

"Goethe's Intensified Border"

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To divide the united, to unite the divided, is the life of nature; this is the eternal systole and diastole, the eternal contraction and expansion, the eternal inhaling and exhaling of the world, in which we live, weave, and move. (Goethe, *Zur Farbenlehre*, 1810)¹

This aphorism on unifying and dividing comes from Goethe's color theory, where he observed some of the subtlest patterns of chaos and complexity in nature. In this context you will notice that Goethe was making a statement about a process of nature, not about an operation of science. There are other versions of this statement from his collection of fragments on science in general, where he said it was a "basic characteristic" (Grundeigenschaft) of a living entity, "to divide itself, to unite, to merge into the universal, to abide in the particular, to transform itself, to define itself, and as living things tend to appear under a thousand conditions, to arise and vanish, to solidify and melt, to freeze and flow, to expand and contract."² In this version Goethe goes beyond color theory to generalize about the complexity of all natural development, in which an entity is defined by images of self-similar structures that are conditioned by varying environments. In this version, he adds randomness to the self-similar forms processed through time and space: "And because all of these effects progress at the same moment, they also can

¹Johann Wolfgang Goethe, "Das Geeinte zu entzweien, das Entzweite zu einigen, ist das Leben der Natur; dies ist die ewige Systole und Diastole, die ewige Synkrisis und Diakrisis, das Ein- und Ausatmen der Welt, in der wir leben, weben und sind," *Zur Farbenlehre. Didaktischer Teil*, Ed. Rupprecht Matthaei, in: *Goethe. Die Schriften zur Naturwissenschaft*, Leopodina Ausgabe (LA), 2 pts., 11 vols. (Weimar: Böhlau, 1947-), I, 4, 217.

²Goethe, "Grundeigenschaft der lebendigen Einheit: sich zu trennen, sich zu vereinen, sich ins Allgemeine zu ergehen, im Besondern zu verharren, sich zu verwandeln, sich zu spezifizieren, und wie das lebendige unter tausend Bedingungen sich dartun mag, hervorzutreten und zu verschwinden, zu solideszieren und zu schmelzen, zu erstarren und zu fließen, sich auszudehnen und sich zusammenzuziehen," in: *Aufsätze Fragmente, Studien zur Naturwissenschaft im Allgemeinen*, Ed. Dorothea Kuhn and Wolf von Engelhardt (LA), I, 11, 357.

each and all emerge at the same time."³

He concludes this fragment on unity and separation by arguing that we must accept "the most particular" (das Besonderste) as an "image and likeness" (Bild und Gleichnis) of "the most universal" (das Allgemeinste, 357), in one maxim without mathematical expression setting forth a view of the world that follows random patterns of self-similar progression through time. How does this actually work in Goethe's narratives? Some answers lie in the way Goethe did science,⁴ and some emerge from the recent science of chaos, where both formal mathematics and computer enhancements recapitulate Goethe's discovery of morphology.⁵

In going back to the first author of chaos theory, to Benoit B. Mandelbrot, we find much that is of Goethe and much that is not.⁶ At a glance we find that Mandelbrot's "fractal geometry of nature" is all about mathematics, and in Goethe we have none, at least of the kind defined by signs, symbols, and algorithms. So where is the connection?⁷ Well, it is in the genius of Goethe's

³Goethe, "Weil nun alle diese Wirkungen im gleichen Zeitmoment zugleich vorgehen, so kann alles und jedes zu gleicher Zeit eintreten" (LA), I, 11, 357.

⁴For a fresh look at the way Goethe did science, see Jean Lacoste, *Science Et Philosophie* (Paris: Presses Universitaires de France, 1997), pp. 15-85, on "La Morphologie."

⁵E. S. Russel, *Form and Function* (Chicago: University of Chicago Press, 1982, 1st ed., 1916), observed that Goethe "seized upon the essential principles of a morphology some years before that morphology was accepted by the workers," p. 45, which Russ Shurig, "Morphology: a Knowledge Tool," *Systems Research*, 3 (1985): 9-19, considers one of the great methodologies next to Aristotle's deductive logic, Francis Bacon's inductive science, Pascal's analytical mathematics, and Leibniz's calculus: "And we may credit Goethe with having founded or at least having resuscitated the morphological approach to discovery and research," p. 9.

⁶Benoit B. Mandelbrot, *The Fractal Geometry of Nature* (San Francisco: Freeman, 1982, 1st ed., 1977), in his chapter on "Of Men and Ideas," pp. 391-424, casts a wide loop of artists, scientists, and mathematicians that have dealt with fractals of nature and the mind, beginning with "Aristotle and Leibniz, Great Chain of Being, Chimeras and Fractals," in the "Epilogue" disclosing his own inspiration for the study of fractals: "This lifetime involvement was triggered in 1951, by a casual side interest in Zipf's law (Chapters 38 and 40). This empirical regularity concerning word frequencies had come to my attention through a book review. . . . I became sensitive to analogous empirical regularities in diverse fields, beginning with economics," p. 422.

⁷Gerhard Schulz, "Chaos und Ordnung in Goethes Verständnis von Kunst und Geschichte," *Goethe Jahrbuch*,

seeing hand, in the fingers of his brain (Figure 1).⁸ Although Mandelbrot and other early chaos theorists recognized something about complexity in Goethe,⁹ it would be an overstatement to say they followed him in some particular technique. Yet, we could say that they simply put into mathematics the same world that Goethe saw and articulated by other mediums.



Figure 1. Goethe as Visual Thinker

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110 (1993): 173-83, looks at the role of "chance" (Zufall) and "order" (Ordnung) in Goethe's theory of history. On these concepts see also, Karl J. Fink, *Goethe's History of Science* (Cambridge: Cambridge University Press, 1991), pp. 66-74: "thus, he argued that history is a product of "law and chance" (Gesetz und Zufall), and that the relationship of the laws of history to the stream of reality are both regular and random, "proportionate" and "disproportionate" (proportionierlich und unproportionierlich, LA,I,6,85), p. 66.

⁸Maurice Merleau-Ponty, "Eye and Mind," in: *The Primacy of Perception*, Ed. John Wild, Trans. Carleton Dallery (Evanston, IL: Northwestern University Press, 1964; 1st French version, 1961), pp. 159-90, writes that "it is no more possible to make a restrictive inventory of the visible than it is to catalogue the possible usages of a language or even its vocabulary and devices. The eye is an instrument that moves itself, a means which invents its own ends; it is *that which* has been moved by some impact of the world, which it then restores to the visible through the offices of an agile hand," p. 159. See also Maura C. Flannery, "Goethe and Arber: Unity in Diversity," *The American Biology Teacher*, 57 (1995): 544-47, who recalls the influence of Goethe on Agnes Arber (1879-1960), who observed the close "association between the fingers and brain" in drawing science, p. 547.

⁹ See James Gleick, *Chaos. Making a New Science* (London: Penguin, 1988), p. 165, 191-97, particularly with reference to Theodor Schwenk, *Sensitive Chaos. The Creation of Flowing Forms in Water and Air* (New York: Schocken, 1976, 1st ed. Rudolf Steiner Press, 1965), who references Goethe's scientific writings but cites only a short stanza on nature revealed through art: "Wem die Natur/ihr offenbares Geheimnis/zu enthüllen anfängt,/der empfindet eine unwiderstehliche/Sehnsucht nach ihrer würdigsten/Auslegerin, der Kunst," p. 80.

