Chapter 12

Is a Qualitative Biology Possible?

The philosopher, Ronald Brady, once wrote about his undergraduate experience this way:

> When I began college as a chemistry major my enthusiasm for science was somewhat dampened by meeting a professor of chemistry who pointed out the difference between my own goals and those he, as an experienced professional, would call mature. My passion, he noted, was entirely focused on direct experience — my sense of chemical change was invested in sensible qualities: in smells, colors, the effervescence of liquids, the appearance of precipitates, the light and violence of flame, etc. But, he countered, this was probably closer to medieval alchemy than to chemistry. The latter is really a matter of molecular and atomic events of which we can have only a theoretical grasp, and the sensible experience on which my excitement centered was secondary ... I was reminded of him when I spoke to a morphologist at Berkeley about my interest in Goethe's attempt to approach science by keeping to direct experience. The morphologist responded: "You are interested in this approach because you are a Nature appreciator, while I am a productive scientist." It is always nice to see where one stands.[1]

Ever since the Scientific Revolution, physical scientists have held to the conviction that, whereas nature speaks decisively in the language of mathematics, the qualities of nature are not actually qualities *of nature*, but rather additions provided "from outside" by human subjectivity. And where physical scientists have led, biologists have done their best to follow.

If, as is commonly thought, qualities reside outside the bounds of any rigorous science, including biological science, then the very idea of a qualitative biology is self-contradictory. There should be no such science. Since this entire book is founded on the contrary assumption — an assumption explicitly defended in Chapters 13 and 24 — it feels obligatory to provide some particularly instructive examples of what a qualitative biology might look like.

In what follows I offer three such examples of widely differing sorts. The first involves the study of a single animal, the second a study of leaf sequences along the stems of certain plants, and the third a study of systematic morphological, behavioral, and other patterns recognizable in evolved groups of organisms, yet inexplicable in terms of present evolutionary theory.

An animal expressing the character of the tropical forest

Craig Holdrege is a biologist with a predilection for what he calls "whole-organism studies". In his research he struggles to arrive at a unified picture of an organism by approaching it from all sides: morphological, physiological, behavioral, ecological, and more. The knowledge he arrives at in this way is irreducibly qualitative. But what does that mean? Before we look at Holdrege's sketch of the three-toed sloth, let's take in some basic information about this creature of the South American rain forest:

- The sloth spends much of its active life clinging to or hanging from the branches of trees. It sleeps or remains inactive for the greater part of every day.
- The sloth has proportionately less muscle mass than most mammals. It also has a higher percentage of retractor (pulling) muscles, and its muscles react more slowly than those of other mammals.
- The sloth makes use of smelling more than seeing or hearing.
- Its body temperature varies more with the ambient temperature than in most other mammals.
- The fur coat of the sloth is often covered with algae. Also, beetles, moths, and various other insects, as well as mites, may inhabit the fur, sometimes with the individuals of a particular insect species numbering a hundred or more.
- Gestation period: four to six months.
- Teeth: continually growing; not pre-formed, but shaped by use.
- Eyes: can retract into their sockets.
- The sloth descends from the trees to the ground about once per week to defecate. Its feces are only slightly decomposed after six months. In defecating and urinating, the animal may lose more than a quarter of its bodily weight.
- The sloth is relatively non-reactive to pain and injury.

There you have a collection of facts about the sloth. But you hardly have a coherent *picture* of the sloth. Based on these facts, viewed in mutual isolation, you can say little about the distinctive *qualities* of the animal. But now let me briefly summarize a part of Holdrege's discussion of the sloth as a "whole organism". (The balance of this section is drawn from Holdrege 2021.)

What first of all strikes one about the sloth is, of course, its "slothfulness". It is indeed a slow creature, spending the greater part of the day sleeping or otherwise inactive. It will sometimes cling so stubbornly to a given position that a tree limb must be sawed off in order to remove it. When it does move of its own accord, it pulls itself slowly along the tree branches from which it hangs "by all fours", drawing leaves to its mouth with its front limbs and eating them. When it descends from the tree to urinate and defecate on the ground, the process is so deliberate and gradual that the wingless moths who have taken up residence in the sloth's fur have plenty of time to crawl off the animal, lay their eggs in the fresh dung, and return to their furry habitat.

But "slothfulness" is much more than mere speed of movement. It qualifies every aspect of the animal. For example, the sloth's digestive processes, about which its life seems to be centered, are remarkably slow. According to one researcher, "after three or six days of fasting, the stomach is found to be only slightly less full". The stomach is four-chambered like the cow's, but digestion takes about ten times longer than in the cow.

Figure 12.1. A three-toed sloth flowing up a tree limb.[2]

With its reduced muscle mass, the sloth generally performs about ten percent of the physiological work typical of similar-sized mammals. "All metabolic processes are markedly measured in tempo. Sloths use little oxygen, breathe slowly, and the respiratory surface of their lungs is small". Further, a four-to-six-month gestation period compares to a little over two months for the similar-sized cat. And even the sloth's dung may be only slightly decomposed after six months — this amid the intense decompositional processes of the rain forest. This is thought to help slow down the high nutrient recycling rates for certain trees, helping to stabilize some components of the ecosystem. In sum,

> The sloth brings slowness into the world. This is not only true of its reactions, movements and digestion. It also develops slowly in the womb and has a long life span for a mammal of its size.

Clearly the sloth is not a creature of rapid or pronounced change. In this it expresses features of its environment. The tropical rain forest is a place of great constancy — days of equal length throughout the year, the air warm and humid with little seasonal variation, the light levels always low beneath the dense forest canopy, afternoon rains every day.

> The uniformity of light, warmth, and moisture — in intensity and rhythm — mark the rain forest. And it is hard to imagine a rain forest dweller that embodies this quality of constancy more than the sloth. From meters below, the sloth is sometimes described as looking like a clump of decomposing leaves or a lichen-colored bough.

But there are many ways an animal can reflect its environment. The sloth exhibits a certain passive, yielding character so that it is, in a sense, “formed from the outside”. For example, in a way that is extremely unusual for warm-blooded animals, the sloth’s internal temperature varies considerably — and does so less in accord with its own activity than with the ambient temperature. (Unlike other mammals, the sloth cannot actively raise its temperature through the muscular activity of shivering.)

Similarly, the sloth does not so much overcome gravity as yield to it. With its skeletal structure loose and flexible rather than fixed, and with retractor (pulling) muscles dominant, it lacks the ability to push against gravity and raise itself up. Placed upright on a smooth, flat surface, its legs will splay out and it will be helpless to move unless it can find toeholds (clawholds) for pulling itself along. (See figure below.) It spends much of its life either curled up in a ball or hanging by its hook-like claws from tree branches.

In maintaining the balance of its life, the sloth does not strongly counter external forces and conditions with its own activity.

This, perhaps, makes it less surprising that the sloth is so oddly nonreactive to experiences of pain or injury. Pain occurs where the boundary between self and world is violated, but the sloth seems to have no vivid sense of this boundary. It will cling stubbornly to the very object that is injuring it. One researcher who kept sloths in his home tells of an animal burning and smoking as it sat on a light bulb in a lamp. But upon being rescued, it only protested and tried to cling to the lamp. Another researcher describes a sloth that acted “normally for a long time after it had received a wound which practically destroyed the heart“. As part of its receptivity to the world, the sloth (Holdrege writes) “seems not to live as intensely in its body as other mammals, being quite insensitive to pain”.

Figure 12.2. A three-toed sloth trying to cross a road. Sloths are rather helpless on a flat surface unless they can find toeholds to pull themselves along.[3]

Even in its digestion the sloth shows its passive and nonreactive character. Although its stomach is four-chambered like the cow's, this stomach "is more like a vessel that needs to remain full than a place of intensive muscular activity, secretion, mixing and breaking down, as it is in the cow". Or, again, the sloth's teeth are not pre-formed with crown cusps and ridges as in other mammals (and especially grazers); rather, they emerge as simple cones and are shaped through their engagement with food. In this sense, the sloth's teeth are formed from the outside.

So we see that in many ways the sloth does not so much respond to the rain forest environment as receive its imprint. Even the sloth's fur, which soaks up water "like a sponge", is often green-tinted from the growth of algae. So it assumes some of the appearance and character of its surroundings. And this fur provides a little rain forest habitat of its own, being the home, as we have noted, for numerous beetles, moths, and other insects, as well as mites.

Like most mammals, sloths do occasionally groom themselves. But, as one pair of researchers reports, the grooming effort is so sluggish that moths "may be seen to advance in a wave in front of the moving claws of the forefoot, disturbed, but by no means dislodged from the host".

