

Goethe's Querelles and the Formation of Scientific Character

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1. In the context of a symposium inquiring about Science and Romanticism, Johann Wolfgang von Goethe is more of a problem than a solution. For more than a century Goethe was, rightly or wrongly, the paradigm of human acculturation, of *Bildung*, for German bourgeois society. With the loosening of the ideal of *Bildung* after the World Wars and the emergence in a more democratic society of a critical attitude toward his apparently aristocratic character and convictions, Goethe's hold over the German and European cultural imagination weakened. Yet although he now tends to be reduced to the status of imposing (but mere) representative of a world dimly remembered, he still needs to be reckoned with when we examine German and European culture in the last years of the eighteenth and the early years of the nineteenth centuries.

Even before beginning to analyze what Goethe's querelles have to do with the formation of scientific character, we must note the existence of a certain irony in juxtaposing Goethe's name with science and romanticism. If I say "Goethe, science, and romanticism," an educated European audience will have in advance a sense that these three topics belong together. That is, if science and romanticism are considered together, if we take the intersection of science and romanticism, then without doubt Goethe is a good representative of the issues involved. If on the other hand we separate the topics and produce two pairings, "Goethe and science" and "Goethe and romanticism," the anticipated relationships become more complicated and more adversarial. For didn't Goethe stand for a kind of science that is at odds with modern science, with the kind of causal, methodical, mathematical science that first emerged in the seventeenth century and is historically continuous with science today? Wasn't Goethe also a critic of Romanticism? In this differentiated light Goethe appears to be representative of neither science nor Romanticism. Instead of being representative, he becomes an outlier, an eccentric. Even if he induced important contemporaries and *Bildungsbürgertum* to share his views, he appears to our more distant and dispassionate vision as atypical, and perhaps (if we regard Goethe's capacious spirit) atypically narrow or limited.

Are we not, here at the outset, approaching the provisional conclusion that Goethe on the one hand rejected both Romanticism and modern science, yet on the other hand was a chief proponent of Romantic science? It would be no exaggeration to say that the conventional wisdom of scholars answers yes to both questions. In what follows I will try to show that the conventional wisdom is wrong, or at least that it wrongly frames the issues. Examining Goethe's querelles, his *Auseinandersetzungen* with science and Romanticism, will provide clues for reformulating the issues more accurately and appropriately.

2. Goethe's reputation for being at odds with modern science is built above all on his polemics against Isaac Newton's theory of white light and colors. Color theory, or *Farbenlehre*, was not the only or even the first science to which he devoted his energy, however. His scientific and technical interests began in the fields of botany, geology, and mineralogy. They were initially awakened in 1776 by practical matters: planning a garden for the house Carl August, Duke of Sachsen-Weimar, gave him as a present, and reopening the mines in Ilmenau at Carl August's

behest. In 1780 and 1781 he undertook intensive studies in mineralogy and anatomy, and by the end of 1781 he was lecturing on anatomy at the Freie Zeichen-Akademie in Weimar. His first major scientific work was an illustrated essay he completed in 1784, a study in comparative mammalian anatomy to determine whether human beings possess an intermaxillary bone (the bone in which the canine teeth are embedded). But, after circulating it among a few leading anatomists in Germany and Holland, he decided to withhold it from publication. (It was not published until 1817.) In 1785 he turned again to intensive work in botany, beginning with Linnaeus' *Philosophia botanica*.

The first major scientific piece he actually published, therefore, was the *Metamorphosen der Pflanzen*, the metamorphosis of plants, in 1790.¹ Then, in 1791 and 1792, he published two installments in what was intended to be a series or works, the *Beiträge zur Optik*, contributions to optics. To his friends he announced that these optical contributions had overthrown Newton's theory. The publications themselves did not overtly polemicize. However, in the twelfth paragraph (the work was divided into short, numbered paragraphs for easy reference) Goethe suggested that there were as yet unrefuted "objections to the Newtonian system," and in the two preceding paragraphs he stated that "more than a hundred years ago a profound man occupied himself with this material, arranged many experiences, erected a doctrinal edifice like a fortress in the middle of the field of this science, and by means of a powerful school compelled those who followed to join themselves to this party if they did not want to be completely suppressed" (LA I 3: 9). The theme of warfare, of *polemos*, was clear, even if no further arguments against anyone or anything were presented in the two *Beiträge*. Goethe published to the world his polemical intentions only several years later in the *Xenien*, which appeared in Friedrich Schiller's *Musen Almanach* for 1797. The *Xenien* were distichs in the manner of the Latin poet Martial that Goethe and Schiller jointly composed to satirize contemporary cultural and intellectual currents. Approximately a dozen were aimed at Newton and Newtonians.

Goethe was nevertheless not a quarrelsome or disputatious person. Throughout his life, both personally and professionally, he tended to flee controversy and conflict rather than to pursue it. Perhaps the most famous example of this tendency was his flight to Italy in September of 1786. At that point he had been living and working in Weimar for nearly eleven years and had begun to find personal relations deteriorating, his social role suffocating, and his professional and governmental responsibilities oppressive. Rather than explode in anger and frustration, he secretly (though with the consent of the Duke) arranged to leave Weimar, and indeed he left unannounced.

A similar pattern of response to an unfavorable situation also marked his early scientific work, from the late 1770s to the early 1790s. When he circulated the illustrated manuscript of the essay on the intermaxillary bone the reaction was mixed: disagreement, mild praise, some encouragement, and not a little misunderstanding. Goethe was disappointed but showed no inclination to insist on his point of view, much less to attack; instead he put the essay aside, though he did not simply abandon work on comparative anatomy.

