement of a metamorphic series. If we are not satisfied to remain content with Kantian paradox that we may intend what we cannot understand, we can follow Goethe in attempting to work through the structure of our intention, or if we use the Kantian term, representation. (I will use these almost interchangeably,

because there are distinct advantages to each. "Intention" emphasizes our own willed activity, "representation" suggests symbolic structure — i.e. the manner in which one level of meaning can "represent" another level to the mind).

The capacity of perceived form to suggest potential form is derived from the context in which the empirical forms are viewed — i.e. the movement of transformation. When forms are so contexted they are no longer independent and complete in themselves. Each form will now call for a before and after, from which it arises and to which it develops (which is the sense of *Bildung* that Goethe evokes), thus suggesting the "missing pictures" of the transformation. The single image now becomes transparent to the whole "gesture" — which it now seems to express — and that gesture moves toward perceptibility as the individual forms move toward continuity. Potential forms come to mind because they are contained in the whole we are trying to see.

Let us turn again to the leaves of Figure 4. Once we have reestablished the context of movement each form will begin to show its distance from the *Gestalt*. The individual leaf now appears to be "coming from" something as well as "passing to" something, and by so doing *represents*, to our mind, more than itself — it can no longer be separated from its before and after. Indeed, its only distinction from these moments lies in the conditions of arrest — i.e. we see it "caught in the act" of becoming something else. Caught, that is, *by sensible conditions* — by the manner of its appearing. Each visible form now emerges as *partial*, and becomes a disclosure of another sort of form.

We must remember that in making the individual images into representatives of gesture, we have not allowed the before and after to be accidental. The leaves become representative by belonging to a specific gesture, which becomes in turn the standard of inclusion and exclusion, designating potentials. Each leaf is now, paradoxically, representative of all the others (which is how the two forms of Figure 5 manage to look alike), and the new form that shows through the old is somehow all the forms at once.

Now that the single image is incomplete, its full import can appear *within sensible conditions* only through continuous transformation — through change. I noted earlier that the movement of the series unifies the forms through their differences. We can now see that the type of form making its appearance here *requires* that difference — i.e. no two forms can possess the same *Gestalt* without losing their representative function.

Form in space allows us to represent distinct loci in space as a unity, but these distinctions are those of "here" and "there," and the loci are "outside" one another and presented simultaneously. In succession we have to do with "before" and "after" rather than "here" and "there." The positions of a succession exclude one another by a distinction in time rather than space. A principle by which we represent the distinct moments of time as a unity, even as we represent the loci of space as unity, is a principle of form. But this sort of form must be a causal principle as well.

Since a time-form can only manifest in sensible conditions through continuous change, it cannot appear as an object but only as a quality of objects — or a type of form. The partiality of the sensible form by which it discloses the larger whole produces a tension between the sensible arrest and the identification of the single image with other forms before and after. The visible image is not static, nor sensibly moving, but displays by its very configuration a *felt potency to be otherwise*. Here is the origin of the productive power that we sense in such form, but notice that *the sensed power is at the same time logical necessity*.

The new form that has supplanted the *Gestalt* (in the context of the movement of the series) has its identity in the whole which it represents to the mind. Its unity includes other members of the series, and thus *it is becoming other in order to remain itself*. Its own identity will demand that the visible form be superseded by another, and then another. The form that appears in the context of movement contains logically what the mathematical model failed to provide — the necessity of change.

A time-form turns out to be a causal form due to the mode of representation it demands — i.e. that a stage in a succession represents the whole (in Kantian terms, a sensible image here represents an idea). The limitations of sensible conditions are such that unless the image is intended in the context of

continuous change it will lose its representative function — lose its identity. That this demand of identity, when contrasted to the sensible conditions — i.e. when in opposition to the sensible arrest — should also be felt as power, may give us pause with regard to the way we ordinarily think of causality, yet it is clear that the sense of power is part of the logical structure of the form, and not a subjective reaction on our part. We may choose whether we shall represent organic form in this manner or not (we could, after all, insist on its *Gestalt* level), but once we have accepted the dynamic context the rest follows of its own necessity rather than by any further choice on our part. And this quality of form will have an important effect on the theoretical views by which life is approached.

