Burtt, E. A.: *The Metaphysical Foundations of Modern Physical Science*, Routledge & Kegan Paul, London, 1950.
Carnap, R.: *Philosophical Foundations of Physics*, Basic Books, New York, 1966.
Du Bois-Reymond, E.: *Goethe und sein Ende*, Buchdrukerei der Koenigl. Akademie der Wissenschaften (G: Vogt), Berlin, 1882.
Goethe, J. W. von: *Conversations of Goethe with Eckermann and Soret* (trans. by J. Oxenford), Smith, Elder & Co., London, 1850.
Goethe, J. W. von: *Dichtung und Wahrheit* (ed. by T. Friedrich), Reclam, Leipzig, 1882.
Goethe, J. W. von: *Goethes naturwissenschaftliche Schriften*, 4 vols. (ed. and intro. by R. Steiner), Union Deutsche Verlagsgesellschaft, Stuttgart-Berlin-Leipzig, 1884—1897. (= rpt. of Kürschner's Deutsche National-Literatur, Vols. 114—117).
Goethe, J. W. von: *Italian Journey* (trans. by W. H. Auden and E. Mayer), Collins, London, 1926.
Hegge, H.: *Erkjennelse og virkelighet. Et bidrag til kritikk av teorien om sansekvaliteters subjektivitet*, Universitetsforlaget, Oslo, 1957 (*Erkennen und Wirklichkeit*, with German summary).
Heitler, W.: *Der Mensch und die naturwissenschaftliche Erkenntnis*, 2nd rev. edn., Friedr. Vieweg & Sohn, Braunschweig, 1962.
Heitler, W.: 'Naturvitenskapens etikk', *Morgenbladet*, 9 March 1967.
Helmholtz, H. von: 'On Goethe's Scientific Researches', in *Popular Scientific Lectures* (trans. by E. Atkinson), Longmans, Green & Co., London, 1893.
Hume, D.: *A Treatise of Human Nature*, Meridian, Cleveland-New York, 1962.
Mach, E.: *Die Mechanik in ihrer Entwicklung*, F. A. Brockhaus, Leipzig, 1908.
Naess, A.: *Innføring i logikk og metodelaere*, Universitetsforlaget, Oslo, 1963.
Newton, I.: *Opticks*, G. Brill & Sons, London, 1931.
Spinoza, B. de: *The Chief Works of Benedict de Spinoza*, 2 vols. (trans. by R. H. M. Elwes), Dover, New York, 1951.
Steiner, R.: *Goethe's Conception of the World*, Anthroposophical Publishing Co., London, 1928. (Published simultaneously by the Anthroposophic Press, New York.).
Steiner, R.: *Goethes naturwissenschaftliche Schriften*, Philosophisch-Anthroposophischer Verlag, Dornach, 1926.
Steiner, R.: *Goethes Weltanschauung*, Berlin, 1921.
Steiner, R.: *Goethe the Scientist* (trans. O. D. Wannamaker), Anthroposophic Press, New York, 1950.
Steiner, R.: *Grundlinien einer Erkenntnistheorie der Goetheschen Weltanschauung*, Berlin-Stuttgart, 1886.
Steiner, R.: *The Theory of Knowledge Implicit in Goethe's World Conception*, Rudolf Steiner Publishing Co., London, 1940. (Published simultaneously by the Anthroposophic Press, 1940.).

Institutt for Filosofi, PB 1024
Universitetet i Oslo
Blindern, Oslo 3
Norge/Norway

ARTHUR G. ZAJONC

FACTS AS THEORY: ASPECTS OF GOETHE'S PHILOSOPHY OF SCIENCE*

For many, the business of science is to search for causes. So when the would-be scientist Goethe declares to Schiller that "... we are not seeking causes but the circumstances under which the phenomenon occurs" ('Erfahrung und Wissenschaft': *HA* 13, p. 25; Goethe, 1952, p. 228), he seems to be missing the point of the scientific enterprise. He only makes matters worse by maintaining that, "Man in thinking errs particularly when inquiring after cause and effect: the two together constitute the indissoluble phenomenon ... ['Maximen und Reflexionen', 591: *HA* 12, p. 446]. "It is rightly said that the phenomenon is a consequence without a ground, an effect without a cause [Goethe, *Maximen* ..., 590: *HA* 12, p. 446].

It is clear immediately that Goethe takes issue with certain naively held convictions about the nature of the scientific enterprise. The scrutiny of the foundations of science, while common today, was not something practioners cared to engage in during Goethe's lifetime. Rapid progress was being made on many fronts, the scent of success was in the air. Yet it seems clear in retrospect that a careful reconsideration of the nature and means of scientific inquiry was in order. By 1890 several philosophers and physicists had launched a critique of the commonly held notions of explanation, law, observation, fact, and so on. The undertaking is certainly even now not complete. In what follows, I hope firstly to show that Goethe's declarations and admonishments concerning the scope and methods of science often foreshadowed later developments, and that his understanding of the 'business of science' was often more thoughtfully conceived and consistent than that of his more orthodox contemporaries. After such considerations we may wish to reconsider Goethe's own scientific efforts. In the second part of the paper, just such a reconsideration is presented. In particular we must discern clearly that for which Goethe is searching in his scientific studies, and also how he proposes to attain his goal. In addressing these aspects of his thought, Goethe's unique and, I think, fruitful way of exploring nature will become evident. But first we must gain some clarity concerning the climate of scientific

F. Amrine, F. J. Zucker, and H. Wheeler (eds.), Goethe and the Sciences: A Re-appraisal, 219—245.

thought in Goethe's day and why the reception of his scientific work was then so negative.

