"Tropes of Transition in Goethe's History of Science"
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Goethe's history of science can be gleaned from writings spanning most of his adult life (1749-1832), although in their most concentrated form they come from the two decades following the French Revolution, from 1790-1810. This period of his mid-life marks a transition in his career from that of the literary celebrity with a position as a court administrator in the small duchy of Saxony-Weimar, to one of a leading intellectual of Western civilization visited by none more prominent than Napoleon. Those of you familiar with his biography will recall that, at the threshold of this period in his life, he had left Weimar for a two-year sabbatical in Italy (1786-88), a leave of absence in which he discovered that he truly was not an artist, that he was a poet with both a practical and romantic bent in his view of nature.

As an administrator in this small principality of central Germany, his supervisory roles had been increased to include projects in civil engineering, in road maintenance, in military budgeting, in mining ventures, and to sitting on boards of universities and museums, at the same time retaining his original assignment to lead cultural life in Weimar. It has not gone unnoticed that his trip to Italy was sparked by administrative overload, along with a social life and personal relationships that had become complicated. Nor has it gone unnoticed that the crisis in his life paralleled the one in Western civilization itself, a watershed by no means unique to the biography of Goethe. In Goethe's the shift was marked most visibly in 1789 with publication of *Egmont. A Tragedy in Five Acts*, (Egmont. Ein Trauerspiel in fünf Aufzügen, WA,I,8, 171-305),

a play about a hero who died in the cause for freedom, and than in 1790 with the first printing of *The Metamorphosis of Plants* (Die Metamorphose der Pflanzen, LA,I,9,23-61), a demonstration of continuity in growth and change, of natural transitions and progression in organic life.

This period of Goethe's mid-life from 1790-1810 is considered by some a dormant phase of his literary career. And indeed it is, by measures of the literary critic. But as Goethe observed from his study of medieval science, the seed, too, is part of plant life (LA,I,6,83). And the seeds of the second half of Goethe's life were his studies in science and history.

Goethe began the last decade of the eighteenth century developing a morphology of organic life, a field of science that many still consider his conception. And while he retained interests in the metamorphosis of plants, insects, vertebrae, and other forms of life, he quickly moved to another field of interest to him, colors; but it was this field that drew him from inspired to rational science, that trapped him in the optics of the Newtonian paradigm, and over the course of the next two decades gave urge to a new inspiration, to study of the history and sociology of science.

Goethe explained in the "Confessions of the Author" (Konfession des Verfassers, LA,I,6,412-29), which he appended to his *History of Color Theory* (Materialien zur Geschichte der Farbenlehre, LA,I,6), that he had came to the study of colors from art and that, what he had found was not color theory but optics, and this practiced in every institution and by every physicist according to Newtonian experiments and conclusions. In 1791, still rather naive to the forces of scientific authority, Goethe rushed the first results of his *Contributions to Optics* (Beiträge zur Optik, LA,I,3,6-53) into publication, beginning a project that did not end until twenty years later, in 1810, when he published his work *On Colors Theory* (Zur Farbenlehre, LA,I,4,5,6), in three volumes, one on the didactics of his theory, another with his disclosure on

Newton's theory, and a third on the history of color theory.

Goethe's research on optics and color theory forms the fourth and last field of inquiry to which he devoted significant effort and from which he derived recognition in the scientific community. The first, his study of granite, and the second, the intermaxillary bone in the human jaw, were inspirations from projects done in service to the court of Weimar-Saxony. While these pre-sabbatical writings are still considered serious scientific work, they are distinctively different in that Goethe does not seem to have had a clear conception of his audience. They were inspired, much as were his poetic writings, although many of the stylistic and narrative features of this early work in geology and comparative anatomy also surfaced in his classical scientific writings, in botany and optics, and then later also in his history of science.

In his color theory Goethe followed the pattern of other scientific writings by framing the text in a context, and by clearly including but distinguishing the author and the relationship of the subject and object, of the author-object in the narration of the project. Also, the search for nature's junctures continued to be a central theme in his effort to present a complete topography of the phenomena under investigation, in this case of the different types of color phenomena. Indeed, at this point in his career, at mid-life, and in the fourth field of study, in his research on color theory, the focus on boundary experiences became a blinding preoccupation, one in which the errors of a significant part of his optical studies is grounded. Yet, it is at the same time this penchant for observation of phenomena in the making, of items in process and development, that inspired him to research in the history of science before the discipline existed. In fact, Goethe himself recorded the anecdote that inspired his polemics with Newton and his history of science, and ironically, the source used today to explain the origin of his errors in physical optics.