(Note: I am aware of course that the coincidence of logical necessity and causality is something that one does not think to see after the work of Hume and Kant. With regard to Kant I can only point to the potential breakdown of his system that threatens to emerge from *The Critique of Judgement*. Goethe may be understood as exploiting the seeming contradiction that we can intend what we cannot understand. Of all our experiences, intentionality is potentially the most clear, for what we do ourselves is open to our intimate gaze. Kant did not attempt to observe his own intentional acts, and thus never investigated this possibility. Goethe, coming to Kant when he was already engaged in this project, was simply made more conscious of it. He read Kant as if Kant were proposing a similar "adventure of reason" (Goethe, 1963: *Anchauende Urteilskraft*).

With regard to Hume we must return to the problem of causality in general. It should be clear to us that however we normally think of causal necessity, we must intend it as a necessity that stretches over different moments in time, and it is the ultimate exclusion of one moment from the next that defeats Hume's attempt to think it out in terms of logical necessity. An identity that bridges that exclusion would also solve the logical problem, and just such an identity is intuited in the observations described. It should be of some interest to rethink Hume's problem on these grounds, for it rests upon the assumption that the distinctions of time are primary. If, on the other hand, the time-form is primary, we should discover that we must intend this unity in order to perceive the "movement of time" itself. The project is too fundamental to consider any further in this discussion.)

The Form of Life

The forms of life are not "finished work" but always forms *becoming*, and their "potency to be otherwise" is an immediate aspect of their internal constitution — i.e. of their representative function — and not something to be added to them. Their "potency" is "self-derived," in that it is inherent in their identity with the whole. The *becoming* that belongs to this constitution is not a process that finishes when it reaches a certain goal but a condition of existence — a necessity to change in order to remain the same. Of course, at some time the leaf or bone loses this capacity — it no longer participates in the continual becoming of its generation and therefore does not remain the same — i.e. does not remain alive.

It can still be morphologically studied, for corpses still display the imprint of the generative process, but such study must be aimed at transformation rather than stasis if it is to recover that imprint. It is unlikely that anyone would do otherwise — corpses make no sense in themselves, having fallen out of their proper context, and were they not referred back to the power from which they came they would be unintelligible. This point is too often forgotten, or never noticed in the first place, and as a result we sometimes speak as if life were something one could add to the corpse in order to vitalize it. But if life is a context, it is an immanent rather than transient cause, and where it is not immanent it cannot by definition be added.

In a somewhat Aristotelian manner, Goethe spoke of the "entelechy" that was the immanent cause of any life form, and understood this through the immanence he had discovered in his concept of

"Type" (*Typus* — Goethe used this term in his later writings). Of course, this notion provided more than a morphological principle — it was a way to understand the organic *per se*, and this is how Goethe applied it. But we should not associate his "entelechy" principle with the speculative excesses of the period. Goethe discovered this concept through his morphological studies, and made it abundantly clear that its use did not imply either a "vital force" or a "purpose" in nature, although these are often attributed to him. Perhaps the best way in which to understand his concept is to see how it led him to *reject* both these concepts, since this rejection is evidently based on the notion of entelechy.

Goethe had read various speculations concerning a "vital force" which would account for the realm of life, but he thought it to be an obscure explanation, borrowed from mechanical habits of thought and made redundant by what we actually know about life. The parts of an organism, for example, are no more separable from their context than is the entire animal — they are all equally alive. Such parts, singly or collectively, are continually transformed by development, and are but a partial disclosure of that development at any point in time. They are, as parts, *inseparable* for the potential-to-be-otherwise that constitutes becoming, for if we think of them without this we think them out of context — they lose their identity and their intelligibility. (Corpses, as I have already noted, make sense only by reference to the generative mode from which they came.) On the other hand a "force" in the mechanical sense of the term is quite separable from the object to which it may be applied, and the affected object is in existence prior to that application and sometimes after its cessation. The objects of a separable force are not made, but simply moved, by the force. The parts of an organism owe their very existence to their potency. In order to exist at all they must be potent (corpses must have *been* potent) and do not need the addition of another power to make them change.