¹⁰ The images were made from reprints collected from various archives of Goethe's works, and they have been noted by owner of the original print. All images were reworked in the graphic lab of the author with the technical assistance of Sarah E. Oswalt and the advice of graphics consultant, Janet Collrin, of the Academic Computing

In Goethe's essays, drawings, and poetry, we find linguistic and pictorial narratives of nature that are mathematically described in modern chaos theory, including concepts of the self-similar progressions of life forms, the random modification of living entities in time and space, and the strange attractors of dynamic organizations. Common to both approaches, those inspired by art and mathematics, is the focus on boundaries, on the outer edge of forms, on the logos of the line.¹¹ Here, where we draw the line in the sand between art and science, Goethe was active. Here, where the radical artist floats transitions with ambiguity and here, where the radical scientist catalogs the brute facts that shape our view of life, here at this kinetic juncture of life Goethe focused his investigation of nature with strokes of pen and brush.

The question is how Goethe went about defining and shaping such patterns of chaos and complexity without the mathematical tools of precision used today. The answer, I would like to argue, lies in his discovery of morphology generally, and specifically in his application of graphics to the service of science. He did it by bringing together sharp lines of brute data and ambiguous transitions of forms from one state into another, in other words by focusing on what is called "boundary basins" in chaos theory.¹² It is with an eye for form in motion that he could sketch such junctures and visually define the threshold of change in a dynamic system, and then from such pictorial representation could articulate in words what today seems possible primarily

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¹¹See Maurice Merleau-Ponty, "Eye and Mind" (1964), p. 182.

¹²James Gleick, *Chaos* (1988), writes that "the boundary is where a Mandelbrot set program spends most of its time and makes all of its compromises," p. 232.

in mathematical terms. It is no accident that "Morph," the leading computer software used to make smooth transitions of form, takes its name from Goethe's primary discovery.¹³ The Mandelbrot set, although based in mathematics, also makes use of morphologies of form to create fantastic images of self-similar processes. His sets, like Goethe's forms, can be produced endlessly, as filmstrips of self-similar variation.

As James Gleick and others on the new science of chaos have pointed out, "the boundary is where points are slowest to escape the pull of the set" (p. 232). Each dynamic organization has a threshold, or as Gleick put it, "each basin has a boundary" that is not stable but driven "by competing options" (p. 233). He reports how physicists began drawing pictures of fractal basin boundaries that showed "the border between calm and catastrophe," and when researchers and engineers began exploring this juncture, they would claim to "have no idea what the boundary looks like" (p. 235). These people looked at maps and grids, invented and natural, and as they looked deeper into the details of a threshold they found more random events, "until suddenly, unexpectedly, deep in the heart of a bewildering region, appeared a familiar oblate form, studded with buds: the Mandelbrot set" (p. 236). When we let the computer morph Goethe's illustrations of rocks, bones, and plants, we also see new forms emerge from familiar images, particularly the kind of forms that follow the self-similar patterns of nature rather than the self-same constructs of the mind.

While some let the computer generate its forms, others, Gleick explains, looked at nature's own images and with a mouse in hand, would create self-similar variations in a predictable

¹³*Morph*, 2.5. San Diego, CA: Gryphon Software Corp., 1992-94.

fashion, "just as, when we go into a new room, our eyes dance around it in some order which we might as well take to be random" (239). This, too, is the sort of randomness that defines Goethe's way of doing science. In his experiments he had no formal quantitative procedure for selecting and designing natural processes. Rather he let the eye roam and select the phenomena without intention. And so today by looking at Goethe's artwork, we have the advantage of seeing boundary basins selected and designed by the genius of his seeing hand. The computer lets us make these pictorial narratives, which Goethe could only imagine or describe with words. But how did he come to rely so heavily on pictorial representations of nature?



Figure 2. Instruments of Continuity

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In Goethe's century, received laboratory techniques called for the isolation and reduction of observable phenomena to a single crucial experiment (*experimentum crucis*, LA,I,5,84-85), to a salient moment of the lab experience. This he came to reject early in the mid-life period, in 1793

focusing the criticism in the title to his essay on "The Experiment as Mediator of the Object and Subject" (Der Versuch als Vermittler von Objekt und Subjekt, LA,I,8,305-15). In his view, the experiment was "a mediator of continuity" (Fink, 1991:36) not only, for example, in the serial relations of intermaxillary jawbones among humans and animals, but also in the connection of the observer and the observed, of the subject and the object. That is, not only was Goethe's science anthropocentric, but the experiment itself was designed as a presentation of natural phenomena both immediate to, and distant from, the observer, as in his color theory. Here he begins his study with colors that form in the eye and ends with optical colors that are created with instruments beyond the eye, as illustrated in Figure 2, where Goethe's instruments are shown in a serial progression from those that reflect light to those that study the affects of light in the eye. In essence this is "the romantic experiment," it is the universality of the organism's relations to its environment. And the task of the scientist is to re-present that totality, to re-create a topography of nature, and to do it from the perspective of the human being.¹⁴

Thus, the main task of the experiment as Goethe saw it, was to organize the phenomena of nature as data in serial patterns, in "spheres of things" (Kreise der Dinge, p. 305) from which they are taken. In his view this re-presentation of nature, this organicism, comes much closer to objectivity than does the experiment grounded in theory. And so "the real duty of the scientist" (die eigentliche Pflicht des Naturforschers, p. 312) is to give a holistic representation of nature,

¹⁴ Günter Altner, "Goethe as a Forerunner of Alternative Science," in: *Goethe and the Sciences: A Reappraisal*, Ed. Frederick Amrine, Francis J. Zucker, and Harvey Wheeler (Dordrecht: Reidel, 1987), pp. 341-50, locates this alternative in the science of "ecology," and in the human "longing for greater wholeness," p. 341. For studies that place Goethe in a tradition of romantic science see recent collections of essays by Andrew Cunningham and Nicholas Jardine, eds. *Romanticism and the Sciences* (Cambridge: Cambridge University Press, 1990), and by Stefano Poggi and Maurizio Bossi, eds., *Romanticism in Science. Science in Europe 1790-1840* (Dordrecht: Kluwer, 1994).

even at the risk of becoming repetitive, of creating boring detail. In his sketch of the three laws of plant growth (Figure 3), Goethe defines the spheres, or border basins, that guide his theory that self-similar forms of the leaf follow plant growth from the seed to the fruit. In image "a" he illustrates the symmetry of root and foliage bifurcation, in "b" the compensation of contracted and expanded plant parts, and in "c" the extension of leaf forms from one node to the next. Put into an algorithm for computer graphics, these three laws can produce endless chains of self-similar forms that begin to look like a Mandelbrot set with random buds appearing in various regions.