In true romantic style, Goethe located the infamous anecdote in the final chapter of his

three volumes *On Color Theory* as the "Confession of the Author" (LA,I,6,412-29). From it we learn that Goethe, one day by chance early in the 1790s, happened to "quickly glance through a prism" (geschwind durch ein Prisma sehen, 419), rather than letting light fall through it in the manner of standard prismatic experimentation. This serendipitous event, with both fortunate and unfortunate results, explains the direction of research in his *Contributions to Optics,* where he recorded his first experiments with the prism. These are all organized around procedures in which the subject looks through the prism: "One takes the prism, observes the objects of the room and the landscape through the same" (Man nehme also zuerst das Prisma vor, betrachte durch dasselbe die Gegenstände des Zimmers und der Landschaft, LA,I,3,17). And from this primal act followed the observation fundamental to his theory of colors, namely, the observation that no matter what the position of the prism, everywhere there are bright colors, especially "at the horizontal edges" (an horizontalen Rändern, p. 8) of small objects. Thus, early in his research on optics he came to focus on the borders, on the juncture where darkness and light meet, where colors emerge, namely, at an intersection of polarities, that point where nature is in tension, dynamic and energized.

The search for boundary experiences is basic to Goethe's scientific approach, as are the tropes of transition to his scientific narration. In his view the scientist's main task is to re-present nature, and to do so is to find the real joints, those borders where organic structure is dynamic, in change, where it is kinetic.

Goethe's first lessons in writing tropes of transition came in his nature poetry where he passionately included himself in the narration, and then distinguishing himself, the author, from nature, the object of the poem. Commanding a narration that recognizes subject-object relationships and at the same time re-presents nature is nowhere better illustrated than in a poem

from 1775 called "On the Lake" (Auf dem See, WA,I,1,78), where he is rocking with the waves in a boat off the shore of a lake in Switzerland. The opening lines show how nature nurtures his soul, and in the transition stanza, a pair of rhyming couplets located between two sets of eight-line stanzas, he refers directly to the organ of observation, the eye, asking why his own are sinking, lulled into a dreamlike state by the rhythm of the waves. In the second couplet he answers his own question, shedding the golden dreams and recognizing a new presence in life at hand. The second stanza of eight lines then offers a discriminating description of the lake and the shore, making clear the transition from inspired to critical experiences, at the same time reflecting the maturing mind of the observer in the boat: "And in the water mirrored / The fruit is ripening" (Und im See bespiegelt / Sich die reifende Frucht, trans. Middleton, 1983; WA,I,1,78).

But it was not poetry alone that offered lessons in writing tropes of transition. In his first scientific essay "On Granite" (Über den Granit, LA,I,1,57-63), he began by acknowledging his enthusiasm for the subject, at mid-point in the essaying quitting the hymn to nature, in the transition paragraph telling his audience that he is returning to his "study" (Studierstube,p. 60) where flights of the imagination will stop. Then in the second half of the essay the reader gets a review of the literature on granite from ancient to modern writings, a definition of granite as rock consisting of quartz, feldspar, mica, and occasionally schorl, or black tourmaline, and finally a critique of volcanic action as primary in the forces of geological change.

In later essays, basalt received the same attention, especially since it presented a problem for Goethe's theory of granite as a primal rock from which others were formed. In an essay written between 1788-90, he compromised the views of volcanists and neptunists, proposing that basalt was a product of aqueous and igneous action, that it was the creation of a "general volcanic ocean" (Ausgeburten eines allgemeinen vulkanischen Meeres, LA,I,1,190), and that it

came from a "period of hot-melt" (in dieser heissen Epoche, 190). In his view the volcanism-neptunism debate was right and wrong in both directions, and that it was in language itself where the answer lies. He argued that basalt and granite were both forms of lava, and the solution to definitions of he located in terms that admit the transitions between molten and solid states of lava, in the adjectives, granitic and basaltic, terms defining the liquid condition, and in the nouns, granite and basalt, terms denoting the crystallized form of lava. Into old age Goethe sought and labelled transition forms in geology, as late as 1820, labelling the Bohemian mountains of central Europe, where he enjoyed the waters of a health spa, "transition mountains" (Übergangsgebirge, LA,I,2,155), emphasizing that the range was not of pure granite but of variations of the archetypal rock.