OF METAPHYSICS AND MECHANICAL PHILOSOPHY

When Helmholtz, in 1853, contrasts Goethe's scientific investigations with those of his more orthodox colleagues, he does so in a manner which places him, Helmholtz, squarely in the tradition of mechanical philosophy begun in the seventeenth century. According to Helmholtz, Goethe, even as a scientist, is "concerned solely with the 'beautiful show' which makes it possible to contemplate the ideal." The true natural philosopher, on the other hand, "tries to discover the levers, the cords, and the pulleys which work behind and shift the scenes" (Helmholtz, 1971, p. 73). Clearly the task of the scientist, according to Helmholtz, is to look behind the scenes, to search out the true mechanical causes which drive nature. In this he merely is paraphrasing an oft enunciated Enlightenment ideal. Two hundred years earlier, in 1686, Bernard de Fontenelle employed the identical metaphor to describe both nature and the task of the scientist:

> Nature is a grand spectacle which is like that of the opera. From the place where one sits, one does not see the theater at all as it really is. The scenery and machinery have been arranged so as to make an agreeable impression. The wheels and counterweights which drive all the movements are hidden from view. Nor do you concern yourself with how these machines are put into motion (Fontenelle, 1973, p. 29).

But it is of great concern to the scientist just how nature contrives to create the phenomena we view. Although it is an exceedingly difficult task, Fontenelle enjoins "modern philosophers" to engage in the elucidation of nature in terms of wheels and counterweights: "... he that would see nature as she truly is, must stand behind the scenes of the opera." From such a vantage point, the universe becomes a clockwork mechanism complicated in detail but simple in principle. Seventeenth-century natural philosophy ends, as Fontenelle puts it, by taking "the world to be in great, what a watch is in small" (Fontenelle, 1973, p. 30). As secretary of the Paris Academy of Sciences, Fontenelle, although not a scientist himself, reflects the common rising scientific world view of his age.

The rational, mechanistic explanation of natural phenomena represented for Fontenelle and his contemporaries a triumph over the

ignorance of scholastic science. In place of Aristotelian physics, a new view of science was promulgated which would embody the discoveries of Galileo, Copernicus and Descartes. In this 'new science,' there was no room for the 'substantial forms' or 'occult qualities' of Aristotelian physics. The program of seventeenth-century science was one which sought to purge such metaphysical vagaries from the vocabulary of physical investigation. In order to do so, the very concept of explanation needed revision. Consider for a moment the Cartesian and Aristotelian explanations of the fall of a stone.[1]

One of the 'essential' qualities of the Greek element earth is, according to Aristotle, gravity. Although a rock may be constrained 'accidentally' to sit on a shelf or in my hand, when that constraint is removed it is carried to its own natural place. We should not imagine that natural place is a cause. Place does not attract its corresponding elements in any modern sense. Rather, "it [place] has some potency [*dunamis*]" (Aristotle, *Physics* IV, 208 b 12). When Aristotle writes that "the movement of each body to its own place is motion towards its own form" (*On The Heavens*, IV, 310 b 33, 310 a 34), he locates the separate, moving body within a larger unity, its own form. Following Machamer's (1978) perceptive analysis of natural place and motion, I understand the potency of natural place to be a result of the natural or organic unity which place confers upon those things which are inherently alike. Objects alike by nature stand in a particular spatial relationship at any moment, but they also form an organic unity through the potency of their common natural place. The formal cause of natural motion thus becomes their organic unity. In moving toward its natural place an object is actualizing a potential. In tuning a musical instrument a potential is actualized. Likewise in the motion of the stone toward its own form what existed only potentially becomes actual. Free fall is certainly not a matter of attraction. Rather, it is similar, Aristotle tells us, to other forms of generation and change, for example the coming-into-being of a plant (*On the Heavens*, IV, 310 a 23). One can maintain, as Furley (1976) does, that the efficient cause of natural motion was for Aristotle nature itself. For Aristotle writes, "Nature is a cause of motion in the thing itself, force is a cause in something else ... (Wallace, 1978, p. 401). For centuries thereafter, from Philoponus to the young Galileo, nature was considered to be a principle inhering in the object and causing its natural motion. Even Galileo in his *Two New Sciences* conceived of the uniform increase of velocity with time as due to nature (Galileo, 1954, p. 160). Whether or not Aristotle saw nature as an efficient cause has been a matter of debate. Historically, however, the matter is clear. By the sixteenth century, the perceived lack of a proximate contact cause for natural motion has become a source of dissatisfaction. It is during this period then that the modern concepts of cause and force developed. By the time Fontenelle composed his *Plurality of Worlds* at the end of the next century, Aristotle's account of natural notion was considered no explanation at all. Motion of an object towards its own form, actualization of a potential and so on, all seemed only a smoke screen for ignorance. A program was therefore mounted by seventeenth-century natural philosophy to criticize scholastic science and to popularize the discoveries and explanations of the new science. The purge of metaphysical notions from natural science was to be complete. In its place a completely physical world comprised of matter in motion, whose single principle of causation is concussion, was elaborated. This is a view not without its own difficulties, of course. The year after Fontenelle's *Plurality of Worlds* appeared, Newton published his *Principia* with its rejection of Cartesian cosmology and his own cautious description of gravitation. Moreover, from our vantage point, it also seems clear that mechanical philosophy merely replaces one metaphysics with another. But more about this later. Let us turn very briefly to Decartes' explanation of free fall as an example of the philosophy of which we have been speaking.