Another typical episode, involving a public exchange with his friend Karl Ludwig von Knebel (1744-1834), occurred right after the two-year-long Italian journey. Before going to Italy, Goethe had encouraged Knebel to follow his example and devote himself to studies of nature. Knebel chose to observe the forms water takes on as it freezes and compared them to forms that appear in plants and the feathers of birds. Knebel shared his results with Goethe, who then wrote

¹ The poem of the same name was written in 1798 and published the following year.

about them in the periodical the *Teutsche Merkur* in January 1789. He cited them as a careful study marred by fancifulness, by fantastic imagination. Knebel was outraged and wanted to publish a vehement rejoinder. Goethe acknowledged that he had gone too far, however, and with the mediation of the journal's editor, their common friend Christoph-Martin Wieland (1733-1813), they agreed that Goethe should try to temper his initial remarks in a subsequent essay.

This episode may, of course, strike us as an act of aggression rather than as evidence of Goethe's peaceloving character. Was it not at least a betrayal of trust to respond to Knebel in so public a forum? Our first reaction needs to be mitigated by the context. Wieland had invited Goethe to write a series of essays about the lessons of his Italian experiences. Goethe's evaluation of Knebel's work was part of an essay concerning *Naturlehre*, the doctrine of nature. The *Merkur* had been founded in 1773 as a new kind of journal for the German public, one that surveyed the full range of cultural matters of interest to an educated reader. It was edited and published in Weimar, and although it had a much wider audience it also often reflected the cultural interests and events of Weimar and the nearby University of Jena. Goethe's discussion might thus be seen less as publicizing a private matter than as sharing with his core audience in Weimar and Jena his assessment of something they already knew about: that Knebel was engaging in scientific work in a supposedly Goethean manner.

Goethe clearly felt the need to use the opportunity to distinguish his own practice from Knebel's. Although it is not hard to imagine why Knebel was offended, Goethe nevertheless does not appear to have meant to attack him. Rather, from a more experienced position he wanted to caution Knebel and his other Weimar/Jena friends about the risk of the imagination running wild whenever widely disparate phenomena are compared. It is more important to differentiate than to assimilate things, he had argued in the first letter, and ended with this advice: "Science is really the intrinsic privilege of man." If in practicing science the human being is recurrently led to "the great concept" that everything is "a harmonic unity, and he [the human being] too is a harmonic unity: then this great concept will exist far more richly and more fully in him than if he should rest content in a comfortable mysticism that agreeably hides his poverty in respectable obscurity."² As Dorothea Kuhn points out, these words express "one of Goethe's great principles that he never surrendered and that preserved him from falling prey to an uncritical *Naturphilosophie*."³

If this was intended as a friendly rebuke, it was still a rebuke, and quite public. The conciliatory reconsideration of the second nature essay softened the distinction of the earlier piece. In place of the sharp dichotomy between making careful distinctions and drawing remote analogies, Goethe's now identified himself with the standpoint of the amateur, of the dilettante. He spoke approvingly of the need for imagination and wit as aids (*Hilfsmittel*) to science. Imagination and wit are what allow the genius to go beyond the common run of discoveries; they are related to intuition, and are invaluable for recognizing the forms, or types, of the phenomena. . Science thus has a threefold basis: the work of researchers (1) who make exact observations, (2) who order and determine what has come to be known, and (3) who take the first two as results and, using imagination, add to them something new. These powers, though problematic, are capable of anticipating more remote relationships, both theoretically and practically. Applied to Knebel, this

² Quoted after Dorothea Kuhn, *Empirische und ideelle Wirklichkeit: Studien über Goethes Kritik des französischen Akademiestreites*, *Neue Hefte zur Morphologie*, vol. 5 (Graz: Hermann Böhlau Nachfolger, 1967), 24.

³ *Ibid.*

means that he did well in his initial observations, and that from Goethe's perspective he had moved too quickly to try the third, more speculative task, before the second was firmly in place.

3. Goethe was in the 1790s seeking a new audience, as poet, as critic, as scientist. He had fled to Italy in 1786 to escape the entanglements of Weimar society and government service. The Italian journey enabled him to rediscover nature, personal spontaneity, the art of classical Greece and Rome, and the natural basis of human social institutions. He had hopes, upon returning to Weimar, of sharing his newly won knowledge and wisdom—his new approach to life, art, nature, and society. Instead he found that his new attitude irritated, even alienated, his old friends, and increasingly he found himself isolated. The isolation in Weimar was only relative, of course, but doubtless his relationships to people there changed after Italy, not least because many were morally offended by his taking up cohabitation with Christiane Vulpius, whom he would not marry until 1806. But his status as poet had changed as well. In part the reason was as simple as the fact that in 1789 he turned forty years old and could no longer be counted among the rising lights of German literature. Another was that in the political turmoil of the French Revolutionary period there was less interest in the kind of cultural and social currents he represented.

Despite his feelings of isolation Goethe continued to be active in public and cultural life. Increasingly his attention turned toward the University of Jena, only twenty kilometers distant, for which he had general responsibility as the relevant government minister. In the 1780s it had begun to attract scholars from throughout the German lands; by the mid-1790s it had become the center of German philosophy and literary activity. Goethe had also started recruiting heavily to improve the sciences faculties. It was not until he and Schiller became close friends, however, that Goethe's sense of isolation fully lifted.