Fully consistent with this image of an animal that receives the environment into itself rather than actively projecting itself outward, Holdrege recognizes in the sloth "a primary gesture ... of pulling in or retracting". We have already noted the predominance of retractor muscles along with the manner in which the sloth pulls itself along a branch and brings leaves to its mouth. The head itself is a picture of this withdrawn and in-drawing manner of being. Lacking the protruding snout of most grazers, the skull is extraordinarily round and the head is not clearly separated from the rest of the body. The sloth's ears are tiny and do not project out into the environment. Its eyes can retract into their sockets. Both sight and hearing are, in the sloth, quite weak; smell — a sense whereby part of the environment is drawn deeply into the organism — is the primary sense. Imagine yourself living in a world of wafting smells: no distinct boundary between self and other is given through this sense.

Slowness and constancy; receptive openness to the environment; a passive, somewhat withdrawn character; a gesture of pulling in or retracting rather than projecting outward; being formed from the outside — each of these phrases emphasizes a slightly different side of a unitary way of being. We can, with inner effort, bring all the sloth's traits into a coherent picture that holds together. And when we do this, claims Holdrege, we find that "every detail can begin to speak 'sloth'". That is, we can recognize a quality of "slothness" that shines through all the details and makes them into a single, expressive whole.

Of course, Holdrege's own description is much more organic than this haphazard, fragmented, and incomplete summary. But, in comparing the list of facts offered at the beginning of this section with the attempt to weave these facts into at least the bare beginning of a connected fabric, perhaps you can begin to glimpse the meaningful unity that a qualitative approach to the sloth might make available. The qualities are, so to speak, recognized *between* the isolated facts. Only by virtue of this bridging function of qualities through which diverse features are seen in a common light can we apprehend the unity of an organism.

It is impossible to comprehend this unity when we approach an organism in the usual terms of evolution and natural selection — that is, when we approach it as a collection of independently arising traits, each of which offers its own selective advantage. There is, in that, no principle of unity. We see the unity only in terms of the organism itself, viewed as a whole, expressing itself out of its own nature. And if typical evolutionary explanations give us no approach to this readily observable unity, then clearly something fundamental is missing from our evolutionary understanding.

The problem of organic form

Johann Wolfgang von Goethe (1749-1832), who pioneered morphological studies (and gave us the word "morphology"), wanted his readers to understand about the new science that "its intention is to portray rather than explain". At the same time, however — and rather mysteriously for most modern ears — he emphasized that the portrayal was itself all the explanation we needed: "Everything in the realm of fact is already theory … Let us not seek for something behind the phenomena — they themselves are the theory".[4]

This is the puzzle that the philosopher Ronald Brady undertook to elucidate in one of the most important (and most widely unread) papers of the twentieth century: "Form and Cause in Goethe's Morphology" (Brady 1987):

> Any modern reading of Goethe's morphological writings must struggle with the author's apparent satisfaction that his "morphology" … 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 … 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.

(All quotes will be from Brady's paper unless otherwise indicated.)

We are assessing form when we judge, for example, whether two trees — one short, thin, and spindly, growing at the alpine tree-line, and one tall and lush, growing at sea level — are both Norway spruce. Likewise, we are assessing form when we ask whether the human arm is *homologous* with the fin of a whale and wing of a bird. That is, can we say that arm, fin, and wing are in some sense the *same* limb, whatever transformations may have differentiated one from another? And a similar question arises when we consider the succession of vertebrae along the spine of a human being or other vertebrate. Can they be seen as transformations of a single entity or idea?

In studying plants during the later eighteenth century, Goethe recognized a commonality uniting such diverse features as the seed leaves, foliage leaves, sepals, petals, pistils, and so on. All these organs in any particular plant, he claimed, are transformations of a single archetypal form, a form he chose to call the *leaf*. The foliage leaves are just one set of embodiments of this archetypal *leaf*. But while the validity of Goethe's discovery has been widely accepted within biology, the nature of that discovery, according to Brady, has been just as widely misinterpreted.

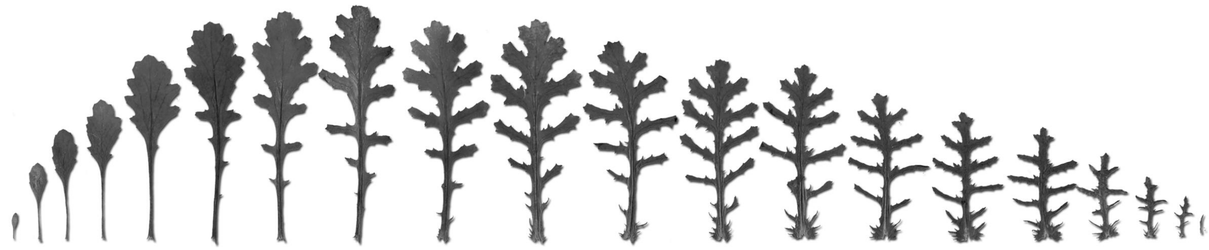

Figure 12.3. Leaf sequence of common groundsel (*Senecio vulgaris*). The figure shows all the foliage leaves of the main stem of a single plant from bottom to top (in the figure from left to right). The first (at left) is one of the two cotyledons of the plant. The sequence is otherwise complete; no leaf is missing.[5]

Goethe was not simply abstracting a set of common features from a diverse set of forms, yielding a fixed schema. As we will see, no such schema can make sense of the processes of becoming we observe, for example, in the leaves appearing in sequence along the stem of a plant that grows anew from ground level every year (whether as an annual or perennial — see Figure 12.3):

> 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*.

In other words, the archetypal leaf of the plant has no form in the usual sense — no *static* material form — but rather is a special dynamic sort of form that is *generative* of particular, sensible forms. We recognize it as a formative power or potential. This is where *something like* causation (for which there is no clear concept in modern science) enters the picture, and it is also where the modern reader stumbles. However, Brady takes great pains to make the point accessible. We will follow his line of thought in some detail.

How to generalize upon a transformational series

The figure below shows, from bottom-left and clockwise around the circle to bottom-right, a sequence of leaves taken in ascending order along the stem of a single meadow buttercup (*Ranunculus acris*). For pedagogical purposes the sequence is somewhat simplified, with some leaves omitted. Also, for some of the leaves only part of the leaf stalk is shown.

You will note that the attempt to abstract a list of features common to all the leaves might yield something more or less like the simple form at the end of the clockwise movement (bottom-right).