Descartes' explanation of falling bodies rests upon the explicit doctrine that a void is a logical impossibility. Since space is extended and extension is one of the primary qualities of matter, then space must be filled with matter. The four Greek elements are conceived of as variously shaped corpuscles. Even the smallest remaining spaces are filled by a fine material *plenum*. Empty space is then, in Cartesian physics, an atomistically conceived fluid in which vortices and other motions can arise. One such vortex exists around the earth reaching as far as the moon. It causes the phenomena we associate with earthly gravity. The propagation of light, electric and magnetic phenomena likewise find their explanation in terms of hidden corpuscular mechanisms (Descartes, 1965, p. 264; Westfall, 1977). The 'forms' of Aristotle's physics are replaced in each instance by an explanation entirely in terms of mechanically conceived 'efficient causes' (Aristotle, *Physics* II, 3; *Posterior Analytics* II, 11). Thus when, at the start of the nineteenth century, Goethe turns away from such explanations and writes,

> The highest thing would be to comprehend that everything factual is already theory. The blue of the heavens reveals to us the fundamental law of chromatics. One should only not seek anything behind the phenomena: they themselves are the theory ('*Maximen* . . . . 488: *HA* 12, p. 432)

the scientific community of his day saw the spectre of an ancient physics once again rearing its head. Goethe is clear in his intentions. His choice of methodology was not made out of ignorance. He was fully aware of the reigning scientific paradigm. Yet he chose consciously not to invoke what he considered but another kind of metaphysics in order to explain nature. He greatly distrusted scientific hypotheses, calling them "the lullabies that the teacher uses to lull his pupil to sleep" (*Maximen* . . . , 557: *HA* 12, p. 432). Working hypotheses he granted as being of great use in the early stages of scientific inquiry. However, they should not be elevated to or mistaken for reality:

> Hypotheses are like the scaffolding erected in front of a building, to be dismantled when the building is completed. To the worker the scaffolding is indispensable, but he must not confuse it with the building itself (*Maximen* . . . . 554: *HA* 12, p. 432; Magnus, 1949, p. 229).

To "free the human spirit from an hypothesis which causes it to see falsely or partially" is already a great service (*Maximen* . . . . 555: *HA* 12, p. 441). Goethe was convinced that many hypotheses had in fact been raised to the level of scientific dogma, the most infamous case being the Newtonian theory of color:

> A false hypothesis is better than none at all. The fact that it is false does not matter so much. However, if it takes root, if it is generally assumed, if it becomes a kind of credo admitting no doubt or scrutiny — this is the real, evil, one which has endured through the centuries ('Analyse und Synthese': *HA* 13, p. 51; Goethe, 1952, p. 239).

Against this Goethe would place his own mode of inquiry with its special attention to phenomena. But let us delay that discussion slightly in order to explore briefly the role of hypothesis in scientific discussion.

HYPOTHESES AND PHYSICAL THEORY

Already in the General Scholium which Newton included in his *Principia* of 1687, the Cartesian doctrine of vortices in particular, and Descartes' whole mode of explanation in general came under attack.

Newton, after indicating that the "hypothesis of vortices is pressed with many difficulties," goes on to admit that he himself had

> not been able to discover the cause of those properties of gravity from phenomena, and I frame no hypotheses: for whatever is not deduced from the phenomena is to be called an hypothesis: and hypotheses, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy (Newton, 1947).

There is, of course, still the subtle question of what counts as deduction 'from the phenomena.' When Descartes deduces a material plenum from his observations concerning primary qualities and matter, Newton discounts the attempt. Likewise, when Newton deduces from the phenomena of refraction and dispersion of light through a prism the "rays differently refrangible" of his *Opticks* (1952, p. 26), Goethe will declare these to be hypotheses merely, not the 'true' nature of light. What then is the proper place of hypothesis in scientific inquiry, and when if ever does a hypothesis become a true statement about reality? A brief consideration of the works of Duhem and Mach will allow us to appreciate better the positions of Helmholtz and Goethe.

Plato's mandate to astronomers that they "save the appearances presented by the planets" begins the tradition which we seek to investigate (Duhem, 1969, p. 5). From a neo-Platonic standpoint, the ontological status of the Greek astronomical hypotheses generated to save the phenomena was clear from the start. If sensory experience was viewed as at best only a semblance of eternal Forms, then hypotheses invented to reproduce these appearances could have little claim to reality. The constraint placed on astronomers that they use circular, geocentric orbits was one derived by Aristotle from essentially theological considerations. As such it was expected to possess greater kinship with the true reality, whatever that might be. Greek and Hellenistic astronomers certainly did not conceive the planets as *actually* moving in the epicycles or along eccentric orbits as their theories described. It is abundantly clear from their careful discussions of the nature and role of hypotheses in astronomy that hypotheses were conceived of as human contrivances which, when theoretically elaborated, could match all the observations of the apparent motions of planets and stars. Moreover, this could be done with great accuracy. Indeed, by merely extending their methods using contemporary techniques of Fourier analysis, planetary and stellar positions can now be predicted to arbitrary accuracy. Ancient astronomers knew that two different theoretical bases existed by which the phenomena could be saved, epicycles and eccentrics. It becomes clear from this that any finite set of data can, in principle, be 'fit' by several, indeed an infinity, of different theories. Such considerations put any theory which begins with hypotheses in an awkward position.