Schiller, with indefatigable energy despite poor health, was in active communication with scholars and literati all over Germany and was prolific in founding and fostering new cultural projects. In July 1794 Goethe traveled to Jena to attend to various tasks, one of which was to discuss with Schiller the latter's proposal for collaboration on a new journal, the *Horae*. They encountered one another earlier than expected. Goethe attended a botany lecture at the recently founded Natural History Society, where Schiller, too, was in attendance. When the lecture was over the men's paths crossed near the door.⁴ Although they were well enough known to each other, up to this time they had had little to do with one another. Goethe had supported Schiller's appointment to a position in history at the University of Jena (the literature professors had blocked an appointment in their faculty), but he kept him at a distance. Schiller's poetic works represented to him a world of unruly passions, something that he believed he had surpassed in his own writings, and Schiller's aesthetic works and literary essays seemed to him to reveal a certain hostility to his poetry. Schiller, on the other hand, had already made several attempts to enter into Goethe's circle.

According to Goethe's account, at the doorway they struck up a conversation about the lecture. Schiller remarked, in a way "very welcome" to Goethe, that "such a fragmented way of treating nature" could have no appeal to laymen. Goethe responded that it was strange perhaps even to initiates, but that there might well be another way of "not taking up nature separately and in isolation, but instead representing it at work and alive, striving from the whole to the parts." The conversation continued as they walked. When they reached Schiller's house Goethe decided to

4 "Erste Bekanntschaft mit Schiller"

accept an invitation to continue the conversation inside. There Goethe described for Schiller his understanding of the metamorphosis of plants, the process of growth and emergence of the whole of each plant and also each of its parts by the variation and transformation of a basic, typifying component. With a few strokes of the pen, says Goethe, he made

[...] a symbolic plant emerge before his [Schiller's] eyes. He listened and looked at all that with great sympathy, with decided power of conception; but when I had ended, he shook his head and said: that is not experience, that is an idea. I stopped short, rather irritated: for the point that divided us was thereby marked in the most rigorous way[...]

I pause in the narration for a comment. At this moment the discussion was headed for breakdown. A full-blown querelle could easily have developed, had either man been so inclined. Irritated as he was, however, Goethe says that

I gathered myself and responded: it is very agreeable to me that I have ideas without knowing it, and in fact see them with my eyes.

Schiller, who possessed far more commonsense, shrewdness, and good manners than I and who also, because of the *Horae*, which he was about to publish, wanted more to attract than repel me, responded to that like a well-schooled Kantian; and as there arose out of my stubborn realism many opportunities for lively contradiction, it was hard fought, [but] finally we came to a stop; neither of us could consider himself the victor, both of us considered ourselves unconquerable. Statements like the following made me really unhappy: 'How can experience ever be given that should be appropriate to an idea? For exactly therein lies the proper character of the latter [of the idea], that an experience can never be congruent to it.' If he considered to be an idea what I called experience, there had to be something mediating between the two somehow, something relating them.

And thus "the first step was done." In a moment of ethical graciousness and openness to one another, rather than a querelle the two created a common ground upon which a relationship could be founded—a relationship that, as it turned out, decisively shaped German and European Classicism.

Let us restrict our focus to the matter at hand. Schiller, speaking as a Kantian, says that the *Urpflanze* is an idea, whereas Goethe insists that it is something that he can see. Goethe describes the *Urpflanze* as though it were directly experienced—to speak with Kant, a matter of aisthesis--whereas Schiller describes it as a product of reason in its search for a unity of understanding.⁵

It was more than five years since the disagreeable exchange with Knebel. In the interval Goethe had had many conversations about science that failed to arrive at agreement. In particular, he had discussed his *Farbenlehre* with physicists and other scientists. They judged his *Beiträge zur Optik* to be a lucid and careful presentation of many phenomena of the refraction of light, and his more recent work on colored shadows and the physiology of color aroused mild interest, but for the most part they told him that the phenomena were already well known, and that it was a misunderstanding on his part if he thought they refuted Newton in any way. Schiller's reaction to

⁵ The common ground was in large part Kant. Schiller, of course, had just completed his letters on the aesthetic education of man, which elaborates a theory of beauty as having a dynamic power that perfects the practical use of reason. It is less well known that Goethe had intensively studied Kant's *Critique of Pure Reason* and *Critique of Judgment* in 1789-1791, precisely in a period when he was wrestling with questions of scientific method.

the *Urpflanze* touched on many of same issues, at least in principle. In both cases Goethe was showing something from which he expected his audience to see immediately the desired conclusion: in the one case that the Gestalt displayed by refractive phenomena was other than what Newton's theory required, in the other that the Gestalt of plant growth and development is perceivable in the form of the *Urpflanze* (without the appendix of a negative conclusion about another theory). Schiller admired the idea, but as an idea, not as a phenomenon; the physicists admired the presentation of the phenomena, but saw no unity or Gestalt that required any criticism of Newton. Both audiences distinguished what is perceived from what is ideated in a way that dissatisfied Goethe.

Is this not evidence that the great poet, enchanted by sensuous immediacy, confused seeing and thinking? The conventional historiography about Goethe believes this to be true. But the claim is absurd. It implicitly appeals to a typology of human nature—poets are one way, scientists another—simpleminded and naive. There is no single poetic type, no single scientific type.

But might it not still be evidence of Goethe's philosophical naivete? Goethe himself, after all, wrote that he did not possess "an organ for philosophy." We should keep in mind, however, that his standard of what having an organ for philosophy meant was decisively shaped by his personal relationships with men named Fichte, Schelling, Hegel, and others—and as well by his intensive study of Kant. Goethe had no organ for philosophy as system, but he was more than capable of thinking problems through philosophically, especially when they were related to the practice and theory of science.