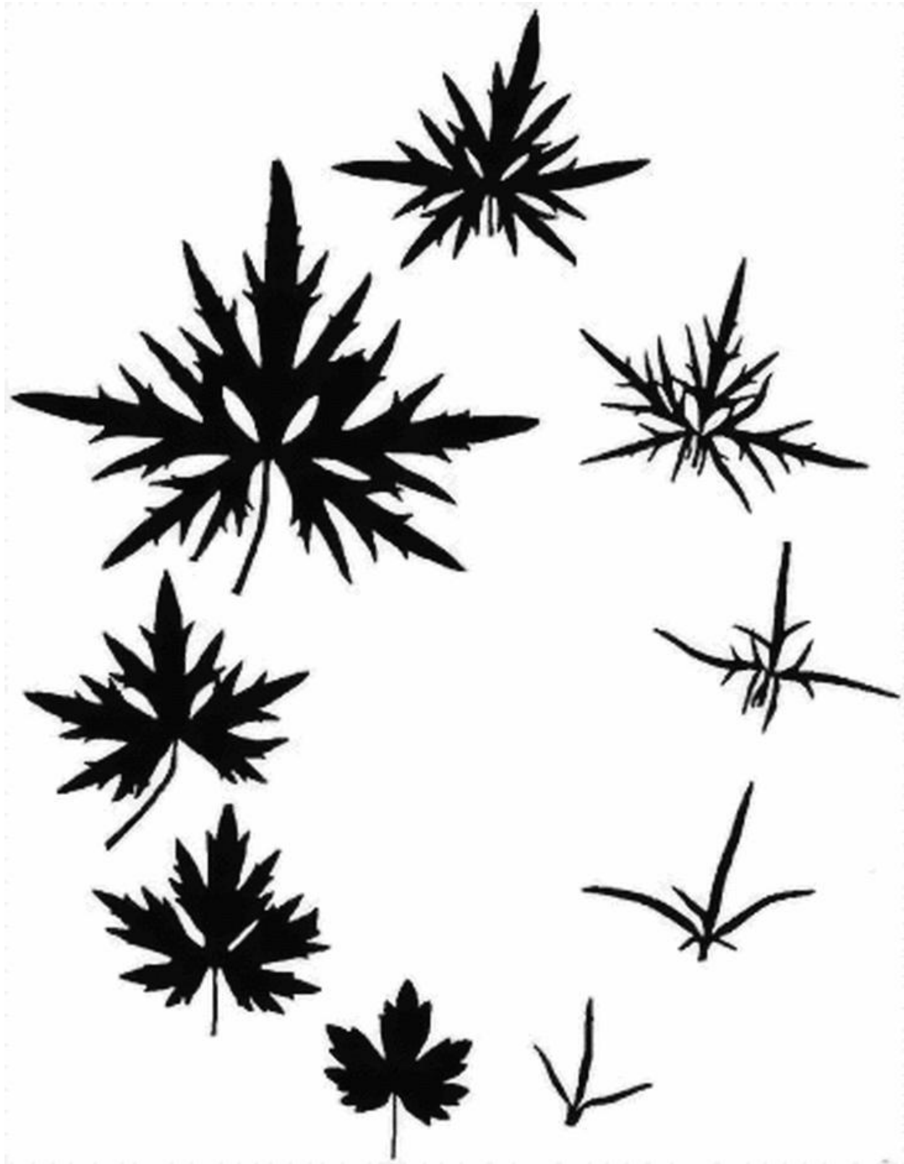

Figure 12.4. A leaf sequence from a buttercup plant (*Ranunculus acris*). See text.

But suppose we declared this one leaf to be the “Gestalt” underlying all the leaves in the sequence. This would be of no value, because the simplified leaf, from which so much detail has been removed, fails to provide a principle for recognizing the fit (or lack of fit) of the other forms — or of any new leaves we might be shown. We can imagine countless different ways for a leaf to be tripartite without at all conforming to the pattern that distinguishes *Ranunculus acris* from other species.

No features abstracted from all the forms so as to yield a single form or schema can generalize upon a series of organically related forms. Such a schema, as Brady remarks, will always be “closer to one stage of the series than it is to the others”. It cannot be equally related to them all. Yet the history of biology is replete with attempts to identify fixed schemas and to make them determinative for various biological “kinds”.

If we want to understand the relations between these leaf forms, we cannot begin with any single and definite form, whether that form be given by nature, abstracted from various exemplars, or invented by ourselves as a mediating design. Rather, “we must begin our study of the series *from the progression itself”*:

> 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 judgment 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 “snapshots” — of continuous “movement”. If we begin with the first leaf (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.

Understanding what is meant here by “movement” is the decisive thing. Brady helps us along with a series of succinct observations.[6]

The movement is continuous and ideal. The formative movement from leaf to leaf in an organically ordered series becomes more vivid to the degree that more transitional forms are supplied between the shapes we already have:

> 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.

But note: while the movement may be said to *produce* sensible forms, the movement itself is neither sense-perceptible nor physical. Yes, each physical leaf goes through its own unique and continuous development, as does the plant as a whole. But the unifying movement, or “gesture”, we recognize in passing from one leaf to the next is apprehended only in thought and imagination. One leaf does not physically metamorphose into the next leaf. So our practical and *objective* criterion for recognizing candidate leaves and correctly placing them in the sequence is an *ideal* movement.

The formative movement requires both difference and sameness. A critical point: "The impression of 'gradual modification' cannot depend any more on what each form has in common with its neighbors [such as an overall tripartite form] than upon what it *does not share* with them. Change demands difference, and continuous change, continuous difference". That is, a transformational series is united as much by differences as by similarities. We cannot have transformation without differences, and the nature of the differences tells us about the nature and distinctive unity of the transformation. One sort of transformation will require very different differences compared to another sort of transformation.

And so we are able to "see" the movement from form to form "only by a distribution of sameness and difference between them". We test in our imagination the dynamic context — the smooth movement that expresses a differential within the context of a unifying gesture — because by this movement *"the lawful relation between the forms is made manifest"*. All this normally happens without our noticing it. But if we want to understand biological form, it can be well worth noticing what we usually ignore.

An awareness of the movement changes our perception of the leaves. In seeing the movement that unites the forms, we shift our intentional focus "from text to context, from the individual particulars to the unifying movement". This necessarily changes the way we see the individual leaf, which now becomes merely an arrested stage of the movement — a momentary expression or visible trace of a passage — rather as we can isolate a series of still shots from a movie.

We can see how this works by considering an extreme case where we are given just the following two leaves of the sequence:

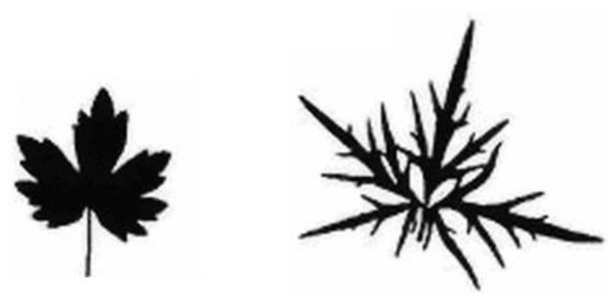

Figure 12.5. Two leaves from the buttercup leaf sequence. See text.

If we were seeing these for the first time, we could hardly regenerate an entire series of buttercup leaves from them. But if we first live with the more complete series, entering into the implied movement, and if we then look again at the two isolated leaves shown here, 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*. <u>Here is the intuited 'single form' of the series, but it cannot be equated with anything static</u>" (underscored emphasis added).

By expressing not just the sameness of one or more features abstracted from all the individual forms, but also a differential running throughout the series, the movement “specifies the forms possible to the series”. Here, in this movement, we have truly generalized upon the entire series in a way that no abstract and simplifying reduction to common features and no fixed image would allow. What the common schema fails to provide is “the differential that runs throughout”.

If there were no differential — if the image above showed two identical forms — then we would have no way to identify any sort of transformative movement. But because there is a differential, our enlivened and mobilized imagination can recognize in each sensible leaf the one true “leaf” capable of generating it. This is not a physical leaf, but rather the *single movement* out of which the sensible leaves have “fallen”. Thanks to our apprehension of this movement, the sensible leaf is no longer perceived as merely itself, but as a manifestation of a gesture.

The movement manifests itself through the particulars. It might seem odd to speak of movement rather than a *thing moving*. But what seems odd for contemporary habits of understanding may be exactly what’s required for overcoming the limitations of our understanding. After all, we have no difficulty speaking of the “movement of thought” — which may, in fact, be an aspect of what we are talking about here. And, in any case, it is not so difficult to see that no static form or particular thing can capture the quality of a movement *between forms*.

And let’s note also that we *are* talking about qualities here. We cannot grasp whatever is distinctive and significant about a gesture of any sort without a qualitative movement of our own thought. Only in qualities do we find the kind of multivalent potentials that can unify different (and otherwise disconnected) expressions or forms. Where a quantitative science might see in qualities only vagueness, a qualitative science gains access to dimensions of reality hidden to quantitative approaches.

The conclusion of all the foregoing (which will require further elaboration) is that “The movement specifies forms … by generating them”.

> The movement … 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 [it is] 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.

So how do we come to terms with a generative movement that is not a material thing? This will bring us to the culmination of Brady’s presentation.

The question of causality

We have been trying to understand the "movement" at work in the leaf sequence as a *form-making* principle. But, Brady remarks, if we are justified in speaking of this movement as a *making* principle rather than a *thing made*, then we seem to be attributing causal efficacy to the movement.

But we have so far been engaging in a purely descriptive project. Can such a project, however accurate, thorough, and fruitful for understanding, yield a causal principle? Brady's concern was to identify the characteristic features of the leaf sequence produced by a particular plant — the features by which we recognize "this plant is a specimen of *Ranunculus acris*". What's decisive, it has turned out, is not a particular static form or material entity, but an imaginal movement with its own distinctive qualities.

Having enabled us to recognize this movement for ourselves, has Brady also given us a causal understanding? Do we now see an *enabling power* by which the leaves manifest as they do?[7]

Current mental habits make it easy for us to picture *things* producing a well-formed movement, but very difficult to believe an ideal movement could somehow govern the production of things. This is the mental block Brady would have us overcome, and in a section of his article entitled "Form and Potency" he proceeds by refining his analysis of our experience with the buttercup leaves. Again we look at key points in his discussion.

Each individual leaf is "coming from" and "passing to". When we grasp the unity of the leaf sequence, we have recognized the differential underlying the transformation of one leaf to the next. The experience is dynamic, and this changes our perception of the individual leaves. As a result, as we discovered above, even two leaves from different parts of the sequence can strongly suggest the character of the overall transformation. The individual leaf at this point is not perceived as a mere fixed form, but rather as a movement "caught in the act".