In refusing, at least in his *Principia*, to espouse a hypothetical cause, Newton consciously joined a long astronomical tradition. Even though he is conscious of the dangers of hypotheses, Newton often does not recognize that certain hypotheses are hidden within the central propositions of his mechanics. For example, when Newton puts forth his second axiom or law of motion, he clearly does not intend to introduce any hypothetical entities: "The change of motion is proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed" (1947, p. 13). Newton goes on to use force throughout as the dynamic agent of his mechanics. His universal law of gravitation is framed in terms of it; objects fall because of a universal force of attraction between masses. Even here Goethe saw the insertion of a hypothesis, namely force, which is then taken to be a fact. In 1793 he writes,

> no one, no matter who, can undertake to give out an explanation, theory or hypothesis as a fact. That the stone falls is fact, that it occurs through attraction, is theory. One may be deeply convinced of the theory, but one can never experience, never see, never know it. ('Über Newtons Hypothese . . .': *WA* II, 5, p. 170).

In this distinction Goethe anticipates Ernst Mach who takes Newton's second law as the definition of force rather than a law of motion (Mach, 1911, pp. 180–185; Nagel, 1961, pp. 187ff). Goethe then goes further than Newton in carefully distinguishing facts from other theoretical components of scientific inquiry. Thus it is not surprising that if Newton was pointedly accused of reimporting occult qualities into science by refusing to frame hypotheses, then Goethe's own efforts at developing a methodology free from hypothetical constructs met with even less sympathy. Newton's immediate followers often chose not to imitate his care in framing hypotheses. Their cosmos was often far more explicitly mechanistic and materialistic than their mentor's as Robert Schofield has shown (1970). Helmholtz, writing 150 years after the *Principia*, appears as part of this later mechanistic tradition and so he and his contemporaries possess little understanding for the critique that an 'outsider' Goethe, gives of their methods and modes of explanation.

By the end of Helmholtz's life, the place of hypotheses, the traditional concepts of law, theory and explanation were all undergoing a penetrating analysis, not because of Goethe's admonishings, but rather at the hands of physicist-philosophers like Duhem and Mach. This critique and its consequences — the so-called 'golden era' of the philosophy of science — are important for us if we are to reconsider Goethe's scientific work properly. Many of the conclusions reached then were anticipated by Goethe. Yet while both Duhem and Goethe dismantle a naive nineteenth-century science, the new understanding of science they each put forth, its methodology, its goals and its ultimate scope will differ radically. I will be at some pains to point out these distinctions as they afford profound insight into Goethe's struggle with science. They may also allow us to appreciate why he considered these pursuits so significant for his own development: "Without my efforts in the natural sciences, I would never have come to know man, as he is."[2]

NEW VIEWS

When Newton refuses to advance a hypothesis as to the 'cause' of gravitational attraction, he does so, at least in part, because his concept of scientific theory is other than that of his Cartesian contemporaries. In place of what the physicist Rankine (1881, p. 209) would later term "hypothetical theories," such as those supplied by mechanical philosophy, Newton utilizes an axiomatic or 'abstractive' method to establish a representational theory. Imitating the presentations of Euclidean geometry, Newton constructs an abstract set of 'absolute magnitudes' — space, time, impressed force, etc. — which may be related to their empirical 'sensible measures' by rules of correspondence. Thus the empirical world of common or laboratory experience is set in correspondence with a purely abstract or formal system of axioms, definitions and theorems. The theoretical physicist may solve a problem by framing the abstract counterpart of his problem — say orbital motion — in terms of his formal system which relates the space and time coordinates of an abstract mass to its initial conditions and the impressed forces via the three laws or 'axioms' of Newtonian mechanics. Once this is done, the equations of motion may be solved to give the coordinates of the mass at any later or earlier time. These may then be set in correspondence with their 'sensible measures' (Losee, 1972, Ch. 8).

The program has not changed materially since Newton's time. One may replace impressed force (as a hypothetical entity) with various potential functions like Lagrangians or Hamiltonians; but whether one uses Newton's original or more 'advanced' formulations, the procedure is essentially the same. One is not concerned with the 'cause' of gravity or of the impressed force in general. The laws of motion in no way depend on whether we are harboring atomistic or field-theoretic visions of reality. We are, in this view, merely representing what we see abstractly, elaborating a theory in terms of definitions which we deem helpful, and positing laws axiomatically according to their usefulness and success in unifying certain groups of phenomena.

By the end of the nineteenth century, many scientists such as Ampère, Fourier and Fresnel had indicated their support for such representational or abstractive theories in place of explanatory or hypothetical theories such as those offered by mechanical philosophy. Robert Mayer would write to Griesinger:

> Concerning the intimate nature of heat, or of electricity, etc., I know nothing, any more than I know the *intimate nature* of any matter whatsoever, or of anything else.[3]

Mayer's declaration stands in sharp contrast to the attitudes of many of his contempories. Lord Kelvin is a famous instance of someone with a predilection for mechanical models: "I never satisfy myself until I can make a mechanical model of a thing" (Thompson, 1884, p. 270; Duhem, 1974, Ch. 4). Neither Mayer nor Goethe is debating the usefulness of models. As evidenced by a previous quotation, Goethe, like Rankine, sees these as productive beginnings, but they should not be taken as an endpoint, nor mistaken for 'reality.' Rankine would have a mature science advance from hypothetical to abstractive theories. To ascribe reality or a genuine ontological status to hypotheses or models is for Duhem and others, ironically, to imbue physical theory with 'metaphysical content.' Seventeenth-century mechanical philosophy, which rode the wave of anti-metaphysics, thus finds itself criticized by positivist philosophers and scientists as importing metaphysics into physical theory! All aspects of science are now subject to careful scrutiny as to implicit theoretical or metaphysical content. The mistaken ascription of reality to primary qualities and to the hypothetical schemes of the seventeenth century Whitehead calls the error of 'misplaced concreteness.' As a result of the ensuing confusion, he declares, "modern philosophy has been ruined" (1925, p. 55).