The same story could be told for his work in osteology and comparative anatomy where the intermaxillary bone by its very name admits a juncture between structures. Here the challenge to Goethe's language of transition was equally great for not only did he seek to demonstrate the existence of the bone chronologically in the human being, but also diachronically in the human species as well as synchronically across animal species. The problem was that this bone, located between the two canine teeth and holding the four incisor teeth, did not always show clear sutures in adult specimen, especially in the human being. But from embryonic samples and from pathological cases of the hair lip he effectively argued that the bone was an isolated structure in transition. That is, the intermaxillary bone is a tropes of transition, as is the leaf, a concept of linkage in the various stages of plant growth. At every stage, especially in garden varieties, the plant appears as a modification of the leaf, from the pod-like structure of the cotyledons to the oval structure found in the fruits of the harvest, a form particularly visible in the peanut.

In colors, rocks, bones, and plants Goethe searched for the threshold of kinetics, for the real joints of nature, real because here he found growth, change, and transition. At the edges and borders he found action and progression, and this he found also in the history of science, but here he faced a different challenge, for he was a pioneer in a discipline that did not exist. Nonetheless, inspired by his confrontation with the Newtonian paradigm he wrote a history and in the process forged a theory with equal emphasis on re-presentation, symbolization, and concept formation as revealed in the language of scientists.

The lessons Goethe had learned during the first fifty years of his life served him well when around 1800 he began serious work on his history of color theory. But the challenge was greater, not only because the discipline did not exist, but because the evidence was of a different kind. In the study of nature he had found continuity so entrenched that it was difficult to find the joints, but in history the gaps, intermissions, and discontinuities were so great that a narration of re-presentation became one of representation, of symbolization. The relationships and connections between one scientist and the next required more art, more fabrication, and in this sense a different style of narration. The task was different, but the search for borders, thresholds, and linkages remained, as did a narration emphasizing tropes of transition.

Goethe's historiography of science is decidedly logocentric and is located in biographic study of the scientist's personality, character, and way of thinking, and in philological examination of texts, textbooks, handbooks, pamphlets, protocols, transactions, letters, and a broad range of literary genres. It is no small wonder that two of his most important theoretical essays are on "Transmission" (Überliefertes, LA,I,6,88-92) and on "Authority" (Autorität, LA,I,6,92-95), the former a concept explaining the development of a scientific canon, and the latter a concept explaining the development of science as a movement, as a function of schools

of thought.

But Goethe did not come to his theory of the history of science overnight, and he did not do it alone. Mostly he corresponded with Friedrich Schiller (1759-1805) about the organization of his project in chromatics, and mostly he took from him lessons on how to apply Kantian categories of the mind to the materials on color theory for which he was seeking distinctions, borders, boundaries, and thresholds. In the course of his discussions with Schiller, the topic moved from science to the history of science where the most vexing question was whether or not to, and then how to, separate science from history.

At the turn of the century, histories of science, with a few exceptions, were written primarily in the Baconian sense, as narrations of a particular branch of science, like Joseph Priestley's histories of electricity and optics. Or they were written with putative intentions, like those of the Göttingen school of historians of science who wrote histories of physics, mathematics, and chemistry, works that functioned like textbooks on the state of a discipline. In the course of his discussions with Schiller Goethe came clearly to distinguish, with the help of Kantian categories of the mind, the branches of his color theory into physiological, chemical, and physical phenomena, and then to distinguish this from a history organized by a theory of his own making. Bridging the two, then, was his disclosures on Newton's theory, a volume in which polemics functioned as a point of departure, linking two worlds of science, his emerging authority over the Newtonian paradigm, and at the same time bridging the spheres of science and history.

Overcoming disciplinary histories, or as he and Schiller referred to them, histories written apriori, was a major step in Goethe's development as an historian of science. It was a step he took alone, as a pioneer, for Schiller with the tools of Kantian categories of the mind offered

convincing arguments for organizing his project differently, in the more traditional science, so that a history would follow each of the disciplines of physiology, chemistry, and physics. Had Goethe not come upon the polemics of transition and had he not been inspired by the logocentrism of scientific movements, he would not have taken the step to isolate the traditional sense of history from historiography. Nor would he have been moved to define the concept of authority, to organize a history by periods and epochs around individuals who in his judgements served as prototypes of the science of an entire era. But once Goethe's intentions were clear to Schiller, he again served to clarify and advance Goethe's history of science, enthusiastically observing that these distinction show a double gain, for they provide "insight into the phenomenon" (Einsicht in den Gegenstand) and "insight into the operations of the mind" (Einsicht in die Operation des Geistes), in a sense making the historian of science "master over all objects" (um Herrn über alle Gegenstände, LA,II,6,304).