> As our familiarity with transformation sequences increases … 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 for vital forces and final causes, we can perhaps understand how easy it has been for observers to imagine them. What is *making* each leaf conform to the pattern revealed by its predecessors and successors, if not some special sort of force? And doesn't the directionality of the overall sequence suggest a goal that can be thought of as the final cause?

But Brady, as we will see below, finds no justification for vital forces or final causes. He wants nothing more than to clarify observation, and his fascination is with the way a perceived form relates to potential forms, given the right sort of transformative context. In this way the individual forms lose their independence. As an "arrested movement" — as a phenomenon *arising from* a predecessor and *developing toward* a successor — each leaf is inseparable from a before and after. This is how it so powerfully suggests the “missing pictures” of the transformation. “The single image now becomes transparent to the whole ‘gesture’ — which it now seems to express … Potential forms come to mind because they are contained in the whole we are trying to see”.

The point is crucial enough to bear repeating in slightly different words. Once we have established the context of movement, each individual leaf — by *coming from* something and *passing to* something — “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”.

The sensible (visible) form shows itself to be but a partial disclosure of a forming activity. The instant it loses (due to our weakened perception) the *coming from* and *passing to*, it ceases to offer this disclosure. It then appears cut off from its own fuller reality — cut off from the reality and the whole in which it essentially participates, from the reality where we must look for causal relations, from the whole that is “somehow all the forms at once”. *So the recognizable truth of the individual leaf is lost when it is detached from the ideal movement, the dynamic context, out of which it arises.*

Whatever specifies the appearance of forms in time has causal significance. We come, then, to the heart of the matter.[8] Just as, in space, we can represent a set of distinct loci as a spatial unity (whether the unity of an imagined triangle or a single tree), so, too, we can represent successive manifestations in time as a unity. *“A principle by which we represent the distinct moments of time as a unity, even as we represent the loci of space as a unity, is a principle of form. But this sort of form must be a causal principle as well”* (emphasis added).

When we have a principle that tells us, consistently and correctly, something about *what we can expect to happen next* — what will follow a preceding event, so that the two events can be understood in terms of a single patterning idea — such a principle accords with what we usually think of as causal explanation.

As we have noted, the individual leaf form, insofar as it discloses a larger context of movement, contains within itself a *“felt potency to be otherwise*” — the sort of felt potency that leads some people to speak of a vital force. But the essential thing to realize, according to Brady, is that *“the sensed power is at the same time logical necessity”*. We are aware of this necessity when, presented with a buttercup leaf not currently shown in the leaf sequence, we find that it *must* be placed at only one location; otherwise, it will violate the living dynamism of the sequential movement.

The idea of logical necessity here tells us that the “sensed power” is not just brute, formless power, but a specific shaping power with its own character, or necessity. This dynamic principle remains itself only through its ability continually to become other in its successive incarnations, thereby maintaining its identity as a consistent principle of transformation. If the generative principle (or archetypal idea) were not determining a successor in this way, it would no longer be the unifying truth we have objectively recognized in the leaf sequence. We discover in it the necessity and power of change — and do so without adding any prejudicial theoretical structure to what observation yields.

> 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 ... once we have accepted the dynamic context the rest follows of its own necessity rather than by any further choice on our part.[9]

In general, we recognize causation when we see one event following another in what we think of as a lawful manner — that is, according to a discernible pattern that reflects one or another sort of ideal necessity. Nevertheless, I suspect that some readers may still have difficulty believing that the kind of ideational or archetypal formative movement Brady has identified in the buttercup leaf sequence plays a role we can properly think of as *causal*. In the next section I offer further supporting commentary.

A clarification of dynamic form as cause. The idea that the dynamic, generative form we've recognized in the leaf sequence — a form or potency we've been calling a "movement" — should be viewed as causal immediately raises a question for most people: "But what is *making things happen?*" Where is the necessary material influence, the matter impinging on matter, the coercive gears and levers that bring something about? How can an immaterial form, however dynamically we imagine it, causally intervene in the growth of a plant?

The questions are understandable in the light of contemporary thinking. But this does not absolve them of extreme naïveté — a naïveté that Aristotle had already overcome when he recognized what he called "formal causes" at work in material interactions.

The fact is that *all* material causation is an expression of immaterial (ideal) relations. Bodies moving at random in the solar system would tell us nothing about causes or laws; but if we observe certain geometric regularities — movements, for example, tracing the forms of conic sections such as ellipses or parabolas — or if, in investigating the fall of objects toward the earth, we eventually arrive at the formulas, $F = ma$ and $F = Gm_1m_2/d^2$, then we have discovered a certain lawfulness. We can talk about material objects acting on material objects, but without conceptual relations such as these — and conceptual relations (including those expressed in equations) are *not* material things — we have no lawful regularity and therefore no causation at all in any defensible sense.

Biologists today remain determinedly focused on material manifestations rather than on the living activity through which the material organism takes shape. Their conviction is that what has already become determines what *will* be. Brady's discussion of leaf sequences shows how wrong this is. The already manifested leaves, as material achievements, do not cause or explain the form of the next leaf. Rather, they, along with all the forthcoming leaves, testify to the ideal movement that has given rise to them and rules them.

We can say much the same thing about the developmental processes we observe in complex, multicellular animals. Nowhere along the path from the zygote to the mature form is the future form determined by what has already come to manifestation. That's why (to take a more extreme example), if we were seeing an insect larva or a tadpole for the first time, we would have no purely physical ground for sketching a clear picture of the butterfly or frog to come.

And, as we saw in the discussion of RNA splicing and Paul Weiss' work in Chapter 6, even at the molecular level the freedom of movement ("degrees of freedom") possessed by molecules in a fluid medium makes it impossible to treat the outcome of elaborate molecular operations as if each step were strictly determined by the material result of the previous step.

So the rule in biology is this: while the previous material achievements may be required (as preconditions) for whatever comes next, they do not *bring forth* the next steps. The failure of a materialist biology to reckon with this truth has distorted the entire science. And the failure extends all the way to evolution. As my colleague, Craig Holdrege, has summarized it, "You can't grasp evolution by staying with its material products".[10]

Threefoldness, the biology of form, and evolution

In 1977 the German biologist, Wolfgang Schad, published a substantial volume called *Man and Mammal: Toward a Biology of Form*. The richly illustrated book was founded so fully upon direct observations, and these observations required so thorough a reconceptualization of the foundations of biology and evolution, that biologists could scarcely afford to take note of it. So (for the most part) they didn't.

But Schad never ceased his undertakings, and in 2020 there appeared in English translation a vast, 1300-page, two-volume, hardcover expansion of the original work, with hundreds of color plates and with a new title: *Threefoldness in Humans and Mammals: Toward a Biology of Form*. It's all there, ready to be taken in by any with the requisite interest and willingness to see the biological world with new eyes. Here I can offer only an inadequate sort of abstract merely gesturing toward the broader themes of this work. It will be enough, I think, to suggest how little the problem of biological form in relation to evolution has yet been recognized by the biological community as a whole.

Schad acknowledges how much biologists have learned about "genetic factors, basic physiological processes, predictable instinctive reactions, and the social behavior of animals". But we can in this way learn a great deal about the physical parts and developmental processes of an animal without coming to a recognition of the formative ideas governing these processes. Similarly, explaining any organism in terms of genotypes subject to natural selection under the pressure of environmental conditions still leaves us wondering *what the organism has to say about itself through its own unique form*.

About the beaver, Holdrege remarks that its "teeth are good for gnawing wood, the large flat tail for swimming and as a paddle to slap against the water to alert other beavers about the presence of potential predators, and the high-set eye sockets for swimming inconspicuously with its head only slightly above the water surface". All this sounds good in terms of fitness and survival strategies. And yet what does it tell us about why the beaver took on its own specific, unified character and fashioned its own special niche within a larger environment inhabited by so many other organisms that traversed very different adaptive pathways? The conventional approach

> leads us to mentally dissect the animal into different traits, each of which has its own type of survival value. The coherence and integrity of an animal dissolves into a collection of traits, and all its characteristics are considered solely as adaptations that secure survival

> (Holdrege 2019).

But we have already seen that, if we looked at the leaf sequence discussed above without attending to its unifying idea, we would miss a decisive causal truth about its character. Similarly, by limiting our attention to the survival value or "fitness" of different animal traits — traits that *could* have taken countless other forms — we remain ignorant of the expressive unity of the specific animal. "No one", Schad says, "can tell us why well-known hoofed mammals, like cattle, deer, and rhinoceroses, have head protuberances, while horses, donkeys, tapirs, and camels do not. Neither molecular biology nor behavioral research concerns itself with the significance of an animal's form" (Schad 2020, p. 2).