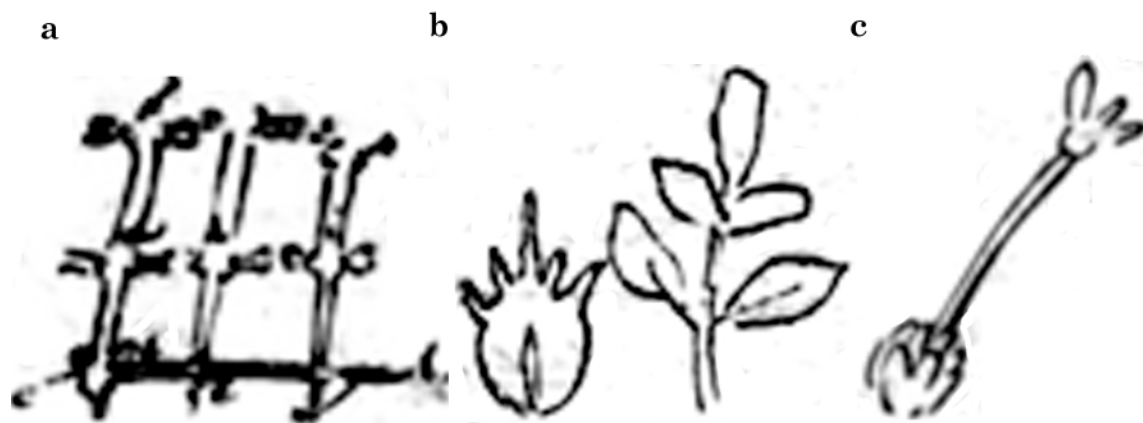


Figure 3. Border Basins in Plant Growth

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Smooth transitions, Goethe argued, are the key to self-similar realization. They depend, he explained, on the type of "demonstration" (Darlegung) and "recapitulation" (Rekapitulation) found in mathematics, which he distinguished from theoretical experimentation that depends on

"arguments" (Argumente, p. 313), such as those used by the rhetorician.¹⁵ In his view the physicist, like the rhetorician, does not seek linkages in nature, rather seeks "completely isolated relationships" (ganz isolierte Verhältnisse, p. 313), which delimit and freeze a phenomenon, and in turn confine and control nature. In autobiographical writings from his post-scientific years, he recalls how he began using graphics to extrapolate forms in motion from images frozen in time and space. It was these experiences that anticipated a gift for visualizing metamorphoses and suggested to him a science of morphology in which form is kinetic.¹⁶

II. Form in Motion

In order to grasp the intention of the Laocoon well, place yourself before it at an appropriate distance with your eyes closed; open them and close them again, and you will see all the marble in motion; you will fear that in opening your eyes the entire group will be changed. (Goethe, "On Laocoon," *Propyläen*, 1798, WA,I,47,107)¹⁷

When Goethe said in the preface to his history of color theory that "Nothing stands still" (Nichts ist stillstehend, LA,I,6,vii), he meant exactly that about everything in nature, culture and history.¹⁸ This statement from 1810 runs like a red thread through his science and poetry, even

¹⁵See Geoffrey Cantor, "The Rhetoric of Experiment," in: *The Uses of Experiment. Studies in the Natural Sciences*. Ed. D. Gooding, T. Pinch, S. Schaffer (Cambridge: Cambridge University Press, 1989), pp. 159-80.

¹⁶See Karl J. Fink, *Goethe's History of Science* (Cambridge: Cambridge University Press, 1991): "That is, the pages of this book are an attempt to shift the focus of Goethe scholarship on those junctures at which Goethe saw growth and change take place; hence, the emphasis is on his tropes of transition, on the language of the intensified middle, on the borders between opposition, for it is at the joints of nature where Goethe discovered the kinetics of life, both in science and in history," p. 153.

¹⁷"Über Laokoon," in: *Goethes Werke*, Weimarer Ausgabe (WA), 4 pts., 143 vols. (Weimar: Böhlau, 1887-1914), I, 47,97-117: "Um die Intention des Laokoon recht zu fassen, stelle man sich in gehöriger Entfernung, mit geschlossenen Augen, davor; man öffne sie und schließe sie sogleich wieder, so wird man den ganzen Marmor in Bewegung sehen, man wird fürchten, indem man die Augen wieder öffnet, die ganze Gruppe verändert zu finden," p. 107.

¹⁸James Gleick, *Chaos* (1988), writes of the legacy of "Goethe's sidelong assault on physicists who, he believed,

through his practical guide to theatrics (1803), where the position of the actor's feet and the gesture of the hands are guided by the anticipation of movement (WA,I,40,139). It is this fundamental principle of life as motion that shaped his studies in morphology, and guided the illustrations that supported his analysis of natural forms as living entities. Without the modern technology of motion picture, Goethe was left to his own devices for showing motion, among them the ambiguous lines of sketches, probably nowhere more often used than in his landscape drawings and paintings. Much of his collected art work is focused on the line, which he presented in mediums that show transition and change, and when reconstructed by the computer demonstrate motion in his concept of morphology.

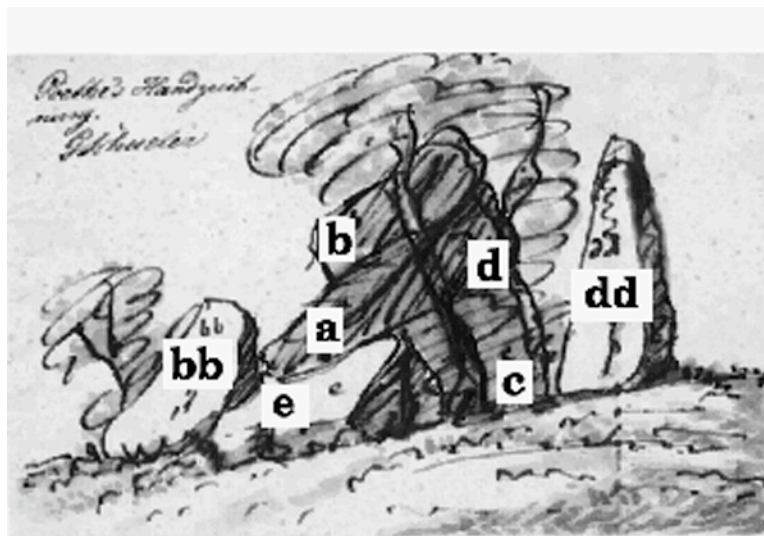


Figure 4. Clusters of Fallen Rock

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worried exclusively about static phenomena rather than the vital forces and flows that produce the shapes we see from instant to instant," pointing out that it inspired among others Theodor Schwenk, who used the term, "sensitive chaos," to describe the relationship between force and form, p. 197.

One of Goethe's first duties as a career administrator in Weimar was to revive the mining industry along the Ilm river valley, where the fossils of stratigraphy and formative forces of geology caught his attention, as did the surface formations of rocks and cliffs that he traced in his many sketches of landscapes. In later visits to the Fichtel Mountains along the German-Czech border these surface formations appeared in more graphic detail as patterns in change and transition, where he observed discrete objects of surface motion, particularly as they appeared in the cluster of boulders lying hard and fast on the Luisenburg at the Spa Alexander near Wunsiedel (Figure 4).¹⁹ Here Goethe labeled each rock with a letter of the alphabet, showing with a double letter the section that fell from its parent at random through time and space.