Certainly, however, the passage is evidence that Goethe needed to refine his understanding of the relationship between perception and conception in the sciences? Yes, that is true. Still, Goethe was no naif, nor was he in need of elementary instruction about the differences between aisthesis, understanding, and thinking for Kantians (see footnote 5, above). But Goethe's description of the *Urpflanze* episode, written in 1817, does remark that he was stuck in a hyperrealistic phase of his thinking, which is to grant retrospectively that Schiller was not entirely wrong in his objection. Indeed, it was the intellectual exchanges with him over the next few years that clarified for Goethe that perception has to be accounted for as a dynamic relationship contributed to both by the perceiver and the perceived. And eventually he would persuade Schiller that there was something to his realistic insistence that the Gestalt exhibited by the phenomena is not an idea pure and simple. Between sensation and conception there was a world to be explored and put into natural order.

5. In Rome Goethe had joined a community of German expatriates, mostly painters. In discussing with them the practice of drawing and composition he quickly gained insight into the kinds of rules and principles they followed, but as for color there was little they could say. He got the impression that physics might have something to contribute to understanding color, however, so he resolved to take this up when he returned to Germany. Probably in 1789 he read the chapter on optics in a German physics text (he also recalled having heard about, but never seeing, the Newtonian experiments at university), but the book did not address principles of relevance to the arts, so he decided to see the phenomena for himself. He borrowed lenses, prisms, and other optical equipment to perform the experiments. Other work intervened, however, so the package lay unopened. Many months later the owner (Hofrat Büttner of the University of Jena) urgently

requested their return. Almost on impulse Goethe decided to tear open the box and at least examine the equipment for a few minutes. It was being stored in a room newly painted white and still empty of furniture. He picked up a prism and looked through it. He was surprised to see no colors, only a now-blurred white wall. Colors showed themselves only where there was some mark or contrast, like the window frames. Where there was contrast some colors appeared, but usually only part of the spectrum, and never the spectrum as the scientific text had presented it. In what Goethe later called his fundamental aperçu, he exclaimed to himself that Newton must be wrong. Thus, it seems, Goethe's physical study of color started in, if not a polemical mode, in one that was oppositional and controversial.

It has been traditional in the secondary literature—even during his lifetime—to claim that this episode indicates Goethe's complete failure to understand Newton's theory. That traditional claim usually has added to it the reflection that Goethe was prepossessed in favor of the notion that white light had to be physically simple because it was phenomenologically simple. Added is a third claim: that as poet he was prepossessed by sensuous immediacy, the surface appearances of things, so that his rebellion against the Newtonian theory is, in the last analysis, to be explained by the fact that he was a poet. What is more, poets are children of imagination, whereas scientists cultivate a rationality that constantly tests itself against hard facts (which are not to be confused with the sensuously immediate). And with these four claims the need to look into the matter any further is done.

All four of these claims are false. I have already said a very few words about what is wrong with (3) and (4), that is, with labeling Goethe 'poet', contrasting poets with scientists, and allowing the inevitable conclusion to draw itself.

Ad (1): Any misunderstandings Goethe might have had of Newton's theory were probably acquired from the textbook he had consulted; besides being sketchy, as the condensed form of textbooks requires, many of them had significant, and even ludicrous, errors. The one that Goethe is most likely to have used falsely says that when one performs the prism experiments according to Newton's most exacting standards one will see seven perfectly separated circles of color. Goethe expected refraction to decompose white light into colors. When he looked at the white wall, however, there was no decomposition into colors at all, except where there was a boundary. At this point Goethe justifiably did what anyone who understands *modus tollens* will do—for example, all followers of Karl Popper—and said that the theory, at least as he had been brought to understand it, was disconfirmed.

Ad (2) There is nothing about Goethe's past that should lead us to think that he was prejudiced against Newton's theory or prepossessed in favor of the simplicity of white light. He was perfectly ready to accept the experimental verification of the theory he had read about. But what he actually saw surprised him. Although it is true that in short order he arrived at the conclusion that white was simple, that conclusion derived from the fact that the textbooks, and even Newton himself, as Goethe discovered later, described the phenomena of refraction partially and tendentiously. Most important of all to Goethe, Newton and Newtonians failed to give a comprehensive accounting of the conditions necessary for the appearance of color. The facts were wrongly, or at least inadequately, described, precisely because the elements of the experimental phenomenon were not comprehensively given.

It is with this question of comprehensiveness that we must remain for a few moments, before we proceed to the third and fourth claims of the traditional interpretation of Goethe's so-called mistake. In the first and second installments of the *Beiträge zur Optik*, Goethe presented a very detailed set of variations on experiments using prisms. His goal was comprehensiveness in two senses: a comprehensive enumeration of the elements or factors that are required for the appearance of refraction colors, and a comprehensive set of variations of each of these elements to determine how their variation affects the appearances. Unlike Newton, his preferred first approach to refraction involved looking through the prism (so-called subjective experiments) as opposed to projecting a spectral image on a wall or screen (what he called objective experiments), although he performed both kinds and intended in the continuation of the series of *Beiträge* to show the close correlations between the subjective and objective approaches.

What he takes great pains to show is a development of the *aperçu* he had in his newly painted room: that refraction produces colors only if there is a boundary; furthermore, the colors that appear at a boundary depend on the orientation of the prism. If you look at a white square on a black background with the refracting angle of the prism pointing downward, you will see red and yellow appear at the upper edge of the square (the red above the yellow), and at the lower edge of the square you will see blue and violet (with violet below the blue). The central portion of the rectangle will still appear white, but the white area will decrease in size as you increase your distance from the display card, substitute narrower rectangles, or use a prism with a greater angle of refraction. At the point when the advancing yellow touches the blue advancing from the opposite side, the image will quite suddenly turn green in the center, and the green area will grow larger as the rectangle gets ever narrower or the distance from the display greater. Gradually the blue and the yellow areas will be reduced, until finally all you see is a spectrum of red, green, and violet.