Of course, the notion of "vital force" might be defended by suggesting that it should not be applied to explain the perceptible changes of organic development, but rather to explain how life arises at all — — i.e the suggested force raises chemical material to organic organization, which organization guides perceptible development. The strategy is now one of reductionism, and easily identified as such through the addition of a crucial assumption — namely, that which is potent in itself must derive from that which is not. Obviously the "vital force" could only be needed to "vitalize" material which is not yet alive. But since we cannot detect, in the phenomena, the distinction between "that which is to be vitalized" and "that which vitalizes," our observations provide no reason to insist on this derivation, and this problem. If the phenomena of life *are not separable* from their potency-for-change (except by death, which is a derivation of the impotent from the potent rather than the opposite) then they are not separable, and if we bother ourselves about how to add the potency of life to the stuff of life we do so after a preconceived notion.

As one might expect from the results above, Goethe also rejected any analogy to human purpose in nature and any notion of "final cause" which contained such an analogy. Teleological judgement, as Kant had explained in the *Critique of Judgement*, gives an account of a structure (or event) by referring it to a purposer and a goal beyond the structure itself. The pocket-watch may be understood as a means to the end of telling time, which means it was constructed by an intelligent agent guided by his concept of that end. On the other hand, life, according to Kant, is "purposive without a purpose" — i.e., seems conceptually designed without any indication of an external designer or an external goal. Goethe took great satisfaction in this attack on teleological judgement in biology (Goethe, 1963: *Einwirkung der neuern Philosophie*), and remarked that Kant had "explained and vindicated" his own aversion to it. Life had no goal or purpose except itself, and to suggest otherwise was to force the phenomena into a pre-conceived mold.

As Goethe admitted, the type was an *idea* (by which the successive was grasped as simultaneous), and its manifestations in time were quite "designed," each preparing for the next and leading over into it. But as I have been arguing, the designing idea is not separable, and living form cannot therefore be modelled on the machine or any other result of an external planner. Nor can any particular goal of development be determined. Aristotle supposed that the adult state could be conceived as goal, since it

was the most revealing stage of development, but Goethe did not make any stage of development primary in this manner. (He accounted for Aritotle's distinction in another way with the notion of *Steigerung*, by which he indicated a progression toward great intelligibility. The sophistication of this concept is beyond the scope of the present discussion however, and it does not constitute a stage for which prior stages are simply means.) Indeed, he could not do so. Each stage of development was equally required by the whole, not as a means to an end, but as a mode of being-in-the-world. Development in time does not proceed towards this whole, but rather *expresses* it. As I have already noted, the representative of a time-form must continually become other in order to remain representative. Any additional reasons are redundant.

The same thing must be said with regard to the modern notion of design by "program" or "teleonomy" (Mayr, 1974). A program must preexist the process which it is to direct, and is in this sense external to it. Since the process of development, when understood as the expression of a time-form, is complete in itself, the addition of a directive program is unparsimonious.

"Teleonomy" is the hypothetical reconstruction of organic form by mechanical means — it models the organism on the machine in general and the computer in particular. It is logically consistent and reasonably convincing, but in order to invoke mechanical means it must assume a separation between elements that appear to be inseparable in the pheonmena of life — i.e. between object and power.

As we can see from these applications, Goethe's notion of "type," "archetype," "entelechy," or as he would sometimes identify it, "spirit," is not a speculative but a descriptive concept. He does not advance it as a theory that explains the phenomena, but a description that clarifies the same. There is a difference.

Description, Explanation, and Parsimony

Goethe remarked that morphology "nur darstellen und nicht erklaren will," which may be poorly translated: "is intended merely to present and not to explain" (Goethe, 1963: *Vorarbeiten zu einer Physiologie der Pflanzen*). A *Darstellung* was, in Arber's gloss (Goethe, 1946: introductory essay), the "representation of an object, brought into relation with others in such a way that its significance is revealed." Goethe did not advance hypotheses in the sense that the term is applied to an explanatory account added to the phenomena by a speculative act. His science was entirely descriptive, its concepts derived from the pheomena. But "description" for him was not a simple abstraction of regularities. Let me review the argument.