Still his first clear understanding of the tension at boundaries of competing systems seems to come from his study of "Metamorphosis of Plants" (*Die Metamorphose der Pflanzen*, LA,I,9,23-61). Here through narration and art Goethe moved the shape of a leaf from the seeds under the ground, to the cotyledons at the base of the plant, to the stamens and pistils at the top. Behind Goethe's plates of colored leaves, there are many sketches in which he tried to show the dynamics of plant growth, most of them illustrating his three principles of metamorphosis: bifurcation, compensation, and extension. In Figure 5 we see how he tried to demonstrate the pull of a set in the transition of the leaf-form from the seed below to the cotyledons above the ground. In this filmstrip of transition forms between the seed and the first foliage leaves at the

¹⁹The illustration of "Die Luisenburg bei Alexanders-Bad," done by Goethe in pen and ink, may be reviewed in Goethe, *Die Schriften zur Naturwissenschaft* (LA), I,8,168, Plate VII.

earth's surface, we have marked the five freeze-frames, "a-e," that Goethe drew to demonstrate this controversial surface transition in his theory of plant morphology.²⁰

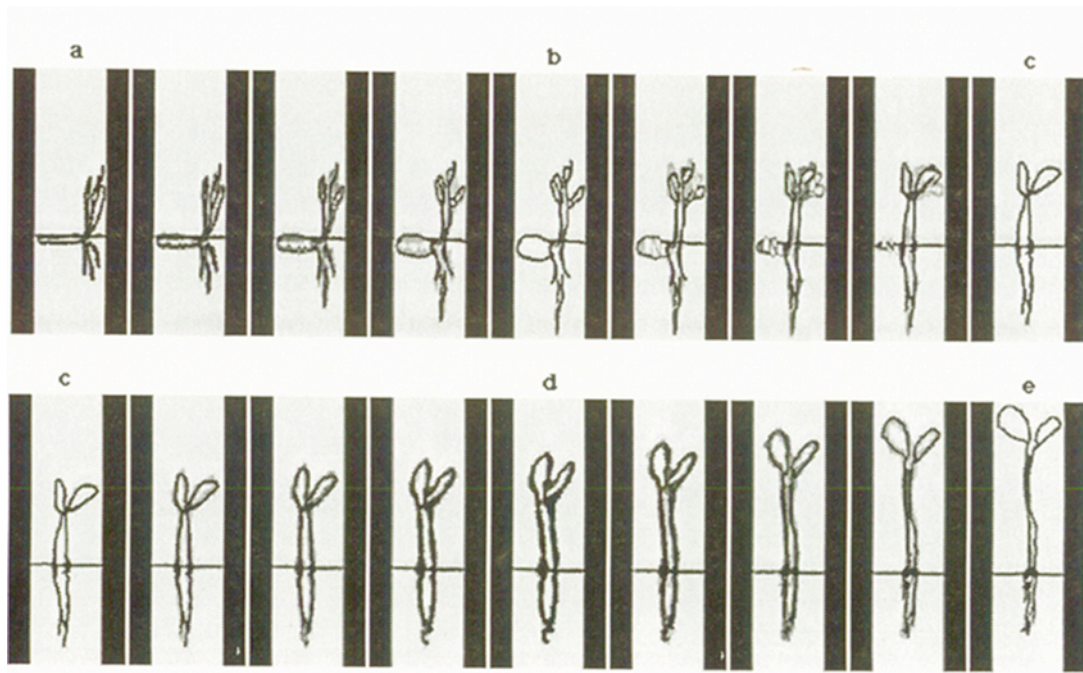


Figure 5. Ground to Surface Root Transition

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In Figure 6, we show a filmstrip of the leaf as it moves through all six stages of plant growth from seed to fruit. Illustrating the dynamics of plant growth by computer focuses all the creative activity of the modern morphologist on the edges and borders of images, at the points of transition, where growth anticipates new forms. To reproduce Goethe's concept of plant metamorphosis, the modern morphologist needs only to set key points between forms and let the

²⁰The sketch of "Die Metamorphose der Pflanzen," done by Goethe in pencil, in 1829 (Femmel, *Corpus der Goethezeichnungen*, 5b, 148), may be reviewed in Goethe, *Aufsätze, Fragmente, Studien zur Morphologie* (LA), I, 10, Plate XXII.

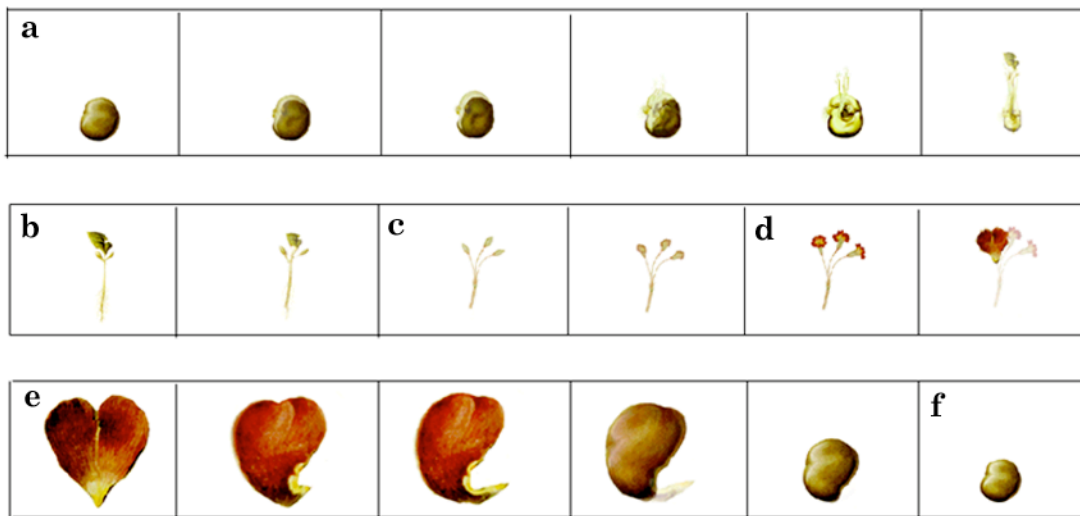


Figure 6. Self-similar Folds of the Leaf

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computer put into motion that what Goethe did with a few freeze-frames and a written narration.

Morphing the color plates of various stages of plant growth involves essentially the same strategies as used in showing surface transitions of the leaf as it rises from seeds to foliage leaves.

This includes setting parameters at key points to maintain horizontal and vertical symmetry as the plant moves through successive stages of growth, which we have demonstrated in Figure 6 with Goethe's freeze frames marked with the letters "a-f."