Goethe fully shares Whitehead's concern regarding the error of misplaced concreteness. He writes in his *Theory of Colors*:

> The investigator of nature should take heed not to reduce observation to mere notion, to substitute words for this notion, and to use and deal with these words as if they were things (1970, p. 283).

But Goethe goes much further than Duhem, Mayer or Rankine when he writes:

> Yet how difficult it is not to put the sign in the place of the thing; how difficult to keep the being [*Wesen*] always livingly before one and not to slay it with the word (*HA* 13, p. 452).

We find here and elsewhere not only a warning against Rankine's 'hypothetical theories' characteristic of seventeenth-century mechanical philosophy: Goethe is also cautioning against abstractive or representational theories which may even explicitly deny any measure of 'reality' to their formal constructs. When N.R. Hanson writes, "What is it to supply a theory? It is to offer an intelligible systematic, conceptual pattern for the observed data" (1958, p. 121) he is stating a commonplace, and yet one which is nevertheless different from Goethe's view. For Goethe, the distinction, so casually drawn between "observed data" and "conceptual pattern" is less an essential characteristic of reality than an accident associated with human cognition. The full sensual experience of nature which Goethe embraces can only suffer at the hands of an abstractive science. Nor will Goethe rest satisfied with a purely 'descriptive' or 'instrumentalist' rendering of natural phenomena. His is a search for the True, an attempt to catch nature showing an Idea in a pure archetypal phenomenon. Goethe's critique of hypothetical entities may sound like Mach or Duhem, but we must not confuse his view of nature or the scientific enterprise with theirs. Goethe was certainly no positivist born ahead of his time. He was remarkably perceptive as to the hidden assumptions of science as he knew it in his own lifetime. But his response was to develop a method of inquiry different in nearly every respect from the positivist school which would follow him. That the positivist program has had its difficulties is well known. It is now time that we explored Goethe's own scientific writings with an eye to the questions: what does Goethe take as 'theory' and what is its cognitive status?

COLOR: FRAGMENTATION AND POLARITY

The first chapter of the didactic part of Goethe's *Theory of Colors* concerns itself with physiological colors; that is, those colors which belong "to the subject — to the eye itself" (Goethe, 1970, p. 1). The discussion which he presents is a lucid and vivid account of color phenomena. These same phenomena stand even today as primary in the field of color vision research. The attention which Goethe gave to these phenomena led to the birth of a new discipline, for which he has often been given great credit. For our purposes, however, the important point is that in beginning with physiological colors Goethe stresses immediately that his concern is with *seen* colors rather than a physical theory or model of color generation. All subsequent experiments and observations are to be viewed with the healthy human faculty of sight. The phenomena investigated are always phenomena seen.

For Goethe, therefore, the primitives or elements of his color-studies are authentic perceptions. Red, for instance, may appear in many shades and with varying purity. It is initially with this individual appearance of color that Goethe deals. Even when 'pure red' is presented and discussed as a kind of ideal color, it occurs as a limiting process of vision, something which is still seeable, although rarely if ever truly manifest in nature. There is never, by any kind of Gestalt switch, a time when red is replaced by 'rays differently refrangible' or by waves of suitable wavelengths. The difference between Goethe and Newton in this is obvious, but it can remain a source of confusion. Contrary to some claims,[4] Newton does not stay with the phenomena throughout. Although he "frames no hypotheses," his is, as we have seen, an abstractive or representational theory. Goethe may idealize or exalt phenomena, but he does not represent a color by anything other than itself. Rather than penetrating through to some 'true,' hidden, mechanical reality supposed to be at work behind the scenes, or generating an abstract, formal system which corresponds to observation at the necessary points, Goethe pursues his own unique path. His is neither a hypothetical nor an abstractive theory. Instead he proposes to let the facts themselves, when fully perceived, be the theory. Before following up this point, I think it important to clarify briefly certain specifics of Goethe's and Newton's color studies.

One of the critical misconceptions in the Goethe-Newton controversy centers around the 'correct' scientific understanding of white light.

Newton's logic is absolutely rigorous in this instance. He maintains that he has proven color does *not* arise through a modification of the rays either by the medium or the shadow (Newton, 1952, p. 113). He is fully aware that this assertion is contrary to the "constant and general Opinion of Philosophers" (1952, p. 158). Rather, the rays, whose "colorific qualities" give rise to the sensation of color, "keep those their original Properties perpetually and the same without alteration" (1952, p. 160). Any color we see must, therefore, be a mixture of such primary immutable elements — colorific rays. Here is a color atomism which Newton, in one of his more speculative moments, makes explicit in his well-know Query 29 (1952, pp. 370—374), and which subsequently became the corpuscular theory of light advanced by his students. The spirit which pervades the argument is that of the inventor of infinitesimal calculus. In gravitational theory one considers a large mass as the infinite sum of infinitesimal masses. Likewise, when explaining edge spectra, a broad light source is decomposed into the infinite sum of infinitesimal slits each producing its own full spectrum (Newton, 1952, p. 161). It is against this '*proof*' of the immutability of rays that Goethe battles. Recall that if this were merely a hypothesis, then there would be little argument from Goethe. But when theory is taken as fact, here a grave error inserts itself and Goethe will protest. In his essay "Über Newtons Hypothese der diversen Refrangibilität" [On Newton's Hypothesis of Diverse Refrangibility] of 1793, Goethe sets forth his objections:

> Newton has in no way shown that colorless light is compounded out of other lights which at the same time differ as to color and refrangibility. I consider, rather, diverse refrangibility only as an artful hypothesis which must fall before exact observation and critical judgement (*WA* II 5, p. 166).