The development of the concept of common positional schema represented a descriptive advance for the biology of the eighteenth century, for it provided a method by which complex appearances could be simplified. Using Geoffroy's principles the investigator could start from two very different organisms and map their parts upon a common set of formal relations, or "connections," thus demonstrating that their differences could be described as variants of the same thing. This is obviously a crucial step in coming to understand their relation, without which evolutionary theory would have remained still-born. But it rests, of course, on nothing more than the fact that organisms *can* be so described. We may assume that they *should* be, as Geoffroy did, because it alters mere difference to intelligible difference — because it reveals that "the other" is still "the same."

Goethe's choice of movements rather than schemas rests upon his dissatisfaction with the attempt to generalize on transformation by stasis. A particular form, as he pointed out, can only be one among many, and every form in the transformation falls equally short of the whole. The schema can generalize on these particulars as long as the transformation is limited enough to preserve all connections intact, but if these are not preserved in the transformation the schema is itself a static particular that abstracts from continuous change. In botanical sequences one could clearly observe

transformations which generate, or dissolve, connections, and there is some evidence that the transformations of vertebrates, or even tetrapods, may be this extensive. Thus while Geoffroy is correct that connections do not admit transposition (which is little more than a tautology, since connections are simply the linkage between positions), it seems they will admit generation and degeneration, a point which excludes the schema. Thus, at least in botany, Goethe was able to show that the schema was inadequate to the proposed task — i.e. grasping difference as a variation of the same. The formal relations of generative movements would perform this task where those of the schema would not, and thus the decision to adopt them as the descriptive concept.

Again, the rationale for this approach is exactly the same as that which I gave for the schematic approach — mere difference is reduced, by the descriptive concepts, to intelligible difference — to another appearance of the same. We may call such description the discovery of pattern or of regularity, but only if these terms are interpreted by the present discussion, their usual meaning being somewhat impoverished. Whatever name we give to this stage of the scientific endeavor, however, it should be clear that it must *precede* the stage of hypothetical explanation. Prior to this sort of description difference is opaque — it does not present a rational structure for our theories to explain. (When Darwin advanced his theory he thought that the common plan of organisms was one of the "facts" that it must explain.)

At this point description becomes a phenomenological project of some profundity, for the formal relations to be found in our perception of a transformational series go far beyond our habitual concepts. Yet if the adoption of movement as a descriptive approach makes difference intelligible, it passes the only test we know. If that movement demands new concepts for its description, these bear with them the same credentials — they are the intentional relations by which we make change intelligible.

The task of explanation begins when we have something definite to explain — one would normally say some clear pattern or regularity, since these would appear to be causally significant. But "something to explain" means not only something definite, but also something that *needs* explanation — i.e. an effect to which a causal account must be added. If description is successful it brings us to "something definite," that is its purpose. Must we suppose, however, that the described "reappearance of the same in difference" will always need further* explanation? We would normally suppose this were the case when we consider the time-sequences involved in our patterns. But if the sequence is an organic becoming, each of the parts of a transformation will be made representative of the whole (in our intention and therefore also in our description) in order to make their differences intelligible. The intuited whole will then be a unity which displays itself in time only throuh continuous change. Since this notion of form unifies the distinctions of time (even as spatial form unifies those of space), it also lends necessity to the events by which it unfolds. But necessity in time — in sequential events — is causal necessity.

It would seem that at least one type of causal account is precluded by this description. We need not ask how the organic is derived out of the inorganic world, for it is not so derived. The "organic" principle of the organism, the time-form, is derived out of itself. If objections are raised at this point I can only suggest that they should have been raised earlier. If my descriptive account of form in transformation is accepted the rest follows. The difficulty one may feel with regard to a principle which determines itself is a problem of recalcitrant habit rather than of logic. A time-form cannot *need* causal explanation — the principle by which time-sequences are made necessary *is* causal explanation.