David Seamon, editor of the journal, *Environmental and Architectural Phenomenology*, and co-editor of the book, *Goethe's Way of Science*, wrote of Schad's work:

> In the holistic biology that Schad presents, each feature of an animal is seen as significant because the whole is reflected in each part. The aim is to recognize the inner organic order in an animal in such a way that its individual features can be explained by the basic organization of the animal itself (Seamon 2020).

A starting point: living polarity in the human being

Schad attempts to appreciate organisms in the living terms that have long been recognized by the best biologists as essential to any profound understanding. I mean the terms of a dynamic interweaving of activities whereby parts come into being and gain their specific identity, not as independent elements, but rather as integrated expressions of a pre-existing whole.

The key to Schad's approach lies in his understanding of the organism as a being organized according to principles of polarity. By "polarity" he does not at all suggest what is usually meant by "polar opposites". There is no absolute opposition or incompatibility of parts. Rather, we see a mutual participation of parts within an integral whole that lives by reconciling the creative tension between opposing tendencies.

A merely static image of polarity is given by a bar magnet, each of whose poles extends as an active principle all the way into the opposite pole. Cut a small slice off one end of a bar magnet, and you have a second, smaller bar magnet with the same "opposition" of two poles. Each pole's character not only penetrates all the way to the opposite pole, but can exist only in conjunction with the activity of that opposite pole.

Our own human organization is a good place to start in seeking a more living example of this "unity of contrary tendencies". But here we discover, as with organisms generally, that this unity is not merely bipolar in the manner of an inert bar magnet. Rather, the active, living interpenetration of the two poles points to a third aspect of our being — a rhythmic and harmonizing activity that mediates between the poles, effectively raising the contrary tendencies to a higher level where unity is achieved.[11]

And so, looking at the human being, Schad sees three functioning systems. One is centered in the head, one in the abdominal cavity and limbs, and one — mediating between the other two — in the chest region.

In the head we find gathered together most of our sense organs, through which we more or less consciously relate ourselves to the “outer” world — for example, through sight (eyes) and our sense of balance (inner ear). The center of our nervous system (brain) is enclosed in a protective, globe-like exoskeleton, comprised of bones largely fused together.

At the other pole we find our limbs, with their endoskeleton. Far from globe-like and fused together, the parts are linear. The bones are connected by elaborate joints allowing the relatively independent movement of parts. The puzzle here might be that Schad conflates the limbs with the abdominal cavity and its intense metabolic processes, as if they comprised a single, coherent system.

What the conflated functional aspects have in common is a power of movement, where “movement” is used in an older (Aristotelian) sense, overlapping with the sense of “change” (*metabolē*). Motion, according to Aristotle, can be of several types, involving change in identity, quality, quantity, or place. “The last named is the primary kind of motion but involves the least change, so that the list is in ascending order of motions but descending order of changes” (Sachs 1998, p. 249). Of course, our movement in space makes intense demands upon our metabolism for energy. We can also say that both the metabolism and the limbs serve to maintain an animal’s autonomy from its environment. They do this physiologically — through the digestion and assimilation of “alien” food into the structure of one’s own body — and in terms of the ability to relocate oneself in space (p. 16).

The organs of digestion in the abdomen are not invested with, or protected by, a bony structure, but are an altogether soft part of the body. Their activity, contrasted with the almost “inert” quality of the brain and its nerves — and also contrasted with the functioning of the limbs — consists of intense *internal* movement. This includes the muscular and mechanical movement of the digestive organs, but also, and most prominently, the transformation — breaking down and building up — of substances.

In this way Schad refers to the *nerve-sense system* on the one hand, and the *metabolic-limb system* on the other. In between, in the chest area, is the *respiratory-circulatory system*, or the *rhythmic system*, centered in the activity of lungs and heart.

This middle region of the body is marked by a transition from the character of the head region to that of the abdomen and limbs. It is surrounded by the partly open rib cage, where the relatively immobile bony structure toward the head is more closed-in, with the ribs circling all the way around from the backbone to the sternum. But lower down the ribs become gradually shorter, straighter, and more mobile, “the last two pairs remaining close to the spinal column, where they ‘float’ freely and point downward. The sternum is broadest near the head and relatively narrow where it ends only part way down the chest cavity” (p. 18).

Here in the middle region we do not see a battle between the two poles, but rather a harmonization of them. The rhythms of breathing and heartbeat bring the breath and oxygenated blood to every part of the body, maintaining complex processes of balance or homeostasis.

> Lungs and heart are rhythmically pulsating organs. In each, contraction and expansion, tension and relaxation, compression and dissolution alternate constantly. The polarities of the organism, therefore, are always present in this region, but here they do not maintain their spatial separateness; rather, they actively complement one another through their

> rhythmical alternation in *time* (p. 16).

That is, this middle system is itself a manifestation of polarity, but through rhythmic alternation the poles are fully reconciled with each other. We see this polarity expressed in the relation between lungs and heart, where

> the lungs tend more toward the upper processes of the body that are centered in the head. Through the trachea, the lungs reach up into the head and establish a direct connection with the outside world … Their passivity, much like that of the head, appears also in the fact that they are incapable of self-initiated motion and are moved by the thorax and diaphragm. (pp. 16-17).

The heart, on the other hand, "initiates its own movement" and is "closed off from the outside world":

> The largest of the arteries originating in the heart, the aorta, turns downward toward the lower part of the body, where the blood relates directly with the processes of the metabolism. Only through the circulation of the blood do the lungs have access to the dominant processes of the metabolism; conversely, the blood gains contact with the outer atmosphere only through the lungs (p. 17).

Interpenetration of the three aspects

Referring to the relative immobility of the head, Schad writes: "Above the runner's flailing limbs and panting chest, the head quietly keeps the goal in view" (Schad 2020, p. 15). But here we need to keep in mind that the threefold aspects of the human being are neither abstract principles nor the material end-products of activity. What we find are qualities of character that continually interact and mutually influence each other, much as motifs, themes, and harmonies may play into each other throughout a musical composition.

It is clear enough that the nerves are not only contained in the brain, but also extend throughout the body, just as do our senses, which give us awareness of many internal processes of our body. Likewise, our circulation and breathing do not exist only in the heart and lungs. The circulating blood, with its finely balanced gases, flows throughout the body, and the breathing function includes the nose, mouth, and vocal organs. And so, too, metabolic activities proceed not only in the digestive organs, but in every cell of the body.

There are other ways we can look at this functional interplay. An example is given by the way our own head organization not only represents one of the poles of our being, but also bears within itself a somewhat muted image of our whole, threefold being. That is, the head has its own opposed (upper and lower) poles as well as a reconciling middle. The nervous system comes to a clear focus in the immobile, bone-enclosed brain. At the opposite pole we have the "limb" system manifesting in the movable, hinged, lower jaw. With its chewing motions to grind food and the digestive processes initiated by saliva, the jaw brings metabolic-limb activity to our heads, where this activity "establishes direct contact with the outside world (p. 19). And through our breathing and speech we see the performance of the middle (rhythmical) system. One way Schad makes this latter point is by referring to the air-filled cavities "found in the middle section of the cranium, between the sensory area of the face and the braincase itself":

> They include the larynx, the cavities of the throat and nose, and the more ossified air-filled cavities in the upper jaw (maxillary sinuses), middle ear, and frontal and sphenoid bones. Here, in a delicate way, the head's own respiration takes place. When the lungs exhale, air is pressed into the head's cavities; when the lungs inhale, the cavities of the head exhale. These cavities are lined with a moist inner layer that allows for gaseous exchange. Thus the middle region of the head also participates in respiration and in the organism's rhythmic functions (p. 19).

Furthermore, even when we look only at the mouth and throat we find all three aspects of the organism coming into play. The forward part of the mouth, with the sensitive lips and tip of the tongue, manifests the dominance of the conscious nerve-sense pole, whereas the middle system comes to the fore in the rhythmic chewing activity. Finally, the food is (with a diminished role for consciousness) moved to the rear of the mouth, swallowed, and passed down into the unconscious, metabolic center of the body (p. 40).

Despite all this mutual interpenetration of functional characteristics, we can certainly say that the nerve-sense system is *centered* in the head, just as the rhythmic system is centered in the chest and the metabolic processes in the abdomen.