The filmstrip of plants leaves shows how Goethe's fractals conformed to nature as self-similar variations rather than as self-same patterns guided by the inventions of the mind. The fractals from his color theory also conform to nature as forms in motion, but they are subtler to the eye and often follow the constraints of the mind. Much of his color theory was driven by his observation of objects through a prism, such as the bars in a window frame, where the spectral

colors agreed in number and sequence with the arrangements of his physiological colors. In his theory the spectral colors on a white background intensify from blue and violet on one side and from yellow and orange on the other into red, and on black backgrounds green is the intensified

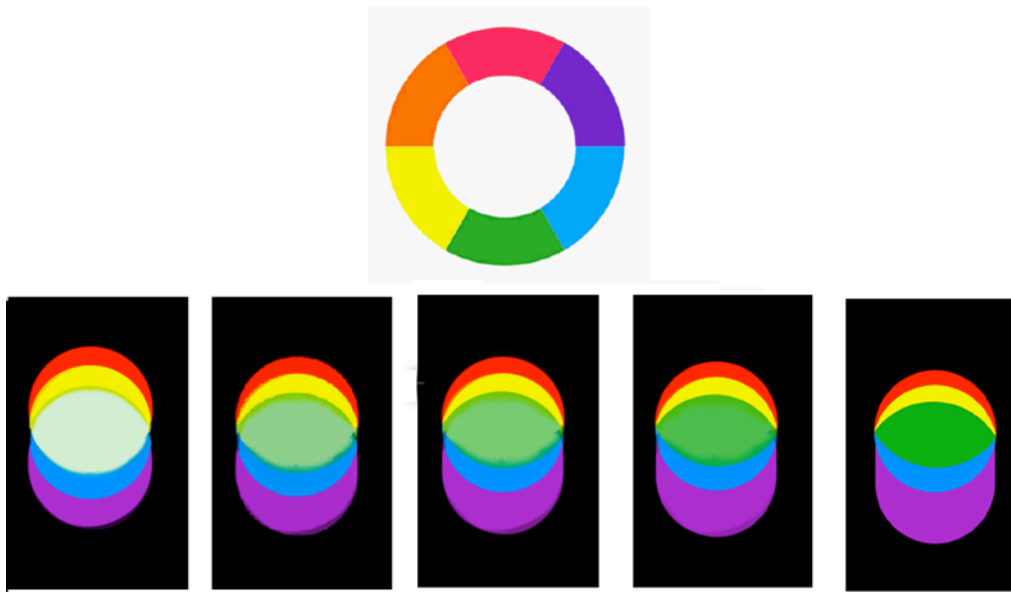


Figure 7. Intensified Color Basins at Green

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border that emerges from orange and yellow on one side and violet and blue on the other. Goethe illustrated this phenomenon in a still image of a circle with an aperture that was half opened, which we closed with a computer model in filmstrips of green at the intensified border between yellow and blue (Figure 7). In this computer version of the spectral progression of solar light, various shades of green emerge, as was imagined by Goethe, between yellow and blue, conforming completely to the complementary pairs in his physiological colors and to the

mixtures in his chemical colors. For Goethe, colors were active, in a constant state of transition. Indeed, for him life was at the edge, at the border of a basin, where the hand of the artist-scientist constructs reality from phenomena that emerge from within themselves to ever new ones. That is, "nothing stands still," but how does this translate into human behavior?

III. Thresholds in Human Behavior

'Forgive me,' said Charlotte, 'as I forgive the scientist, but I would never see a choice here but rather a natural necessity and indeed hardly that; for in the last resort it is perhaps only a matter of opportunity. Opportunity makes relationships just as much as it makes thieves; and where your natural substances are concerned, the choice seems to me to lie entirely in the hands of the chemist who brings these substances together'" (*Die Wahlverwandtschaften*, 1809, WA,I,20,53).²¹

Goethe's *Elective Affinities* (*Die Wahlverwandtschaften*) is a poetics of human nature, in which the spheres of discrete parts, the border basins, are shaped by four characters, who act out an experiment in marital relationships, organized with symbols of chemistry and guided by a mediator of the clergy (Figure 8).²² In the experiment a child is born, and so the question here is

²¹Goethe, *Elective Affinities*, Trans. R. J. Hollingdale (London: Penguin, 1971), p. 54. "Verzeihen Sie mir, sagte Charlotte, wie ich dem Naturforscher verzeihe; aber ich würde hier niemals eine Wahl, eher eine Naturnothwendigkeit erblicken, und diese kaum; denn es ist am Ende vielleicht gar nur die Sache der Gelegenheit. Gelegenheit macht Verhältnisse wie sie Diebe macht; und wenn von Ihren Naturkörpern die Rede ist, so scheint mir die Wahl bloß in den Händen des Chemikers zu liegen, der diese Wesen zusammenbringt" (WA,I,20,53).

²²Uwe Pörksen, "Goethes Kritik naturwissenschaftlicher Metaphorik und der Roman *Die Wahlverwandtschaften*," *Jahrbuch der Deutschen Schillergesellschaft*, 25 (1981), 285-315, explores this ambiguity by studying Goethe's comments on language from his *Farbenlehre*, noting particularly his concern that "linguistic seductions of the mind" (*Sprachverführung des Denkens*) have led to an unbalanced emphasis on diversity (*Sphärenvermischung*) over unity (*Idee der Einheit*) in studies on nature, pp. 285 and 290. Then in the second half of his essay Pörksen finds expression of this concern in the novel: "Der Roman *Die Wahlverwandtschaften*, der gleichzeitig mit der letzten Fassung der *Farbenlehre* entstand, fällt in eine Zeit, in der Goethe sich dem Gedanken einer die ganze Natur umfassenden Zeichensprache am weitesten annähert und zugleich vor der Gefahr einer *Sphärenvermischung* am eindringlichsten warnt," p. 300.

about the extent, to which Goethe allowed this precipitate of marriage to follow the mind of the characters or the inclinations of nature, namely to mature as fractals of self-same or self-similar realization. The task for Goethe here, as in his plant and color theory, was to define the boundary basin and then to intensify the border where the kinetics of life take place. In this literary version, human nature is different than nature, for self-similar forms are realized through the mind of the actors, who condition the shape and direction of their growth. In this sense the novel raises interesting questions about the random interplay of will and free will in the tension that pulls human beings at the border between their natural inclinations and social constraints.

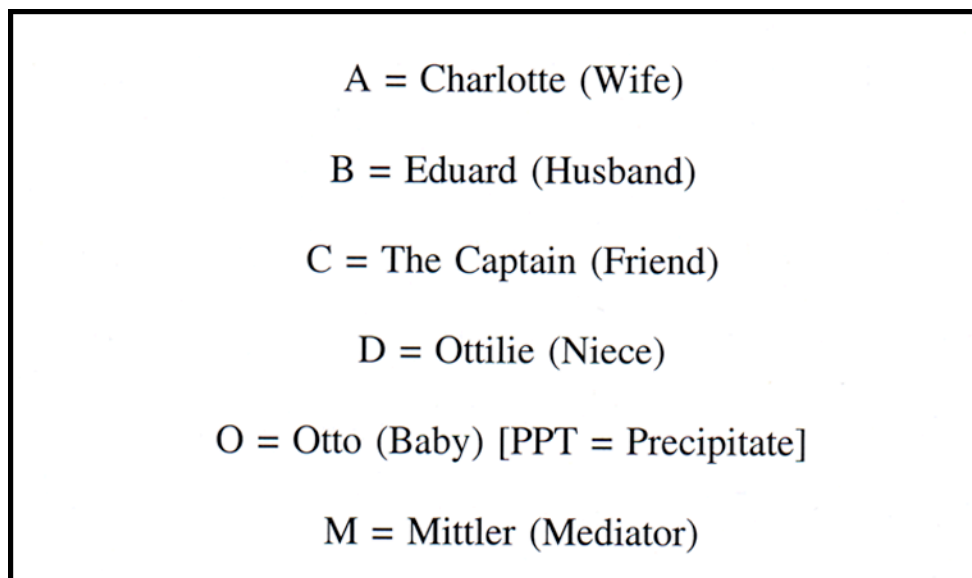


Figure 8. Signs of Chemical Affinity

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Goethe begins the novel with a description of the peace and serenity of life on a country estate, where Charlotte and Eduard, each previously married and divorced, were enjoying the

prospects of a successful match in their affinity for one another. Early in the novel this serenity is disrupted when Eduard's friend, the Captain, is invited to stay with them until employment opportunities appropriate to his skills become available. Since Charlotte is then left without a companion, Otilie, her niece, is also invited to live with the pair, a decision which emerged from a discussion of the language and concepts of eighteenth-century chemistry, which through the course of the novel came to symbolize the actions of the characters.²³ The symbols that Goethe used came from the notations of acids and bases with affinities for one another, including, for example, limestone and sulfuric acid which forms gypsum and gives off a thin gaseous acid. As the Captain explains in the story, when an agent is introduced to the limestone, a new bond is formed leaving an acid that was once part of the limestone on its own with no bonding partner.