Perhaps nowhere did Goethe apply the tropes of transition more vividly than in his discussion of medieval science, which to him was an opaque period, a lively and dynamic seed bed, but one not yet researched. Acknowledging his own limited resources for bridging the science of the ancient and modern worlds, he filled the space in his history of color theory with statements on historiography ranging from short aphoristic observations to longer pieces such as the essays on authority and transmission. These he introduced by observing that he was taking a cue from the geographers of Africa who filled uncharted areas with exotic figures of tigers and elephants. He did it, he explained, because, like in the theater, the audience should never be left with a gap, with a break in the action.

In many ways Goethe's approach to history was not much different from the way he practiced science. In history the fine line of continuity at times seemed broken, although he

described it as a labyrinthine garden, where entrance, direction, and outcome are not clear from any particular point, although a certain order is everywhere evident. As his guide through the garden, he chose biography for study of the forces of authority, and secondly he looked at the text for understanding the language of science, in combination showing Goethe the path in the development of the scientific canon. Especially the corpuscular imagery could be traced from antiquity to Newtonianism, although other forms of symbolization were also used to explain the phenomena of nature, including mathematical, mechanical, metaphysical, and moral expressions, each of them revealing a penchant of the scientist for a particular way of thinking.

It was from this taxonomy of scientific symbolization that Goethe defined science as a movement, as schools of thought supported by friends, populists, textbooks, professional societies, and by academic institutions. The epoch in his history "From Newton to Dollond" (Von Newton bis auf Dollond, LA,I,6,238-360) illustrated all of this, including the crisis of the paradigm which Goethe located in the discovery of "achromatism" (Achromasie, LA,I, 361-65) in telescopic lens, an event ending the chapter of Newton's authority. With this topic Goethe marked a new era in the history of chromatics, at the same time presenting it as an essay at a juncture introducing the last chapter in his history, "From Dollond to the Present" (Von Dollond bis auf unsere Zeit, LA,I,361-412). In the episode leading to the discovery of achromatic lens, Goethe thought he saw the end to the litany of the guild of physicists who examined colors primarily from the perspective of optics, largely ignoring the physiological and chemical colors, and in his view limiting the field to an authority in crisis.

Goethe's own scientific aspirations were to re-present nature, to symbolize it with a language that focused on the kinetics of organic form. And from this perspective he studied and evaluated texts in the history of science, at mid-life recognizing that a topography of nature

cannot be re-created, that only the illusion of reality can be created. In the introduction to his "History of Science" from 1810 he observed that scientists are usually predisposed to one or the other "way of thinking" (Gesinnung), but that their "individuality" (Individualität), their form of "discourse" (Vortrag), the "peculiarity of the idiom" (Eigentümlichkeit des Idioms), indeed, "the change of times" (Wendung der Zeit, LA,I,6,viii) will modify this predisposition.

In Goethe's view all of science was anthropomorphic, it was not necessarily parochial, but was by definition human. In fact it was much like poetry, an expression of dark subjective feelings about noble appearances of the universe. Indeed, as he observed two years before his death, at age eighty, we tend to praise the anthropomorphisms that surface in poetic language, but ignore them in the sciences: "We think we are speaking in pure prose and are already speaking tropologically, the tropes are applied differently, are used in a related sense, and in this way the quarrel becomes endless and riddle insoluble" (Man glaubt in reiner Prosa zu reden und man spricht schon tropisch; den Tropen wendet einer anders an als der andere, führt ihn in verwandtem Sinne weiter und so wird der Streit unendlich und das Rätsel unauflöslich, LA,I,10,398). This crisis in discourse he observed in the Saint-Hilaire and Cuvier debates in the Paris Academy of Science, but he also saw it in the individuality encouraged by the motto of the Royal Society of London: "Nullius in Verba," I take no man's word (LA,I,6,246). It is no wonder that his theory of the history of science was logocentric, and it is no wonder that his Faust story, completed in the year of his death, came to represent modern scientific man saved by the urge to re-create nature.