Professional scientists told Goethe that these phenomena were already well known and that they were perfectly well explained by Newton's theory. Neither of these assertions is fully true. Although most of these scientists were professedly empiricistic and inductive in their conception of method, they were convinced that Newton's theory had been proved in a practically perfect empirical induction. Unfortunately Goethe was not, in the early 1790s, in a position to clarify for his physicist friends all the phenomenological, experimental, methodological, philosophical, and historical issues involved. As Goethe remarked in his narration of the *Urpflanze* conversation with Schiller, he was still thinking in terms of a rather crude realism that it would take several more years for him to abandon, as he discovered the essential contribution of the constitution of the eye or visual system to the perception of color and as he intensively discussed methodological and conceptual questions with Schiller.

Let me now point out just one elemental problem that the phenomena of the *Beiträge zur Optik* pose to Newton's theory. According to any reasonable interpretation of that theory, the more perfectly you separate white light by refraction, the greater the number of colors you ought to perceive. Although Newton in describing the spectrum usually spoke of five or seven colors, in principle the hues are innumerable. What Goethe's experiments show, however, is that the number of colors you see is quite limited—the fields of red, yellow, green, blue, and violet are relatively uniform in hue—and that when you perform the experiment so as to, in Newton's conception, more perfectly separate the rays, you see fewer and more uniform expanses of color rather than an ever more finely nuanced variegation of colors—ultimately just three uniform patches of violet, green,

and red. This is a fundamental incommensurability, an anomaly between the prediction of theory and the outcome of experiment.

If you are thinking that such experimental phenomena are hardly an overthrow of Newton because we have not taken into account the intensity of light and the response of the eye to different colors, your thoughts are ultimately of the utmost importance but hardly germane to the immediate point. With regard to Newton's theory of white light and colors, these further considerations—especially that of the eye's response to different colors—would be ad hoc hypotheses added in order to save the theory rather than the phenomena. With regard to the future of the science of color and Goethe's future research such additional considerations were extraordinarily important. What we must keep in mind in judging the reasons for the polemic is this: that Newton had not investigated the way in which the eye detected colors, and neither had any of his followers before Thomas Young in the first decade of the nineteenth century. As far as he and his theory are concerned, the eye is a passive detector of differences in color-producing tendencies of light rays. Neither Newton, nor Newtonians, nor other investigators of light and color seriously looked into the possible contribution to color perception of the physiology of vision. Goethe was only beginning to see the importance of these things as he tried to complete a third, never-published installment of the *Beiträge* on colored shadows in 1793. As Goethe later confessed, he had simply added to the confusion when early on he thought that what he was doing was chiefly a contribution to optics; it was, instead, a contribution to chromatics, to the science of color. Yet insofar as Newton inextricably entwined chromatic with optical issues, he committed an error that adversely affected physical optics and inhibited independent developments in the study of color.

Note that at this point I am making no appeal to any positive theory of light and colors that Goethe may or may not have held. What is at issue is the simple question of whether Newton's accurately and comprehensively described what is observed, not just in one or two or three specially selected refraction experiments but in a survey as comprehensive as possible of conceivable variations on the basic experiments he privileged.

4. The first two *Beiträge zur Optik* were intended to show how to produce a superexperience of refractive color, based on the creation of a superexperiment. Any particular phenomenon of refractive color would thus be a specific experience of a specific experiment, both of which could be located as one possible position or value within the field of the superexperiment.

What do I mean by the terms 'superexperiment' and 'superexperience'? It is something fairly simple that involves an elaboration of what Goethe understood by an *Urphänomenon*. Think of the basic refractive experiment from Newton's earliest statements of his theory: we close off all light sources in a room except for a small hole (say about 8 mm) in the window covering that admits of beam of sunlight, this beam is refracted by a particular glass prism (with a refracting angle of about 60 degrees) about 10 cm from the hole in the windowshut, the refracted light travels to a screen about 7 meters distant, where we observe the pattern it creates as so many centimeters high and wide. All the particular specifications can be varied by changing the initial conditions. We can make the hole larger or smaller, and we can change its shape; we can use different light sources; we can use prisms made of different materials and different refracting angles, and we can place it at different distances from the hole; we can rotate the prism back and forth so that the angle of incidence changes; we can vary the distance to the screen. We can also do similar sorts of

experiments with similar variations, with the difference that we look through the prism at the light source (or at a white figure on a contrasting dark ground). The total of all such possible variations is the superexperiment; the experience and understanding of any particular experiment as a single possibility of specified conditions is the superexperience.

In essence the *Beiträge* identified the main features of Newton's experiment and subjected them to this kind of variation. Goethe's aim was to relativize the value of any single prism experiment, including the specific ones that Newton chose. If Newton's theory was perfect it would account for the superexperiment as a whole, in all its possibilities; if less perfect, for only some conditions in limited variation.

The kind of superexperiment Goethe produced in the *Beiträge* was not anything entirely new. It derives from the method of dynamic observation that he had already used in his study of the intermaxillary bone and the *Urpflanze*, now applied to the conditions of physical experiments. With the intermaxillary Goethe invited the reader to consider the bone as it appeared in the course of development of a single organism, as it appeared in relationship to the variations in appearance of the animal, as it appeared in relationship to the life functions (like eating, gnawing, and ruminating) that it supported. Goethe's aim was to view the bone in sequences or series of variations. Only a person with practice in this dynamically sequentialized seeing would be able to answer such questions as whether the intermaxillary was present in humans. With the *Urpflanze* it is dicotyledons that are presented in a dynamic sequential comparison, beginning with the typical forms of development in individual plants. The evocation of the *Urpflanze* is, of course, methodologically more ambitious than the demonstration of the human intermaxillary. There was little doubt in most cases that the intermaxillary bone was present; only extreme cases presented a problem of identification. With the *Urpflanze* the first goal was to see the development of each kind of plant as a set of variations on the form of a single unit or organ, and then to gain from those experiences insights about the development of a typical dicotyledonous plant, of the plant type, the *Urpflanze*.