Thus we come to the rejection by parsimony that Goethe uses with regard to "vital force" and "final cause." Both theories are redundant in that they seek to add what is already superfluous. This notion of parsimony is perhaps stronger than most, for it is not merely a matter of the multiplication of explanatory principles, or even of explanations. Here the question is not only whether we shall

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* [The word "need" does not occur in the published text, but the context strongly suggests that its omission is accidental (as were a fair number of more obvious "glitches" in the text) — ed.]

multiply elements beyond what we need, but whether we shall treat a simple unity as if it were multiple. The principle of form that Goethe has developed cannot be distinguished from a principle of cause. To seek for further explanations is to violate this identity.

Epilogue: Relationship to Modern Biology and Phylogenetic Morphology

The popular commentators on Goethe's work have been split between those who would make Goethe a forerunner of Darwin, and therefore a true scientist, and those who would have him an exponent of *Naturphilosphie*, and therefore a fantast. A few astute critics, like Cassirer (1950) and Steiner (1962), have rejected the dichotomy. Cassirer, for instance, had high praise for Goethe's abilities as a researcher and his contributions to botany, yet with regard to Goethe's relationship to descent theory he wrote:

> The theory of metamorphosis has nothing to do with this question of the historic sequence of the appearance of life. It is quite separate from every sort of "theory of descent" not only in its content but in the posing of the question and in method. Goethe's concept of "genesis" is dynamic, not historical; it connects widely unrelated forms, demonstrating how they are constantly intermediated, but it aims to set up no genealogical trees of the species. The transformation by virtue of which various parts of the plant, its sepals, petals, stamens, and so on, originated from one common archetype, the leaf, is an ideal, not a real genesis. "It is not a broadening but a deformation of the science," said Kant, "when their boundaries are allowed to run together." It would be such a deformation if we were to confound Goethe's biological idea of knowledge with that of Darwin or Haeckel.

Instead of supposing this distinction between the "dynamic" and the "historical" to represent an opposition, Cassirer argued that the two approaches were complementary. Goethe was concerned with principles of biological law rather than historical process, but life has a history as well as a law, and the study of the latter cannot deny the former. With regard to those whose study is historical, Cassirer added that biological laws were already "presupposed" by any study of historical process.

We have only to remember our most basic impressions of living things in order to understand the argument. The simplest behavior of an organism, for example, will always display the self-regulation of the organism. This arises for the mind when we become aware that the influence of external factors upon the organism is never unmediated (unless the organism is destroyed). The organism alters itself to meet each influence, and selects a response appropriate to its own nature. The same tree planted at tree-line, on high slopes, or on valley floors, will present three different shapes, but each will be a modification of the characteristic form. An organism possessed of irritability responds to stimulus, but we cannot understand the response as the mechanical effect of the stimulus without supposing the organism to be dead. Any individual organism manifests a constant identity through whatever local modifications it is forced to make. If we fail to understand the organism in this manner we fail to notice that it is alive. Biologists, like anyone else, must intend the self-regulation of the organism in order to perceive its "life," and must therefore tacitly assume whatever principle this entails.

The principle that this entails, at least according to Goethe, is the "entelechy," for in distinguishing the self-determining element from the external conditions we have implied a mode of change that cannot be environmentally derived (as are the alterations properly treated by mechanical or chemical law, both of which explain change by deriving it from external additions). Of course, one should not equate this identity with the physical organism but rather with its internal principle. The relation of this to the empirical organism was reviewed by Steiner (1962) in a rather long, technical discussion, a part

of which is quoted below. Having explained Goethe's "entelechy" as a whole which determines its own parts and which "of itself, calls itself into existence," Steiner distinguishes the principle from the physical organism, which cannot be a pure expression of the entelechy:

> Since it [the physical organism] is subject not only to its own formative laws but also to the conditions of the outer world — since it is not what it should be were it derived in conformity to the nature of the self-determining entelechy, but as it becomes from its dependence upon other things — it appears as if it were never quite in accord with itself, never obeying only its own nature. Here human reason enters and forms an organism *in the idea* which does not reflect the influences of the outer world but answers only to the inner principle. Thereby every accidental influence, which has nothing to do with the organic *per se*, falls away. This idea, which corresponds purely to the organic in the organism, is the primal organism [*Urorganismus*], Goethe's *Type*.