Goethe goes on to write that although Newton may begin by considering his ideas only as a theory, "by and by he binds himself so in spirit to his doctrine that he gives out diverse refrangibility as an actual fact." Newton's followers continue in the same manner, taking what is theory as actual fact. By trying to prove that the cause of spectral phenomena "must lie with the light itself" and is not due to a modification of white light by the prism, Newton falls, according to Goethe, into this his "first and greatest error." It is an anticipation of the mind against which Bacon warned and which only becomes more firmly entrenched by Newton's skillful arrangement of selected experiments. Newton produces an idol of the study, and it is taken for scientific fact throughout the following centuries.

From a contemporary perspective, Newton's theory is helpful for a limited range of simple color phenomena, but Goethe rightly stated that when one considers a truly full range of color effects, then the theory is found wanting. Certainly this is no disgrace, but rather an attribute of all theories. Light is mutable. Colors do arise through the modification of that input energy we call light by the medium. The spectral decomposition of light, whether performed by a prism or mathematically through Fourier analysis, tells one about the prism or about the character of the formalism used, but not about light itself (Hecht and Zajac, 1976, p. 43; Sommerfeld, n.d., Ch. 3). One can only muse what might have been Newton's reaction to second harmonic generation in which red light enters a crystal only to be refracted so as to come out violet. The immutability of rays is truly a hypothesis.

In light of the above, what is Goethe's contribution to color science? As was already indicated, we must not attempt to conceive it as just an alternative representational theory. Rather, his is a non-representational theory in which hypothetical entities have no place. We are not to be surprised when Goethe declares white and black to be primary and unitary in nature. One works throughout with what one sees. It becomes then rather a question of transforming the organs of sense for a more comprehensive and deeper vision. With genuine phenomena as a starting point, how does one proceed, according to Goethe, to a higher view which unifies a diverse realm of phenomena?

GOETHE'S METHODOLOGY

Although his own thought evolves in this matter, especially under the influence of Schiller, the main features remain clear. In his essay 'Experience and Science,' sent to Schiller in 1798 (*HA* 13, p. 23; Goethe, 1952, p. 228) Goethe maintains that one begins with ordinary 'empirical phenomena,' the simple ordinary observations any attentive observer might make. From these we can rise to data of a higher type by varying the conditions under which the phenomenon appears and noting the essential preconditions necessary for the effect to arise. These he termed 'scientific phenomena.' Some would suggest that one rest content with these, writes Goethe, presenting the instances of appearance and non-appearance (*HA* 13, p. 317; Goethe, 1970, p. xl).

But he would seek a still higher logical level on which to experience phenomena; this he termed the 'pure phenomenon' later to be called the 'archetypal phenomenon.'

In writing of 'scientific phenomena,' Goethe likely has in mind Francis Bacon's tables of presence, absence in proximity, and degrees which are to act as the basis for induction to intermediate and general axioms. That Goethe owed a great deal to Bacon is certain. Yet he is also highly critical of Bacon's inductive method and the sterility of any approach based on pure classification. Bacon captures a highly important aspect of the enterprise, but, according to Goethe, his position is unbalanced:

> ... he [Bacon] still has an excellent influence, so long as we appreciate that his doctrine is one-sided and allow the mind to exert its influence also (*LA* I.10, p. 295).

The mind too must play its part, not in the reduction or representation of phenomena by hypothetical entities, but rather in the search for pattern and constancy in the phenomena. "The constancy of the phenomena is the one important thing; what we think about them is quite irrelevant" (*WA* II.13, p. 444).

From these scientific phenomena one mounts to a still higher class of phenomena — Goethe's well-known pure, or archetypal phenomena. Such archetypal phenomena stand as the ulitimate goal and endpoint of any field of Goethean research. With this the pattern stands fully before one as experience:

> In order to describe it [the archetypal phenomenon] the intellect fixes the empirically variable, excludes the accidental, separates the impure, unravels the tangled, and even discovers the unknown (*HA* 13.p. 25; Goethe, 1952, p. 228).

By thus moving from one logical level of phenomena to another, Goethe successfully meets an important criterion for explanation. As N. R. Hanson points out (1958, pp. 59—60), it is impossible to express causal relationships, or in any sense 'to explain' through language, if all words are on an identical logical level. There must exist a hierarchy allowing certain words, or in Goethe's case phenomena, to exhibit meaningful theoretical content when experienced in a particular context. They become "theory-loaded," to use Hanson's term. If Goethe wishes to refrain from reducing "observation to mere notion, to substitute words for this notion ... " (*HA* 13, p. 482; Goethe, 1970, p. 283); that is, if he wishes to remain within the phenomenal, then

phenomena too must be theory-loaded. I hasten to add that by this I do *not* mean that nature is seen in terms of a theoretical model such as is very often the case in orthodox science. Rather, through the process of investigation itself, certain otherwise ordinary phenomena become representatives or symbols of very general relationships or principles which manifest themselves within a finite phenomenal realm. We should recall that the simple process of 'seeing' is not an uncomplicated one.