After some discussion of the concept of affinity in science, the conversation turns to its value for guiding their own relationships. It is here where the characters translate the language of chemical affinities into symbolic actions, where they apply the metaphor to their own situation: "Now then,' interposed Eduard, 'until we see all this with our eyes, let us look upon this formula as a metaphor from which we may extract a lesson we can apply immediately to ourselves'."²⁴ And so the significance of this discussion is not the metaphor of science itself, which the Captain explains was already dated by ten years, but rather the application of a

²³Kenneth Burke, *Language as Symbolic Actions: Essays on Life, Literature and Method* (Berkeley: University of California Press, 1966) devotes his first chapter to a "Definition of Man," pp. 3-24, arguing in the first of five definitions that man is a "symbol-using animal," distinguishing this definition from traditional ones in that they, like Spinoza's "featherless biped," for example, "would be inadequate because they would confine the horizon to the realm of motion," p. 9.

²⁴Goethe, *Die Wahlverwandtschaften*, Trans. Hollingdale (1971), p. 56, (WA), Pt. I, Vol. 20, p. 56, "Nun denn! fiel Eduard ein: bis wir alles dieses mit Augen sehen, wollen wir diese Formel als Gleichnisrede betrachten, woraus

metaphor and its translation into action, to use the scientific discussion as a basis for the decision to invite Otilie to the home of Eduard and Charlotte. In this decision they decided to test the language and metaphors of science as a model for human behavior.²⁵

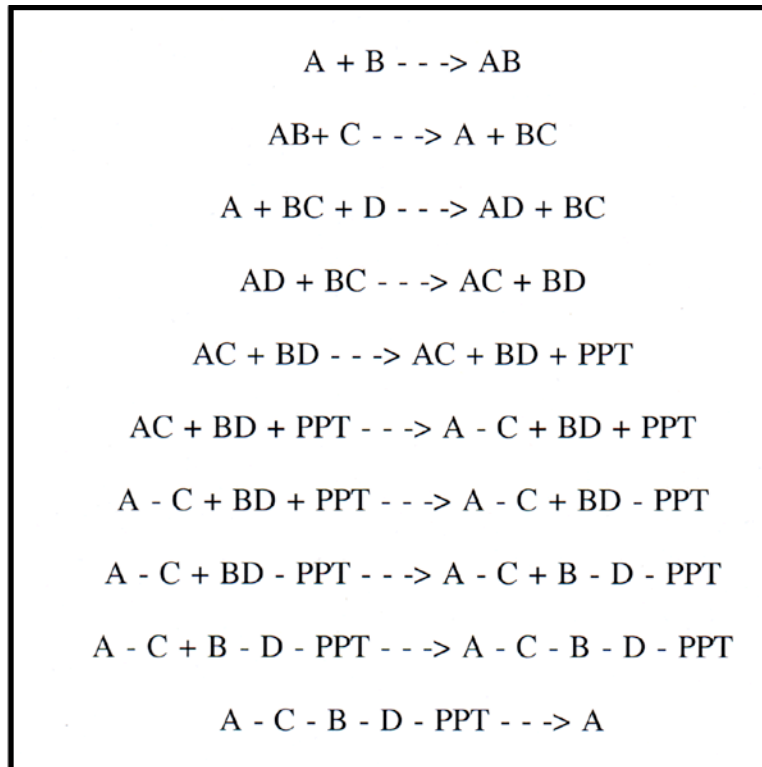


Figure 9. Algorithms of Border Behavior

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The symbols that Goethe used for his chemical reaction were acids and bases with an

wir uns eine Lehre zum unmittelbaren Gebrauch ziehen."

²⁵Burke, *Language as Symbolic Action* (1966) defines man essentially as Goethe describes the four characters of the novel: "Man is the symbol-using (symbol-making, symbol-misusing) animal/ inventor of the negative (or moralized by the negative)/ separated from his natural condition by instruments of his own making/ goaded by the spirit of hierarchy (or moved by the sense of order)/ and rotten with perfection," p. 16. See also Burke's application of these categories to Goethe's *Faust*, pp. 139-185.

affinity for one another, the former a proton-donor and the latter a proton-acceptor. When the two react and form a covalent bond, a gaseous substance is given off free to bond with another substance. By assigning the four main characters with these symbols in this environment, Goethe organizes the entire plot of the novel around reactions that can be translated into algorithms of human behavior (Figure 9). The novel begins with Charlotte and Eduard as individuals bonded by marriage ($A + B \rightarrow AB$), which changes with the arrival of the Captain, who is supposed to bond with Eduard, which leaves Charlotte alone ($AB + C \rightarrow A + BC$). The third reaction is designed to find a bonding partner for Charlotte and introduces her niece, Otilie ($A + BC + D \rightarrow AD + BC$). However, the reaction follows natural inclinations rather than planned expectations and we find Charlotte and the Captain attracted by common interest in landscaping and music, yet each maintaining their individual character in patterns of self-similar realization. Eduard and Otilie, on the other hand, bond in the self-same patterns of each other with common headaches, music skills, handwriting, and habits of eating ($AD + BC \rightarrow AC + BD$). Stimulated by elicited bonding, the married couple conceives a child in the images of elected affinities, creating a precipitate (PPT), which normally ends the chemical reaction ($AC + BD \rightarrow AC + BD + PPT$), and might have signaled an end to the story. But this is only the end of part one of the novel, where we find Charlotte pregnant with a baby conceived with her husband in the image of the Captain and Otilie.

The second part of the novel is the mirror opposite of the first, or the negative undoing of the precipitate from the first half. At the pregnant threshold between parts one and two of the novel, the experiment goes on, but the bonding unravels. The first to go is the Captain, who

leaves with a suitable employment opportunity ($AC + BD + PPT \rightarrow A - C + BD + PPT$).

In the seventh reaction, the child drowns as Otilie is rowing with him across the lake ($A - C + BD + PPT \rightarrow A - C + BD - PPT$), and as we near the end of the novel we find Otilie in such severe guilt that she starves herself to death, which Mittler, the family pastor, hastens with a short talk on the Seventh Commandment ($A - C + BD - PPT \rightarrow A - C + B - D - PTT$). And at the end of the novel, Eduard dies under mysterious circumstances, leaving his wife Charlotte alone in the experiment in human behavior guided by the chemical reactions of elective affinities ($A - C + B - D - PPT \rightarrow A - C - B - D - PPT$). With the formation of a precipitate, the chemical reaction was at its climax, where nothing new could be formed and the reaction was irreversible, except for the removal of the reactants. These are removed piece by piece in the second half of the novel, where each of the characters experiences anew the trauma of elusive boundaries, transitions, change, and loss of affinity. The negative bond leaves each character with a dysfunctional relationship and at the end of the novel, marriage as an institution is set into question, as is the notion of organizing social behavior by models of science.