Of course, one cannot accept this project (of forming an idea of the unchanging in the organism) unless the two causal factors of the original description — i.e. the internal and the external — are taken as irreducible.

Cassirer was correct about the necessary presupposition of a principle of self-determined development — i.e. of the organic *per se* — but it does not follow that this principle must be given a central position. In practice the "presupposition" is denatured by a reductionism that makes it derivative. We do not observe the production of the organic from the inorganic in nature, but current theory treats this production as necessary. In keeping with this framework, the descriptive results above are referred to the past for explanation. Thus, although the organism's reaction to its local environment is understood as the response of a self-regulating and therefore constant entity, we take that very entity to be a historical product. If modern biology incorporates, to a degree, the distinction between external influence and organic response, the organic principle is not accorded primary status.

The present lack of emphasis on the organic as a principle is probably a reflection of the lack of emphasis upon description as a method. The reductionism we see here is contingent upon a practice that introduces the stage of explanation before description is fully developed, undermining even those descriptive results that have been gained to that point. We do not, for instance, push our descriptive investigation of self-regulation to the concept of a self-given principle of organization. Failing this, we still need a further clarification of self-regulation. We supply this by semi-mechanical speculations on "teleonomy," adding something that was not needed, and making the self-regulation of the organism derivative by explaining *it* rather than making it a principle of explanation — i.e. a law. Even so, our evolutionary understanding of morphology depends upon the recognition of an underlying commonality within a phylum — a constant within change. Unfortunately, the nature of the *constant* remains obscure. We propose therefore to clarify it by the only explanatory principle that remains to us — i.e. *change*. Whatever the common structure of the vertebrates, it was simply a transformation of something earlier, for "everything is a transformation of something else." Again, we have left no space for the question of law.

Turning to modern morphology we find, of course, that the historical element has eclipsed the dynamic, and morphology is at a far remove from what the term indicated when it was first applied. The purpose of today's studies is largely phylogenetic — i.e. the classification of organisms according to their genealogies — a direction initiated by Darwin's own suggestions. The relations between the general and specific detected by these studies are taken as indicative of lines of descent, and the branching diagrams which display these relations give "evolution by descent with modification" a visible shape. The plan common to the organisms of the diagram is the plan of the common ancestor

(unfortunately unknown), and commonality within transformation is understood as the common possession of static form (in practice this possession is decided on the basis of a few general characters).

Of course, if "the theory of metamorphosis has nothing to do with this question of the historic sequence of the appearances of life," and is "quite separate from every sort of 'theory of descent'," as Cassirer says, then we should expect Goethe's notion of classification to rest on another principle, and so it does. The Type, as Goethe explained, designates potential rather than actual forms. He had considered the problem of the evolution of empirical forms, admitting that both heredity and environment would play a part in releasing or constraining the underlying potentials (Goethe, 1963: *Versuch einer allgemeinen Vergleichungslehre*), but he never progressed far enough to work out such an account. We can already see, however, that while the actual forms cannot be pure expression of the Type, they also could not be merely historical. If we must distinguish between potential and actual forms, we must also distinguish between environmental constraints and the underlying constant. Classification, the study of the relations of empirical forms, rests *between* organic law and history, and is a record of both.

I have already indicated that Goethe's Type could not be derived from anything but itself. It is thus a-historical. But historical influences will modify its productions, and when we study these productions we must treat them as the self-modifications of a constant entity responding to historical condition. But that would lead classification into a logical problem as well as a historical one. "Once one has grasped the idea of this type," wrote Goethe (*Entwurf einer vergleichenden Anatomie*: translated in Cassirer, 1950),

> he will see how impossible it would be to set up a single order as a criterion. An individual cannot serve as a standard of the whole, and so we must not seek the model in any one. Classes, orders, species, and individuals are related as cases to a law; they are included under it, but do not constitute it.