At the end of the second installment of the *Beiträge*, in a section titled "Nacherinnerung," Goethe claimed that all the experiments (*Versuche*) of the first two installments were derived (*sich ableiten*) from a single experience (*Erfahrung*): that of the emergence of the colors from the boundaries of the object viewed through the prism. He then says that the manifold experiments of his work are related to the single experience—what I have called the superexperience—as all the varieties of calculation are related to a single formula, or as all the behaviors of magnets are related to the fundamental fact of magnetism—that every magnet has two poles, each of which is attracted to its opposite and repelled by the same. His goal is to find such a simple, unchanging law. And he makes a claim that is of considerable methodological importance: "Such a law can be found, made clear, and applied in a thousandfold way, without choosing or venturing a theoretical type of explanation [*theoretische Erklärungsart*]" (LA I, 3: 51).

What Goethe is suggesting here is in essence the conception of method he presented in his second response to Knebel's studies of ice formation. The proper relationship of observation to theory required three stages. Science is built on (1) the careful gathering and securing of observations; (2) the organization and ordering of these the most closely related observations; and (3) the application of hypotheses or other kinds of imaginative schemes for bringing the organized observations into connection with more remote phenomena. This schema was developed at greater

length in the methodological essay that he wrote upon completing the first two installments of the *Beiträge zur Optik*, “Der Versuch als Vermittler zwischen Objekt und Subjekt.”

What Knebel had done was to move quickly from stage one to stage three, without taking sufficient care of the difficult work of organizing multiple observations into relevant and coherent superphenomena and types. We can see now that Goethe considered the *Beiträge* (and presumably his other scientific work as well) as concentrating on the tasks of stages one and two, and leaving stage (3) to the future. From his criticism of Newton and Newtonians it should be clear that at least at this point in his career Goethe thought that they had made the same leap of Knebel. They had carefully observed specific experiments—that is, they had performed task (1). But they skipped the work of task (2): they had not related those experiments to other, closely similar ones that nevertheless displayed significant variances. Instead, they leaped to the imaginative schema of differential refrangibility according to rigidly fixed color. Before speculating, before resorting to imaginative hypotheses like differential refrangibility, they should first have secured a comprehensive basis for their science in superexperiments, experimental types.

This is, I believe, also the solution to what Goethe was upholding in his resistance to Schiller’s claim that the *Urpflanze* was an idea. The issue can be reduced to this: is the superexperiment and the superexperience an idea or is it seen? Is the basic refractive experiment, analyzed into its basic conditions and varied, ideated or seen? The fact is that after you spend time viewing the experiment evolve as a screen is moved closer or further from a prism, after you increase and decrease the size of the aperture, after you substitute one after another prisms with increasing and decreasing refractive angles, it does not make much sense to say that you have merely developed an idea. It is certainly not an idea in the sense that it is an idea to think that there are innumerable particles flying through the air and being refracted to different degrees according to differences in properties that also lead to colors. The superexperience seems closer to the individual experiment than to the hypothesis about the microscopic nature of light. Similarly, a botanist who has watched thousands of dicotyledons grow in the most varied circumstances has an understanding of dicotyledon development not as mere abstraction but as something experienced.

6. In all his major publications on science, Goethe’s chief aim was methodological. Accordingly, in the *Beiträge*, his principal, but implicit, criticism of Newton and Newtonians was that they had failed to comprehend the phenomena, to survey them comprehensively. Rather than provide a thorough acquaintance with a realm of nature, they selected a few experiments that flattered their imaginative-speculative hypothesis. The middle stage of good science had been neglected, and that meant that both that the shortcomings of the theory were overlooked and that other approaches required for an adequate grasp of the phenomena of color were ignored. If you leap over stage two you put yourself in a situation where the imaginative construction—we would say the social construction—of reality becomes almost inevitable. Omitting stage two leaves a gap between facts and theories, in fact creates the gap between them. The facts have to be contextualized in relationship to one another in superfacts—the superexperience of the superexperiments and superphenomena—before one introduces speculative hypotheses.

In the early 1790s Goethe’s historical studies were not far enough advanced for him to gain sufficient insight into the reasons for the unwillingness of physicists to reexamine the basic phenomena of color. Gradually he recognized two sources: the politics of the scientific community,

and the existence in human beings of different tendencies of conception, or ways of conceiving things, *Vorstellungsarten*. In elaborating his understanding of these sources Goethe became the greatest of the nineteenth century historians of science, and, I would argue, one of the greatest *simpliciter*.

Already in 1791 Goethe had begun assembling some of the most important works on optics and color from the preceding 150 years. It was in early 1798, in conversations and correspondence with Schiller, that Goethe finally worked out in principle the schema not just for the didactic presentation of the phenomena of color but also for the demonstration of how the stages and events in the history of any science become embedded in its theories and approaches.

Elsewhere I have argued that, precisely at the moment when Goethe began to recognize the complexities introduced by the historicity of science, European scientists were headed in an ever more positivistic direction. The building blocks of science were the facts, and they were to be contrasted in dichotomous fashion with hypothesis and theory. Goethe's three stages of method enunciated in response to Knebel already in 1789 make clear that his conception started out as more nuanced than the positivistic view, and became ever more nuanced with the accumulation of experience and historical insight.