A great part of Schad's research consists of a kind of "musical" analysis whereby he traces the endless lawful interplay within the threefold organization of the body. We will see more hints of this subtlety before we finish our discussion of his work.[12]

Threefold organization in mammals

It is commonplace to note that many animals possess specializations that make them, in one regard or another, superior to humans. The sight of an eagle, the dog's power to follow a scent, the gnawing ability of a beaver, the sonar-like hearing of the bat, the digging skill of a gopher — we could scarcely hope to match these abilities with our own natural equipment.

Humans, we might say, specialize in non-specialization. Our hands and arms, good for neither digging nor flying, neither swimming nor swinging from tree branches, can employ an endless range of tools of our own devising, from computer keyboards to the knitting needles through which we have long fashioned clothing adapted to numerous environmental conditions. While we lack the well-developed instincts that fit animals for particular environments, our brains remain plastic throughout our lives in decisive regards. "Most of the regions of our neocortex have to be differentiated through active learning. We can change established habits and continue learning indefinitely without ever exhausting the functional potential especially of the right hemisphere" (p. 10).

A central truth found in Schad's work is that the various mammalian groups develop the threefold organization of their lives with different balances among the three functional systems. In other words, they can "specialize" not only in specific behavioral traits or morphological features, but also in one or another of the three functional systems.

For simplicity, Schad's work is often presented initially by focusing on three groups of mammals. One group shows an especially strong development of the nerve-sense system, one emphasizes the polar opposite metabolic-limb system, and one reflects especially well the principles of rhythm, harmony, and balance characteristic of the middle system. These are, respectively, the rodents, the ungulates (hoofed mammals), and the carnivores.

Mice, with their nervous sensitivity and refined sense organs, exemplify the emphatic nerve-sense development typical of rodents. This is evident even in the limbs of rodents, which tend to be small and delicate, with long and narrow fingers and toes, and nails shaped like tiny claws. “The forepaws of squirrels, for example, are adept at grasping, handling, and feeling. Their limbs have acquired a sensory function. Long sensory facial hairs (whiskers), and shorter ones over the entire surface of their body including their bushy tail, project beyond their warm coat and enable squirrels, fitfully twitching and hopping, to find their way in the surrounding world … Agile and quick in its reactions, a rodent lives in constant agitation, alarmed pauses, and rapid flight. Even in sleep, nervous spasms periodically run over its small body” (p. 38).

This differs greatly, for example, from the powerful digestive processes and strong, hoofed limbs of the ungulates such as the dairy cow. “In contrast with the five-digit type of limbs of the less specialized mammals, the ungulates’ feet have regressed to a few bones, which, however, are very strongly formed. This specialization of the limbs extends even to the powerful enlargement of the nail into a hoof … The limbs of horses and cattle support massive bodies and, in stamping and galloping, horses express the powerful, animating forces within them” (p. 38).

Whereas a mouse must eat frequently, preferring energy-rich, easily digested foods and leaving behind dessicated droppings with little fertilizer value, the ruminants (which Schad considers the “most characteristic” group of ungulates) are well-known for their four-chambered stomachs, their extremely long intestines, and their ability to digest cellulose.

> Contented peace and restfulness suffuse the cow’s placid gaze, especially when, ruminating for hours, she devotes herself entirely to her food. Her eyes, and the eyes of all ruminants, lack the yellow spot, the *macula lutea*, which is the part of the retina with clearest sight. To the ruminants, the outside world appears diffuse. They have a stronger experience of smell and taste, senses more connected with the inner working of the metabolism than the eyes and ears. A cow is never as completely awake as a mouse; the unconscious processes of digestion predominate even in the ruminant’s state of half-wakefulness. (pp. 38-39).

The carnivores, with their intermediate character, which lacks the distinctive and one-sided development of the rodents and ungulates, are less easy to describe. Schad spends a good deal of time working out the sometimes subtle ways in which different groups of carnivores lean slightly more toward the nerve-sense pole or the metabolic-limb pole, while generally falling in the broad middle area between the two poles. (See his discussion of dogs and cats below.)

It happens that organisms in each of the three major groups tend to fall in different size categories. Rodents are smaller, ungulates larger, and carnivores take up a position between them. And there is an inverse relation between size and the quality of the food each group favors. Rodents prefer highly nutritive, energy-rich foods — fats, oils, and starches. Breaking these down for immediate use, they tend to store very little in the way of bodily reserves of energy. Ungulates, on the other hand, eat poor-quality food, and build up from it great energy reserves — illustrated by the hump of a camel or the subcutaneous tissue (ham) in pigs. And so,

> While nervous constitutions characteristically break down substances, metabolic ones rebuild and augment them. The nutritive processes of the carnivore represent an intermediate state. When a leopard devours a gazelle, a true change of substances does of course take place during digestion, but the change from one form of protein to another hardly alters the chemical energy level (p. 40).

Schad notes what might almost seem a counter-intuitive relation between, on one hand, the nerve-sense or metabolic-limb emphasis and, on the other hand, the overall form of the animal. The rodent, with its strong nerve-sense orientation, tends toward an accentuation of the posterior end of its body, with long tail and the hind legs longer and stronger than the forelegs. The head is not dramatically separated from the rest of the body (think of the mouse). For a rather extreme example of this posterior emphasis, see Figure 12.6.

Figure 12.6. Taxidermied lesser Egyptian jerboa at the Natural History Museum in London.[13]

By contrast, the American bison, with its highly developed metabolic-limb system, presents an anterior emphasis, with its powerful neck and head, and the great hump above its shoulders (Figure 12.7). The giraffe, with its long neck and forelegs and its even more “shrunken” hindquarters is an extreme example of this tendency.

Figure 12.7. An American bison.[14]

The carnivores in general occupy the middle ground, where balance is achieved between the posterior and anterior ends of the animal (Figure 12.8). Or one can picture the chase, where a lion pursues its prey with a burst of energy, its forelimbs and hindlimbs contributing equally to the task. And then, in the natural rhythm of its life between sudden exertion and inactivity, the great predator, having eaten its fill, is overtaken by lassitude. Its rest and sleep are the very picture of flexible bodily relaxation.

Figure 12.8. Bengal tiger (*Panthera tigris tigris*) female, Kanha National Park, India.[15]

Compare that with the ungulates:

> [Speaking at first of the bison:] The front pole of the body with its morphological over-accentuation constitutes the animal's center of gravity. When cattle stand up, they first straighten their less heavily burdened hind legs; only then do they raise the heavier, front part of their body. They lie down, too, in a way that seems strange to us: First, they bend their front legs, laying the main burden of their body down upon the ground, and then the hindquarters follow effortlessly …
>
> In a rodent — a squirrel, for example — the posterior limbs and the tail are over-accentuated. The lighter front part of its body and its smaller forelegs are less ponderous than most ruminants', enabling it to sit up on its haunches and raise its head, which is quite typical for all mice, hamsters, dormice, chipmunks, ground squirrels, marmots, beavers, etc. This is quite the opposite of the buffalo, whose mighty head is bowed down by heaviness (pp. 294-5).

Subtle interweaving

I mentioned above that a certain threefoldness manifests within the "one pole" of the human head — and again within just one part of the head, the mouth-throat area. (Schad also discusses at length how the teeth alone strongly manifest a threefold nature.) This illustrates the general principle of "the whole within the part".

This kind of interweaving is in fact evident everywhere. But it occurs in a continually different expressive fashion. Schad subtly traces the differing relative prominence of the three functional systems not only in the three major groups (rodents, carnivores, and ungulates), but also within many of the subgroups as well as entirely different major groups. He shows, for example, how, in two subgroups of carnivores — felines and canines — we see a degree of leaning toward either the nerve-sense or the metabolic-limb pole. This is despite the fact that both groups clearly exhibit, overall, the rhythmic or middle emphasis of the carnivores.

Cats, with their highly developed senses of sight and hearing, and their sensitive whiskers, tend toward the nerve-sense pole. The dog's primary orientation is toward that of the rather duller sense of smell. "The cat's sensitive constitution is also revealed in its paws, with their retractile claws, so different from the dog, whose limbs have become tools for running, with immovable claws" (p. 48).

As for the cat, "even its method of hunting is in keeping with its strongly developed senses: it prowls stealthily, then crouches motionless with all its senses focused on its prey, and finally pounces with lightning speed. By contrast, wolves, as well as their descendants, the dogs, hunt by pursuit. Tirelessly, they drive their victim until it is exhausted and must surrender. Cats hunt primarily with their senses, thus avoiding great physical exertion; dogs hunt with their limbs, powerfully activating their metabolism. Dogs and cats have thus developed polar modes within the 'attack' behavior of all carnivores … And yet in their supple agility, well-proportioned form, and moderate size, both are typical carnivores, shaped primarily by the rhythmic system" (p. 48).