Goethe's argument begins by rejecting the assumption, common to both Darwin *and* Owen, that transformation is to be understood by treating the *Gestalt* from which the transformation begins as the theme underlying the variations. As we have already seen in a purely morphological study, no one form can generalize upon a transformation series. It is the same for historical development. Whatever comes first in actual history provides only certain boundary conditions, not the law that must realize itself within them. Since the response (the actual organism) to boundary conditions *will be determined by that law, rather than the conditions*, it is to the former we must look for understanding.

Given a principle that comprehends all potentials, classes and orders must be determined, with regard to their possibility, by this same principle. In order to understand *what* they are — i.e. what commonality they represent and how they modify it — we must have recourse to a principle powerful enough to generalize on transformation. I have already given Goethe's reasons for believing that the schema will not perform this task. Instead, he thought to follow the derivation of all organic forms from his Type. In order to understand how this or that potential came to realization, however, he would be forced to reconstruct, at least in part, the historical process by which it took place. The history of life becomes the history of the accidental (historical) realization of a set of pre-determined potentials.

(A word of caution at this junction. The suggestion that the potentials of a phylum, or even of biological life as a whole, are predetermined *does not mean* that some underlying schema is preserved by all forms, but rather that all answer to the same law, which is quite another matter. As the preceding discussion shows, morphological "law" cannot be equated with static form, for such form lacks the requisite powers of generalization.)

With these ideas in mind, let us look again at phylogenetic practice. Modern morphology has labored to trace the relationship betwen organisms, living and extinct. To do so it constructs branching

diagrams in which smaller groups are subordinated under larger groups in a hierarchical order. In purely morphological terms, this practice identifies groups by "rooting" them according to shared characters and "branching" them according to difference. The hierarchical patterns so produced have two levels of interpretation. As description, they are simply branching diagrams that serve to summarize the distribution of similarity and dissimilarity between taxa, resulting in a hierarchical subordination of groups within groups. Perhaps the clearest version of this approach is found in the "cladogram," in which every taxon is an end-point and the characters form the defining elements. (The argument that a cladogram is a purely descriptive device has been clearly set forth by Nelson and Platnick, 1981.) If we add certain explanatory assumptions, we can recast the same set of taxa as a "tree," in which taxa take up positions not only at the ends of the branches but also between branching points — i.e. some taxa become hypothesized ancestors. The tree, of course, is no longer a descriptive result, but a hypothetical reconstruction of the events by which the pattern of the cladogram came about.

The relations found in the cladogram are purely logical — i.e., the cladogram displays the manner in which the same thing reappears in difference. Groups bear a resemblance to logical classes, each possessing its own unique set of defining characters, which set is itself a distribution between more general and less general elements. Obviously, on this level we can find no opposition to Goethe's approach. The next interpretive level, that of the tree, does produce such an opposition, not because a historical element is introduced, but because the other half — i.e. the a-historical, is not. The reasons for this omission have already been covered.

Since only the prevailing habits of thought separate phylogenetic morphology from the wider possibilities that Goethe offers, it would seem that Cassirer was correct in suggesting that these approaches were not opposed in any fundamental way. On the other hand, Goethe's approach will be of little or no interest to a scientific community that has allowed evolutionary explanations to obscure the descriptive study of form. In a certain sense this community already knows too much to return to the basic question of biological form as a realm of order. They are no longer addressing the problems that faced Geoffroy, or Owen, or Goethe, but have moved on to derivative problems.

That transtion, however, is clearly based on the supposition that the nature of form in transformation is properly understood by the concept of a "static theme" preserved in all "variations." This was the very notion that Goethe successfully criticized, even though his contribution did not make its way into the mainstream of biological thought. His own approach is consistent, and cannot really be faulted for its distance from modern morphology since he began from a fundamental criticism of that morphology. The difficulties which have emerged from this comparison are not *Goethe's* difficulties. Whether future work will address them remains to be seen.

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Sources of Illustrations

Fig. 1. R. Owen, *Report on the Archetype and Homologies of the Vertebrate Skeleton*. Voorst, London, 1848.
Fig. 2. *Ibid*.
Fig. 3. R. Owen, *On the Anatomy of Vertebrates*. Vol, I. Longman, Green, and Co., Londond, 1866.

Note

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