Even before he developed his theory of *Vorstellungsarten* Goethe recognized that the sciences need to be organized in a multidisciplinary fashion. That is, for the most part no single discipline could claim to exhaustively study and master any type of phenomenon. It was characteristic of the sciences that they approached things with leading principles, techniques, and hypotheses; but those things of the world in their own right entered into manifold, new, and unexpected relations with other things—especially when we take into account human invention and cultural innovation. He first began developing this kind of interdisciplinarity in morphology. According to a scheme he wrote in 1795, to understand the forms of living things one would need the contributions of natural history, physical theory, anatomy, chemistry, zoology, physiology, and morphology.⁶ (So much for the idea that Goethe was the sworn enemy of modern sciences!) In the case of color he recognized that investigations had to begin with the tripartite division into physiological, physical, and chemical aspects of the phenomena;⁷ that significant relationships to philosophy, mathematics, dyeing and coloring, general physiology and pathology, natural history, general physics, acoustics (for comparative purposes), and linguistics (for an understanding of the nature and commensurabilities/incommensurabilities of terminology) would have to be investigated;⁸ and that studies of the various effects of colors on human beings would have to be undertaken.⁹

The *Vorstellungsarten* presented a yet deeper level of refinement. Even before 1798 Goethe had begun to recognize that the three stages of method could not be kept radically separated. The persistence in the opposition of Newtonians to his ideas and their reluctance to admit to adopting a few of his points made him wonder whether the imaginative-speculative power that he wished to postpone to stage three did not inevitably enter into action already during task two, in which individually ascertained experiments are worked up into coherent types. His historical studies presented a pageant of different approaches to phenomena that he began to schematize into

6 HA 13: 122-123.

7 HA 13: 329-475.

8 HA 13: 482-493.

9 HA 13: 494-521.

Vorstellungsarten, typical human ways of presenting and representing phenomena that affect even the way we see phenomena. Most individual human beings did not possess just one of these types but rather tendencies toward several and perhaps aversions to others. So, to mention just a few of the *Vorstellungsarten*, some researchers are inclined to look to a phenomenon in its genesis; some are inclined to look to it according to mechanical causality; some are inclined to schematize it mathematically; some think we have to look to the matter that is involved. One can rarely rule out any of these tendencies a priori, although they will be variously fruitful, and some are likely in certain cases to produce greater distortion and limitations than others—though they might nevertheless have a certain pragmatic or heuristic value.

Thus Goethe's notion of multidisciplinary had to be further amplified: even within any given discipline there will be differences in approach, not just because each researcher is an individual (we have native tendencies, to be sure, but we are also trained in ways of conceiving things, for example by acquiring a scientific discipline) but even more because different ways of conceiving things will highlight different phenomena, problems, and connections, many of which will have at least an initially legitimate appeal to our attention. Already at stage two of the method he propounded to Knebel one will organize coherent phenomenal wholes according to some *Vorstellungsart*, which is not to be simply identified with any particular imaginative speculation about the interconnection of phenomena but that nevertheless will tend toward some and away from others.

Although it may seem paradoxical that as Goethe developed a more sophisticatedly pluralistic approach to the sciences he at the same time decided to publish in the 1810 *Zur Farbenlehre* a two-hundred-page-long polemic against Newton. Of course the work was not two hundred pages of insults but rather a close reading, analysis, and multidimensional critique of the entire first book of Newton's *Opticks* and its leading ways of conceiving the phenomena. Moreover, the doctrine of *Vorstellungsarten* does enforce a strong element of scientific pluralism, but not relativism, much less cultural relativism. One can still compare the preferred phenomenal organization of a *Vorstellungsart* to that of others, and more importantly to the more concrete experiences and experiments, superexperiences and superexperiments. Claims can still be called accurate or inaccurate, tendentious or dispassionate, fruitful or sterile, probable or improbable, plausible or implausible, even true or false, especially when we are at the level of the first two stages of scientific work. And with Newton's optics he was not ruling out forever an approach or a *Vorstellungsart*, but trying to shake researchers loose from their prepossession with and exclusive dedication to a theory that was rife with problems when its founding texts and experiments were rigorously analyzed and exhaustively compared to relevant experimental types.

A better example of how Goethe's mature conception of the diversity of science should work is manifested by his intervention in the querelle between Geoffroy de Saint-Hilaire and Cuvier that took place in the French Academy of Sciences in 1830. Geoffroy was closer to the kind of morphology that was practiced in Germany and had been profoundly influenced by Goethe's work, so it is not surprising to see Goethe defending Geoffroy. But Goethe was no blind partisan, and in fact what becomes clear from his critique is that he believed each side desperately needed the support of the other, that the concepts used (and in some cases coined during the conflict) needed analysis, refinement, and correction, and that the methods needed to be amplified. In particular, Goethe thought that Geoffroy's stubborn attempt to understand structure apart from function was

misbegotten, and that he needed to acknowledge the central contribution of function to morphological structures, which was a decided superiority in Cuvier's work.¹⁰