Briefly: we see a similar polarization within the ungulate group. With its strongly developed digestive system, the bison (or cow) exemplifies the least development of the nerve-sense pole, while the giraffe, with its more refined head raised high above its digestive organs and alert to the larger environment, shows a relatively strong nerve-sense emphasis. And just as the lion and wolf occupy a middle place among the mammals generally, the deer, with its nerve-sense and digestive functions more or less in balance, holds a middle ground among the ungulates.

I hope all this illustrates a crucial truth. We are not talking about fixed schemas and opposing structures, but rather about qualitative tendencies that can play into each other with infinite subtlety and variation. Clearly, as with all qualitative science — and as illustrated by our discussions of the sloth and plant leaf sequences above — science must engage with art in the effort to apprehend the morphological and functional characteristics of animals. The faithful grasp of polarity requires a lively imagination immersed in the rich world of phenomena.

To a bench scientist in the laboratory, bent on uncovering unambiguous causes and "master molecular regulators", it may seem that a qualitative science is no science at all. And yet, to anyone profoundly attuned to the living world, it is within the laboratory that, all too often, the organism disappears and biology comes to a dead end.

Can evolutionists escape responsibility for explaining these patterns?

It's worth mentioning that the polarity we are speaking about here bears strongly on evolution. The differing but ordered qualitative emphases among the different groups of mammals are invisible to current evolutionary theory. So we are forced to ask, "What is missing from this theory?"

The observed patterns, according to Schad, include this one: Within any group there is an evolution from smaller, more active, nerve-sense-dominated animal forms toward larger, less active, metabolically oriented forms. The latter represent a kind of conclusion, after which evolution takes up a fresh start from another point, just as, upon the extinction of the dinosaurs, the tiny mammalian forms existent at the time became the basis for a new evolutionary thrust.

Such regularities of form can hardly be understood in terms of conventional evolutionary theory. Someone else who appreciated the difficulty of the problem of form relative to contemporary concepts of evolution was the widely respected twentieth-century Swiss zoologist, Adolf Portmann, as evidenced by his observations in a book that has been translated into English as *Animal Forms and Patterns — A Study of the Appearance of Animals*.

By paying attention to form, Portmann recognized trends and relationships overlooked in standard approaches to evolution. He found the external appearance of animals to be the self-presentation of creatures with an inner way of being — a presentation that includes ways of perceiving, moving, behaving, and all forms of color and shape expression in space and time. This expressiveness with its meaningful patterns, he claimed, goes far beyond what might be advantageous relative to natural selection.

Portmann offered a simple, but useful reminder of the expressive luxuriance of nature when he mentioned in passing how plants present us with "a variety of leaf shapes in a profusion of unsuspected magnitude" despite their not being "favoured by any animal selection". That is, the leaf shapes cannot be explained by selective pressures such as those that might involve the leaves and the insects or other animals that feed on them. Similarly with "the many varied types of design on the shells of snails and bivalves", and also with "the whole world of astonishing shapes found in the shells of the microscopically small, one-celled Radiolarians of the open sea" (Portmann 1967, pp. 114-5, 124).

Portmann's excellence as a zoologist is undisputed. But he had the misfortune of pursuing the main body of his work on the eve of the all-out triumph of molecular and genetic approaches to the organism. Few wanted to look at the animal in the qualitative manner he did, so they did not see what he saw.

Among those who do look at animal form in its own terms — and who have extended Schad's work by applying it to their own research — we should at least take note of biologist Mark Riegner and his investigation of the plumage patterns and coloration in birds.[16] Then there is the Welsh dinosaur expert, Martin Lockley. As a paleontologist and professor of geology for thirty-two years at the University of Colorado Denver, Lockley wrote his popular 1991 book, *Tracking Dinosaurs: A New Look at an Ancient World*, as well as numerous technical publications.

In his 2007 paper, "The Morphodynamics of Dinosaurs, Other Archosaurs, and Their Trackways: Holistic Insights into Relationships between Feet, Limbs, and the Whole Body", Lockley wrote that within the two main dinosaur groups,

> one can detect a spectrum of form between small, long-tailed, narrow-bodied, bipedal species (posterior emphasis) and large, wide-bodied, shorter-tailed, quadrupedal species with various cranial processes (crests and horns), indicating an anterior emphasis. These same or similar formative movements reiterate at many different taxonomic levels, and even reiterate within organs of the whole organism such as skulls and feet. (Lockley 2007).

Noting that these morphodynamics of dinosaurs can also be recognized among birds and ungulates, Lockley recommended that paleontologists pay much more attention to such patterns of form, and he suggested that the "traditional emphasis on Darwinian functionalism will assume less importance, while the significance of inherent morphodynamics becomes more fully appreciated". After all, we can't be so easily satisfied with the explanation that some particular dinosaur developed a large head "for use in combat" when we find that the movement toward larger heads happens repeatedly and lawfully — in harmonious relation to many other morphological trends — within every group of dinosaurs.

This, of course, amounts to a startling rejection of conventional evolutionary reasoning. The typical causal, deterministic language of biology is simply ill-suited to an understanding of changing patterns of form. Lockley formulates this rule: "*rather than single organs changing for specific adaptive purposes, all organs may change simultaneously as part of a shift in a complex, highly dynamic organic system*". And what is true of the individual organism seems to be true also of the way species are ordered within higher taxonomic groups, so that "*the evolution of species may be, at least in part, an inherent biological dynamic associated with large-scale evolutionary shifts affecting multiple species*" (emphases in original).

This dramatic claim leads to another one of those bombshells Lockley rather casually drops throughout his paper as he unfolds the implications of wide-ranging, repeated patterns of form in the animal kingdom. He notes that different animal groups show three sequential cycles, first of posterior, then of balanced, and then of anterior development, and that the great dinosaur extinction terminating the Mesozoic era came at "*precisely* the end" of the third cycle, “when horned dinosaurs (like *Triceratops*) had developed maximum head size ... This seems to be a rather remarkable coincidence, in which a large-scale, inherent biological cycle coincides so precisely with a purported extrinsic cause (meteorite or comet impact)”. He goes on:

> If a significant number of morphodynamic cycles, culminating in anterior (metabolic) specialization, also result in, or coincide with, extinction, the implication is that extinction, at least to some degree, is an inherent, biological dynamic analogous to a large-scale "life cycle".... Therefore, efforts to seek external causes may be unnecessary and result in misleading, or at best incomplete, explanations and correlations.

And in yet another jettisoning of standard evolutionary thought, Lockley questions whether evolution proceeds “by some process of random mutation.” After all, given repeated and dynamic morphological tendencies exhibited widely among different animal groups and manifesting their own relational lawfulness, it is hard to reconcile these with the supposedly random generation of variation. If, as Lockley suggests, “it may be possible to predict the general form and physiology of the whole animal from an analysis or understanding of the parts”, and if a similar coherence of form exists within the “superorganisms” comprising the various taxonomic groups, then we are a long way from both the usual adaptationist explanations of the features of animals, and also from chance as the primary generator of variation for natural selection to act upon.

More generally, Lockley argues for a holistic approach to animal morphology, rather than an attempt at feature-by-feature explanation. The latter focuses upon adaptive function (horns are used for butting) whereas the former reckons with the fact that in any organism the modification of one part “will lead to a compensation or ripple effect throughout the whole” organism.

Lockley’s work on dinosaurs is vastly more complex and subtle than I could possibly indicate here (or properly understand in my own right). But, following Schad, he is clearly suggesting the need for radical new perspectives on evolution. Yes, we must investigate how the various features of an organism help to make it fit for the requirements of its life within a particular environment. That’s part of getting to know what sort of organism (and environment) we’re dealing with. But when this investigation is narrowed down to a search for survival mechanisms offering a competitive advantage — when the explanatory significance of every feature is reduced finally to the terms of a quantitative judgment about fitness to survive, so that the feature itself is not taken to express anything significant apart from its contribution to survival — when the artful pattern on the butterfly’s wing becomes no more than, say, a deceit aimed at birds to avoid being eaten — then we lose the organism as such.