Here, then, Goethe presents the central question of the novel: How does the language of science translate into the personal and social behavior of human beings? Framed in this way, the character Mittler takes on a much more meaningful role in the novel, for it is he who monitors the experiment. It is he who facilitates, controls, and checks on the experiment in marital life. It is Mittler who follows the progress of individuals in the marriage, as argued by Kenneth Burke, who defined the human being (pp. 3-24), as a "symbol-using (symbol-making, symbol-misusing) animal/ inventor of the negative (or moralized by the negative)/ separated from his natural

condition by instruments of his own making/ goaded by the spirit of hierarchy (or moved by the sense of order)/ and rotten with perfection" (p. 16).²⁶

Mittler is interested in the natural inclinations of the individuals only to the extent that they conform to the abstraction of social law. He looks primarily to the rules that bring the characters together in an experiment designed to support a particular point of view, in this case a theory about marital relations. Mittler inhibits true understanding of natural growth patterns, of the development of a holistic harmony, namely, of a natural process in which the married couple, Eduard and Charlotte, could separate and fulfill their natural inclination by respectively joining Otilie and the Captain. That is, the human being, as described in this novel, is indeed a "symbol-using animal," and is in addition an "inventor of the negative (or moralized by the negative)," as well as "separated from his natural condition," for as Eduard recognized, "it even used to be a title of honour to chemists to call them artists in divorcing one thing from another".²⁷

Mittler enters to check the experiment in human relationships at least five different times, but only three times in which he interfered with the natural progression of the experiment (Figure 10). And while the novel is divided into two parts, marking a significant juncture in the change of relationships, the appearance of Mittler at the edge of the scene, marks those thresholds when the rules of the experiment are threatened and are about to change by some foreign intervention

²⁶Elizabeth Petuchowski, "Mittler as Comment. An Observation on Goethe's *Die Wahlverwandtschaften*," *Forum for Modern Language Studies*, 18 (1982), 1-22, provides a close study of the changing role of the character "Mittler" in the novel, emphasizing his grand entrance into the story on horseback and the gradual fading of significance in the lives of the other characters. Much of the discussion focuses on the "arrival-motif," p. 17, and the "horse-motif," p. 18, neither of which provide the scope of Mittler's symbolic value in the novel.

²⁷Burke, *Language as Symbolic Action* (1966), p. 16. Goethe, *Die Wahlverwandtschaften*, Trans. Hollingdale (1971), p. 35; (WA), I, 20, 52, "Allerdings, erwiderte Eduard. Es war sogar ein bezeichnender Ehrentitel der

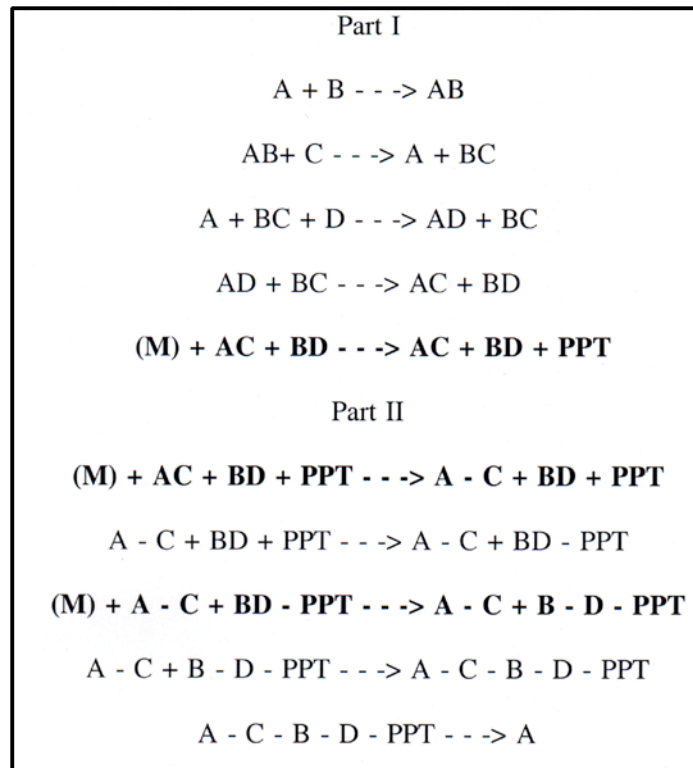


Figure 10. The Pull of the Set at the Border

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in the sequence of sacraments and rituals that guide his control of the cooking process. Each time he returns to the experiment, the conflict zone is stretched to the maximum. And the zone is always defined by the tension between the natural inclinations of the four characters and the rules and conventions of the experiment in relationships, which Mittler, the preacher, had been called to nurture and control by external measures of his profession.

Mittler's first visit was by invitation following the wedding ceremony and the second visit, too, at Eduard's birthday followed traditional rituals of expectation. The third visit Mittler took on his own initiative, when at the middle of the novel all forms of chance had invested the

Chemiker, daß man sie Scheidekünstler nannte."

experiment with separations and threats of divorce that followed from the natural affinities of the four characters. Mittler did not come back again until well into part two of the novel, when the child was born and at the baptism, as was his custom, he stood in as godparent, along with Otilie. Perhaps few scenes from Goethe's writings show greater intensity than this one as Mittler uses the occasion to intrude in the experiment and to officiate for the clergyman with a lecture on the duties of the godparents and on the hopes he had for the child. Otilie did endure the moment but the old parson died and so at this juncture, Mittler's second intervention, they celebrated a birth and a death on the same day. And so the seasons pass and the child "begotten in twofold adultery" (p. 260; WA,I,20,358, aus einem doppelten Ehbruch erzeugt!) grows each day to look more like the Captain and Otilie, the objects of Charlotte and Eduard's mental conception.

Mittler shows all the symptoms of the way the modern scientist behaves toward the design and results of the experiment. On a visit to the home of Eduard and Charlotte, he is disturbed by the interference of other visitors, a Count and Baroness with whom he had previous dealings, a couple that makes him uncomfortable because they discuss alternatives to Mittler's view on the institution of marriage, alternatives such as marriages consummated in five-year contracts with possible renewals: "I ought not to have come, and now I am being driven away. for I will not stay under one roof with that pair. And you watch out for yourselves too: they bring nothing but harm! They are like a leaven, that spreads and propagates its own contagion."²⁸

²⁸Goethe, *Die Wahlverwandtschaften*, Trans. Hollingdale, p. 89; (WA), Pt. I, Vol. 20, p. 106, "Ich hätte nicht kommen sollen, und nun werd' ich vertrieben. Denn mit jenen will ich nicht unter einem Dache bleiben; und nehmt euch in Acht: sie bringen nichts als Unheil! Ihr Wesen ist wie ein Sauerteig, der seine Ansteckung fortpflanzt."