Consider Duhem's lovely example (1974, p. 145) of someone walking into an electrical laboratory and innocently asking the scientist present what he is doing. We see the bits of copper, batteries, vessels of mercury, etc. Our eyes register accurately the forms and colors of all objects in the room. Yet the surprising answer is, "I am measuring the electrical resistance of a coil." Implied in this simple statement is a huge body of electrical theory of which we may be unaware. Scientists often 'see' phenomena — meter movements, a flickering light, etc. — in terms of the dominant theory. It becomes the language and conceptual grid onto which all raw experience is projected. The collection of rods, batteries, and other paraphernalia is 'seen as' an ohmmeter. Seeing is obviously more than opening one's eyes.

In like manner the recognition of a pattern or ideal form is the prerequisite for any further analysis and is often based in "tacit knowledge" (Polanyi, 1969, pt. 3). For the craftsman or artisan the recognition is sufficient in itself; for the scientist it is usually merely the beginning. Hanson puts it this way:

> Perceiving the pattern in phenomena is central to their being "explicable as a matter of course" ... This is what philosophers and natural philosophers were groping for when they spoke of discerning the nature of a phenomenon, its essence: this will always be the trigger of physical inquiry. The struggle for intelligibility (pattern, organization) in natural philosophy has never been portrayed in inductive or H-D [hypothetico-deductive] accounts (Hanson, 1958, p. 87).

What Hanson describes as the "trigger of physical inquiry," becomes for Goethe the goal and endpoint of scientific inquiry. The moment of discovery, of seeing a pattern in the phenomena, falls outside of inductive and H-D accounts (Hanson, 1958). The *aperçu* is, for Goethe, the explanation. Therefore when Goethe 'explains' the phenomena of prismatic colors, he does so by tracing them back to an antecedent and simpler one, namely the archetypal phenomenon of light meeting darkness within a turbid medium. The archetypal phenomenon is a natural form in the Aristotelian sense. Light, darkness and the turbid medium are parts of an organic unity or form which also includes the warm colors on the one hand and cool colors on the other. When light, darkness and a semi-transparent medium configure themselves, or are configured by an experimenter, in the proper way, then the form is complete only when the requisite colors appear. It is never a question of efficient or mechanical causality. The division of the monochord into two equal parts entails the octave. Likewise if the 'conditions of appearance' are present for certain colors, they will manifest.

The physicist might wish to formalize the discussion by modeling turbidity in terms of scattering from dispersion electrons sited on regularly-spaced atoms or from randomly-spaced particles in the atmosphere. Light and color then become suitably weighted integrals of the spectral intensity over a large wavelength range, and so on. One might ask: has the physicist through this program actually increased our understanding of light and color? Goethe writes in a letter of 1823 to Soret: "In science, however, the treatment is null, and all efficacy lies in the *Aperçu*."[5] The moment of insight expands into genuine understanding for Goethe. Any subsequent reconstruction of the perceived regularity in terms of hypothetical or abstracted constructs is gratuitous and distracts from the phenomena themselves. Seeing, the highest sense, becomes when fully developed, a metaphor for the much rarer faculty of intuition:

> Ordinary vision [*Anschauen*], correct inspection of earthly things, is an inheritance of the general human understanding; pure vision of the outer and inner is very rare (*Maximen* . . . 243: *HA* 12, p. 398).

The manner of scientific inquiry, then, which Goethe proposes, is one which begins by thoughtfully exploring and arranging the circumstances and facts of experience. From these, knowledge of essential relationships arise. They are not to be expressed abstractly by such rules as: if these conditions prevail, then such-and-such occurs: Rather, the elements light, darkness, turbidity and color are all *seen* as a unity. Only our intellect breaks them down into cause and effect. In his late nineteenth-century study of Goethe's science, Rudolf Steiner connects this with Kant's distinction between *Verstand*, understanding or intellect, and *Vernunft*, reason:

> Let no one be deceived on this point, the [mathematical] unit is an image created by our Intellect [*Verstand*] which separates it from a totality just as it separates effect from cause, and substances from their attributes (1968, p. 62).

Goethe was well aware of Kant's distinction and interpreted it in his own manner. After a full empirical investigation, the highest faculty of the mind may grasp the newly perceived unity in a moment. In so doing it reaches beyond pure sense data; it reaches beyond the visible pattern to be discerned in nature itself. It reaches, for Goethe, to the ideal. The felt kinship between prismatic and atmospheric colors is possible only because reason has given us, through the archetype, a perception of the ideal. In conversation with Eckermann Goethe says:

> The Intellect [*Verstand*] cannot reach up to her [Nature]; a man must be able to rise up to the highest plane of Reason [*Vernunft*] in order to touch the Divine, which reveals itself in archetypal phenomena — moral as well as physical — behind which it dwells, and which proceed from it.[6]

The divine idea stands behind the archetypal phenomenon. It may manifest through natural phenomena or in the mind as concept. It quietly structures our very seeing and speaking:

> The Idea is eternal and unitary . . . All that of which we become aware and of which we can speak are only manifestations of the Idea; concepts we express and in as much as we do so the Idea itself is a concept (*Maximen* . . . p. 12: *HA* 12, p. 367).

The archetypal phenomenon is also unitary. Its impact can be so powerful that in the heat of discovery one meets it not so much with wonder as with fear and the faculty of analysis:

> Before the archetypal phenomenon, when it appears unveiled before our senses, we feel a kind of shyness bordering on fear. Sensible people save themselves through wonder: quickly, however, comes the busy pimp *Verstand* and would procure in his way the most precious with the commonest (*Maximen* . . . 17: *HA* 12, p. 36).