Contemporary theory of science, that is, what goes under the name philosophy of science in the English-speaking world, seems to me to be fruitlessly trapped in some of the fundamental dichotomies of understanding from which Goethe was trying to escape. There is still, for example, an overwhelming tendency to dichotomize what is fact from what is concept—unless you are a social constructivist and reduce the former to the latter. The fruitful Goethean middle ground of types and superexperiments is virtually terra incognita. Moreover, one thing that has been almost definitively left out of philosophical accounts is how fundamental it is to science that it is the socially formed yet still personal activity of diverse human beings. In her brilliant study of Goethe and the Geoffroy-Cuvier controversy Dorothea Kuhn argued that already in the 1780s, especially in his drama *Torquato Tasso*, Goethe had begun to conceive human social interactions according to characterology—the logic of personal character—that then is extended to his understanding of the context of science. I would suggest that we conceive this characterology as a branch of moral psychology, to use an antiquated term, and to understand Goethe's historiography as developing the moral psychology of science. Moral psychology, I might remind you, was a philosophical approach to the mind or soul in its ethical aspects that was practiced preeminently in the eighteenth century. As such it was the part of moral inquiry devoted to articulating concepts that allow us to describe and partition the psychological constitution of moral agents and examining normative issues involving those concepts. The *Vorstellungsarten* fall quite precisely under this rubric, and they allow us to understand the interactions of scientists at a level other than that of the bare relationship of facts and theories on the one hand and of merely contingent events on the other. The *Vorstellungsarten* might further allow us to postulate for communities of scientists appropriate norms of totality and comprehensiveness as a kind of regulative idea.¹¹ They could, one might then presume, offer a foundation for a new type of historiography of science.

7. My concluding reflection brings us back to the theme of the conference. Nearly forty years ago Hans Joachim Schrimpf argued that a common set of problems underlay two of Goethe's querelles, his polemic against Isaac Newton and his criticisms of Romanticism in art and literature. He concluded that

[...] two sides of the same historical conflict mirror one another in them....Thus in both cases the same implacability rising to injustice of Goethe, an implacability otherwise so foreign to his nature. In both cases no isolatable special problems, but a thoroughgoing, common concern. We can say, summing up: Goethe's battle against the Romantic subjectivism of inwardness in art corresponds exactly to his resolute polemic against modern mathematical-abstract natural science. The one is the condition of the other. On the one side the evermore desolating "objective" exterior world, deprived of soul and deprived of the sensuous, interpreted by a mechanistic natural science, in which the human being as human no longer finds a home and sees himself robbed of his humanity, on the other side completely inwardized subjectivity that wants to rescue the

¹⁰See Dorothea Kuhn, *Empirische und ideelle Wirklichkeit*.

¹¹ My description is in fact meant to suggest that there is some direct connection to Kant in Goethe's notion of the *Vorstellungsarten*, a connection that needs to be investigated.

*personal, [but] is thereby pushed out of the present, loses the appertaining world, and must end in despair.*¹²

While sympathizing with Schrimpf's claim, I must assert that it is time we abandoned old conceptual habits that inevitably leave us with an exasperated sense of the relationship between Romanticism and the modern sciences. I think that Goethe's critical concern with Newton and Romanticism is much more unified than Schrimpf portrays it. The question is precisely what motivated his methodological concerns in the 1790s: at what point, and how, does one move from what one has experienced to what one imagines. And I would insist here that imagination is precisely the psychological faculty (to use again old-fashioned terminology) that must be invoked. This is not just because among Romantics it was a key, indeed the central, human faculty. Goethe specifically argued that Newton had prematurely allowed the imagination free rein in his optics and color theory; this closely aligns him, in his practice of optics and color theory, with the more general practice of the Romantics. (Note, by the way, that Goethe never made this claim about Newton's mechanics; in fact quite the contrary. So much for Goethe's poetic, sensuous, immediate incapacity to understand the ways of modern science!) In the historical part of *Zur Farbenlehre* Goethe provided a more elaborate portrayal of the *Vorstellungsarten*, in particular his mechanical and mathematical tendencies, as they affected Newton's imagination and conception of color.

We have over the centuries become unaccustomed to associate imagination with mathematics and science. I say this despite the fact that it is possible to find, from D'Alembert to Steven Weinberg, protestations that imagination is far more important in the sciences than most people think. I will make a claim here at the end that I have substantiated elsewhere: before the early modern period it was commonplace to think of mathematics as an imaginative activity, and—what I am sure will sound more controversial to you—it is precisely Descartes who proposed a modern approach to mathematics, in what we call analytic geometry, which he introduced as the most rigorous use of the imagination ever conceived or practiced by human beings. In the course of the centuries since then, however, and especially since the eighteenth century, the practice of mathematics and its application to physical science has been more commonly conceived as one of the basic forms of rationality.

What we have here is a case of a fundamental but unanalyzed historical shift in a tacit but nevertheless effective moral psychology. I believe that it is precisely our centuries-long unwillingness (or inability?) to think through the consequences that has left us at a philosophical deadend.

To his poet and artist friends Goethe always gave the injunction: "Study nature!" Goethe knew that the Romantics failed to heed this, that they heard the siren's lure of imagination toward infinity and toward the conception of the human being as proportionately infinite and therefore able to emulate, even surpass nature through imagination. I will therefore end with an extraordinary claim about Newton, the Romantics, infinity, and imagination, a claim that I do not wish this audience to take as Goethe's but as my own. In responding to the infinite aspirations of imagination the Romantics were only exaggeratedly following the example laid down by Newton in the ambitions of his mechanics and the famous *Queries of the Opticks*.¹³ They rushed from stage one,

¹² 81-82.

¹³ But not of Descartes, who understood the essential finitude of human being and thus is closer to Socrates and Goethe than to Plato and Newton.

the fragmentary intuition of basic experiences, to an inflated stage three, the achievement of infinity in subjectivity. If I am right—though I have only suggested, not demonstrated, it here—Newton was the first great Romantic thinker. I am not sure that Goethe would agree with this conclusion in its generality of scope. Yet I believe that, on the basis of his characterology, his moral psychology of science, he would understand the point as something arguable.