Mittler cuts this visit short but does not interfere in the experiment, even though he is disturbed by the challenges to the marriage institution. Indeed, he is annoyed with himself even more for having indulged in the thought of enjoying a visit with Eduard and Charlotte, for becoming emotionally involved with his experiment, for not remaining the disinterested scientist.

Mittler, recognizing the failure of his rigid views on marriage, hopes with his fifth visit at the end of the novel to make adjustments to his earlier system of thought. Here he makes his third and most dramatic intrusion into the experiment. He questions the language and symbols of his paradigm of thought and begins to argue the dangers of the "Ten Commandments." Yet, his views remain basically unchanged for he maintains the fundamental truth of the commandments and only argues against the way in which this truth is stated; he seeks to patch up the weakened language of the law.²⁹ He argues that the commandments are statements too coarse for the tender ears of children. And Otilie, a child of nature, who arrives in the midst of his ranting and raving, hears only that Mittler insists upon the fundamental truth of the "Seventh Commandment." She returns to her room, while Mittler, goaded by his system of beliefs, seeks modification of his former rigidity, yet, continues to preach about the fundamental value of the commandments. However, it is too late, for Otilie dies in the next moments, a death soon to be followed by that of Eduard, the third death hastened by Mittler, by a Mediator, namely, by scientist.

²⁹ See John Neubauer, "Goethe and the Language of Science," in: *The Third Culture: Literature and Science*, Ed. Elinor S. Shaffer (Berlin: de Gruyter, 1998), pp. 51-65, who argues that in his mature views, Goethe considered science to be a "function of language," cautioning that "scientific language is only figural" with strong social and personal implications: "Much of Goethe's later writings on science is concerned with the question, what personal, social, and institutional forces contribute to the intersubjective validation of scientific concepts and theories.," p. 51.

Through the character of Mittler, Goethe presents the mediating role of the experimenter, the individual who acts upon nature, designs experiments, and makes judgements about the results. In terms of scientific behavior, Mittler could just as well have been Newton, Einstein, or Goethe himself, for scientific beings are at all times subject to passionate and reckless belief in the order and sanity of their perception of reality. In Goethe's view the experiment mediates nature (Objekt) and the self (Subjekt); therefore, science consists of anthropomorphic symbols, for scientists can only frame observations in a language which they create. In fact Goethe felt all symbols of science, even those in mathematics, were anthropomorphic: "Ethical symbols in science (for example that of elective affinity discovered and used by the great Bergmann) are more imaginative and can be related more easily to poetry, indeed to society, than all the others, which also are only anthropomorphic, even mathematical ones."³⁰

Conclusion

In his post-scientific years after 1810, when he practiced more philosophy of science

³⁰Goethe, *Goethes Gespräche*, in: *Gedenkausgabe der Werke, Briefe und Gespräche* (GA), Ed., Ernst Beutler, 25 vols. (Zürich: Artemis, 1949), Vol. 22, p. 565, "Die sittlichen Symbole in den Naturwissenschaften (zum Beispiel das der Wahlverwandtschaften vom grossen Bergmann erfunden und gebraucht) sind geistreicher und lassen sich eher mit Poesie, ja mit Sozietät verbinden, als alle übrigen, die ja auch, selbst die mathematischen, nur anthropomorphisch sind." This view, that there is an intrinsic tie between the writer's language and his perception of history, that his historical narratives manipulate reality, did not begin with Goethe and is discussed by Nancy S. Struever as a phenomenon of Renaissance thought, *The Language of History in the Renaissance* (Princeton: Princeton Univ. Press, 1970), p. 7: "The main theme of this survey, however, is to show internal as well as external similarities between the experiments can disclose nature's failure to conform to a previously held set of expectations," p. 261. Hayden White, "The Historical Text as Literary Artifact," in: *The Writing of History: Literary Form and Historical Understanding*, Ed. R. H. Canary and H. Kozicki (Madison: University of Wisconsin, 1978), pp. 41-62, asserts that these differing personal conceptions are fundamental to the structure of historical narratives and that the differences are grounded in linguistic protocols: "The implication is that historians constitute their subjects as possible objects of narrative representation by the very language they use to describe them." p. 57. Indeed, White argues that "historiography too, can be characterized in terms of the dominant trope which serves as the paradigm, provided by language itself, of all significant relationships conceived to exist in the world by anyone wishing to represent those relationships in language," p. 58.

than science, Goethe claimed that morphology was a talent that could not be transferred because of the paradox that existed between the constructs of our mind and the continuity of nature. In a short essay called a "Problem and Response" (Problem und Erwiderung, LA,I,9:295-306) included in his notebooks on morphology from 1817, Goethe reflected on the process of extrapolating form in nature, observing that the study of morphology could not be systematized, because "nature has no system" (Natur hat kein System, p. 295). In his view life processes emerge "from an unknown center" (aus einem unbekanntem Zentrum) and they evolve "into an unrecognizable border" (zu einer nicht erkennbaren Grenze, p. 295). He had developed the idea of morphology as a means to study the elusive forms of nature, but that did not mean he believed he had found reality in this approach. He thought morphology was the art of bridging the gap between constructs of our mind and the real world. Goethe did not pretend that his images of nature were real, he knew they were virtual, even as are the artist images of Goethe in Figure 11. As a stochastic being, each illustration must accept Goethe as the sum of any random number of events from his past, so that with each successive image, we must include those from the past as a part of his being. Thus, a morphology of Goethe, too, must show forms in motion and with self-similar modifications.

In this essay on the paradox of morphology, he proposed that it was an art grounded in a "gift" (Gabe, p. 295) which the scientist used to give shape to chaos and disorder. With this "gift" Goethe had defined borders and transitions in nature, but this did not mean the paradox was solved. Indeed, in this essay he argued the opposite, namely, that a talent for extrapolating form was "a dangerous gift" (eine gefährliche Gabe, p. 295), because of the human inclination to

move from nature to systems in a denial of the paradox, and often with the destructive belief that the image was more real than virtual. Here, in a reflective mood, the older Goethe was skeptical about the possibility of formalizing an approach to morphology, observing that the reduction of



Figure 11. Random Images of a Stochastic Being

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Stiftung Weimarer Klassik, Goethe-Museum Düsseldorf

talent to an "artificial procedure" (künstliches Verfahren, p. 296) was in itself recourse to an abstraction and a departure from reality. And, he continued, even if one could arrive at "a symbolism" (eine Symbolik, p. 296) for a doctrine of morphology, who besides the author would recognize it, much less act it out.

Goethe did not see a resolution to the paradox, but he did offer a response to the problem. In the closing lines of the essay, he advised that, rather than formalizing the procedure for extrapolating form, that is, rather than systematizing visual education, individuals should learn to

listen to nature (ablauschen, p. 297), for only in this way do we avoid making her obstinate by our "prescriptions" (Vorschriften) and being led astray by her "caprice" (Willkür, p. 297). This is the lesson learned by an ancestor in our era without margins, an experience that he framed in a poem called "Permanence in Change" (Dauer im Wechsel, WA,I,1,119), where change is as much in us as around us and in the end leaves us grateful for only one thing, the muse that moves us to shape and form a world without borders.

Karl J. Fink. "Goethe's Intensified Border," in: *Goethe, Chaos, and Complexity*. Ed. Herbert Rowland. Amsterdam & New York: Rodopi, 2001. Pp. 93-104