We lose it because we’re not really *seeing* it; we’re not allowing its features to speak for themselves, in their own expressive terms. Everything has to be reduced to fit an interpretation that says a feature is *for* some particular survival benefit rather than for the entire, uniquely formed way of being of the organism itself. We thereby ignore the lawful patterns visible in the way an evolving species picks one path rather than another through the infinite landscape of survival possibilities

Naturalists may develop a profound sense for the inherent lawfulness of a particular organism’s way of being. But, unfortunately, naturalists do not have much standing in the age of molecular biology. As Schad puts it on the opening page of his two-volume work: “The immediate observation of nature and the study of natural science as commonly practiced today have generally become different activities". A profound truth whose disturbing implications are not often considered.[17]

If, however, it is true that the organism is a recognizable unity; if there are consistent harmonies sounding through its various "survival mechanisms", bringing them together in one song — a song as distinct from those of other organisms as a lullaby is from a patriotic march; if the organism, not only as a product but also as a shaper of its environment, takes up its creative opportunities and employs them with all the coherence and expressive focus we find in the work of a perceptive artist; if, in sum, there shines consistently through all the morphological, physiological, and behavioral details of an organism a character declaring something more than "I have survived", but also "I am my own sort of being, unified, bound by a lawfulness not only of matter but also of form, and this lawfulness is accessible to those who approach me respectfully" — well, then, the supposedly solid foundations underlying contemporary evolutionary theory will have crumbled beneath us.

WHERE ARE WE NOW?

We Have Seen What a Qualitative Biology Can be

Despite the several-century effort within science to formulate a quantitative discipline without any explicit acknowledgment of the role of qualities, the goal is impossible to achieve, and we always in fact have an “invasion” of qualities in our science. But because the qualities go unacknowledged and are rarely if ever consciously taken up as an issue for scientists to come to terms with, the invasion generally takes unhealthy form — something I have hinted at in Chapter 13 (“All Science Must Be Rooted in Experience”).

In the present chapter I have drawn on the work of three researchers in order to present diverse examples of biological work where qualities are not only front and center, but also where the qualitative nature of the work is fully recognized as decisively important for scientific understanding. With these examples we have addressed the following questions: (1) How can we characterize the way of being of a specific kind of organism (the sloth)? (2) What sort of immaterial and qualitative understanding gives us our basis for recognizing the material, species-specific, leaf sequence patterns in certain plants? (3) Do we discover distinct and lawful relations between the forms of the various mammalian groups, and do these relations present problems for current evolutionary theory?

What then are qualities? It will be evident from the discussion in this chapter that there is no great mystery here. A qualitative language describes what a thing is in its own, observable and sense-perceptible terms — the terms that are a prerequisite for our having a conviction that anything material is actually *there*, anything from which we can, if we wish, proceed to abstract mathematical relations.

In Chapter 24 I address the broadest and most fundamental question of all: whether, within science or outside it, we can speak coherently of a material world without first taking qualities seriously.

Notes

1. (Brady 2006). The last sentence of this quote (“It is always nice to see where one stands”) is not present in the current cited source, which reads instead: “I left his office feeling very deflated. Again a representative of science had put his finger on my immaturity”. The quote I have reproduced in the main text was from an earlier version of Brady’s book chapter.

2. Figure 12.1 credit: Craig Holdrege.

3. Figure 12.2 credit: Craig Holdrege.

4. Goethe 1995, pp. 57, 307. On the relevance of Goethe’s scientific work to today’s science, see Craig Holdrege’s "Goethe and the Evolution of Science" (Holdrege 2014), an expansion of

a talk given in October 2013 to an interest group at the New York Academy of Sciences.

5. Figure 12.3 credit: Craig Holdrege.

6. Keep in mind that, without our active participation in the leaf progression — without experiencing qualitatively through our own willed inner movement the character of the transition from leaf to leaf — we will not come to any full appreciation of Brady's discussion. It is, in any case, not an unhealthy exercise to bring about through our own effort the transformation of one leaf form to the next, an exercise requiring a muscular and fluid imaginal activity that habits of abstraction easily bypass.

7. It is important to realize that the movement Brady speaks of cannot by itself wholly determine leaf forms:

> 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.

Only a few out of a continuous series of possibilities are actually realized on a single plant, and the form of those few will be influenced by environmental factors. Unusually cold or dark or dry weather will have its effect — but always consistent with the recognizable potentials of the species we are looking at.

8. Brady considers form and cause in the context of Immanuel Kant's treatment of organic form in the *Critique of Judgment*. My present purposes forbid extending the discussion in this direction. But see the following footnote.

9. For the philosophically minded, Brady offers the following aside:

> 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 Judgment*. 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".
>
> 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.

Regarding Kant, Brady provides a succinct summary of the issues in another luminous article (Brady 1998) not currently available online:

> Kant made science into a study of appearances aimed at bringing them under rational law, that is, if we could understand and predict appearances, our inability to understand their ultimate source would not be a serious debility.
>
> Unfortunately there were some appearances that resisted this project. Kant was acutely aware that our notion of life was formed by the sense of inward unity, an agency that produced and governed the organism from within. This inner agency could not be brought to the understanding by a conceptual summary of its parts, as is the case with inorganic compositions. In its earliest stages, in fact, the organism had yet to develop the organs by which its later existence would be supported, making the inward unity *antecedent* to the developing parts, a whole which makes its own parts necessary rather than a result of the combination of the parts. To the degree that the combination of parts may be said to be causal, each part aided in the production and maintenance of all the others, and all the others did the same for each. As a result, the physical organs had to be recognized as both cause and effect of themselves. The linear chain of causes by which mechanical events were understood here curled up into a circle, depriving the chain of explanatory power.
>
> If one reflects more deeply, it seems obvious that the mechanical laws do not show the requisite logical structure to explain life. Inert objects were moved from without by impressed forces. Laws governing their movement, therefore, are also “external” to the things moving, that is, the laws of mechanics sum up the interactions of objects while being perfectly indifferent to the individual natures of those objects. The organism, however, could not be known in this abstract manner, and predictions concerning its changes were dependent on a knowledge of the species. Even the sort of materials out of which it was constructed are an expression of species identity, and thus the governing laws had to be identified with the object they governed, that is, such laws not only governed, but also produced, their objects. Or, at least, Kant argued, these results express the way things *appear* to immediate perception …
>
> Analytic thought, which understands the whole through summing the effects of the parts, could not comprehend a whole that preceded the parts or accomplish a path of thought that moved from the general to the particular. Such a movement, Kant argues, would be that of an *intuitive* intellect, which humanity does not possess.

Brady goes on to say that, while Kant never made a project of actually testing whether a properly developed scientific understanding could embrace the becoming of an antecedent, organic whole, this was exactly the test that Goethe did make — and made successfully, as shown by his work on plants.

10. Craig Holdrege, personal communication.

11. Schad’s “threefold” understanding of the human being draws from the threefold picture first offered by Austrian philosopher Rudolf Steiner in his 1917 book, *Von Seelenrätseln*. That work has been translated into English under various titles, including “The Riddles of the Soul”.

12. Schad’s description of the relationship between the organism and the world shows the impossibility of any rigidly schematic notion of threefoldness:

> Initially, I characterized the whole upper system as *directed outward toward the world*, and

> the lower system, by contrast, as *self-enclosed*, with the rhythmic system mediating between the two. Though this relationship is an essential characteristic of the threefoldness of the bodily organism, we can, as we have also seen, come to a more nuanced understanding of this pattern in its particular characteristics. On the one hand, the organism communicates with the outer world in three quite different ways: primarily via the *sense organs*, but also through *breathing* and through *limb activity*. On the other hand, it establishes its *specific physiological competency*, its independence [or autonomy relative to the world], chiefly through the *digestive organs*, but also through its relatively closed *circulatory system* and its almost wholly encapsulated *nerve center* (p. 23).

He immediately adds that the human organism “is as much a member of the surrounding world as it is an independent world of its own; and by mediating between these two kinds of existence, between its biological self and the surrounding world, it creates an active interplay between the two. It always gives the lie to any one-sided explanation of its reality, which we can approach only by adopting multiple perspectives” (pp. 23-24). So we find a unity of polar opposites, not only within the organism, but also between the organism and the world.

13. Figure 12.6 credit: Emöke Dénes (CC BY-SA 4.0).

14. Figure 12.7 credit: RedGazelle123 (CC BY-SA 4.0).

15. Figure 12.8 credit: Charles J. Sharp (CC BY-SA 4.0).

16. See Riegner 2008. Riegner’s work on birds would take us too far afield to allow for coverage here. He has also written an important paper in the philosophy of biology, dealing with the “new archetypal biology and Goethe’s dynamic typology as a model for contemporary evolutionary developmental biology” (Riegner 2013).

17. Schad goes on to remark on the second page: “My purpose is to place in the absolute center of inquiry the direct perception of the animals most closely related to us — the mammals — as they live in their natural environment. We shall approach them with the confidence that their lives openly and plainly convey what is essential for our understanding of them. As we recognize the unique quality of each animal form, it poses a much neglected question whose answer … can be supplied only by the living form of the animal itself”.

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