The unitary idea can, however, manifest and be left unmolested if we use reason in place of the intellect. Then also we will not be tempted to treat the achetype as just another theory from which to make deductions, predictions or draw conclusions. Five years before his death, Goethe wrote to Christian Dietrich v. Buttel:

> Moreover an archetypal phenomenon is not to be considered as a principle from which

manifold consequences result. rather it is to be seen as a fundamental appearance within which the manifold is to be beheld (3 May 1827: *HA Briefe* IV, p. 231).

Thus the archetypal phenomenon is neither to be arrived at by pure induction, nor are we to deduce consequences from it. It can, I think, be more fruitfully understood as akin to Aristotle's doctrine of forms, so dreaded by seventeenth-century philosophers. By this I mean that the seeming independence of empirical phenomena actually reveals an organic or unitary form after one rises to the level of archetypal phenomenon. Certainly one can go on to model the individual elements and establish mathematical relationships. In so doing one is not 'explaining' phenomena. but only re-expressing selected aspects in a theoretical language. Much is lost in the translation, although doubtless the procedure is highly useful and even harmless if undertaken with philosophical maturity. or as Goethe says. 'with irony.' If one were to follow Goethe, the archetypal phenomenon would be left in its native purity and simplicity. For the natural scientist:

should forbear to seek for anything further behind it: here is the limit. But the sight of an archetypal phenomenon is generally not enough for people: they think they must go still further: and are thus like children who after peeping into a mirror turn it round directly to see what is on the other side (Eckermann. 1964. p. 147).

Heinrich Henel characterizes Goethe's attempt as one which "wished to gain universals without abstraction" (1956, p. 651). Goethe, with Schiller's help. came to realize fully the boldness of this attempt. To bridge the gap between the real and the ideal, between the universal and particular, to bring these two worlds closer together seemed an unavoidable necessity:

We live in an age when we feel ourselves more compelled everyday to regard the two worlds of which we are a part. the upper and the lower. as linked: to recognize the Ideal in the Real. to assuage our occasional discontent with the Finite by an ascent into the Infinite (Viëtor. 1950. p. 156).

In his essay 'Indecision and Surrender,' Goethe wavers before the task and 'takes flight into poetry' (*HA* 13. p. 31; Goethe, 1952, p. 219). Yet the next day we find him composing his little essay 'Intuitive Judgement.' confident that he in his science had embarked upon the "adventure of Reason" which Kant reserved for the *intellectus archetypus*. that faculty of the mind "which proceeds from the

synthetically universal and advances to particulars" (*HA* 13, p. 30; Goethe, 1952, p. 223). The cognitive status which Goethe affords his 'theory' — the beholding of archetypal phenomena — is then quite other than that associated with instrumentalist, or positivist positions. Goethe is no nominalist. The Ideas of which he writes are real and potent, and are not to be confused with their sensible reflections in nature, nor with their mental image as concept. He is searching for the True and not just the fruitful. If he finds the former, he is confident the latter will follow. We do not have direct access to Truth:

The True is god-like: it does not appear unmediated. we must guess it from its manifestations . . . Only in the highest and most general do the Idea and the Appearance meet (*Maximem* . . . , 11 and 14: *HA* 12, p. 366).

In the archetypal phenomenon we may hope to unite what arises within as concept with that which confronts us as percept so that the Idea itself stands in experience.

Clearly Goethe's science strides far beyond the normally accepted bounds of strict scientific inquiry. About this one must be utterly frank. He is expanding the horizons of science to include the ideal in reality, to place spirit back into nature. He embraces metaphysics, but his is a *perceptual* metaphysics in which the ideal. Schiller's criticisms notwithstanding, does become experience. In this undertaking Goethe stands in a long tradition, as Ernst Cassirer mentions (1970. pp. 198—202); one which surfaces periodically and at times even dominates Western intellectual history. Goethe recasts the tradition in a highly unique and sophisticated manner. In his scientific investigations he seems everywhere to move patiently to and fro in the sense-realm rising from empirical through scientific to archetypal phenomena. The phenomenal world thereby becomes transparent for a supersensible reality:

. . . we cannot escape the impression that underlying the whole is the idea that God is operative in Nature and Nature in God from eternity to eternity. (*HA* 13. p. 31: Goethe. 1952. p. 219)

Goethe in his studies of that whole is seeking his God not so much 'behind the scenes' as through or even within the scenery of Nature.

One final important question remains: how are the boundaries of natural science, or more generally, of human cognition to be expanded? If Goethe is indeed hoping to rise to the ideal while remaining within the perceptual. through what means can such a development take place? The answer will be, through the transformation of man. The very method of investigation which Goethe has chosen may give rise to new faculties or organs of cognition.

BILDUNG

When confronted by any group of raw sense impressions, how is it that we come to 'see' them? It is a rich and complex question, one beyond our means to summarize, but we need a few results from cognitive psychology for a proper understanding of Goethe. The notion that we receive raw sensory reports and subsequently sort and order them according to a master algorithim leading to cognition has been discredited for the most part by vision research itself (Tibbetts, 1969). Even a minimum of experience with ambiguous figures like the Necker cube leads one rapidly to the conclusion that sight at least is far from a simple linear process. Studies of subjects surgically healed from lifelong blindness support the conclusion that there is a great deal more to seeing than a properly functioning eye. Phenomenologists have taken Brentano's concept of 'intentionality' as a basis for the discussion of the mental activity operative in vision. In that view the confused, swarming, chaotic field of colors and forms is structured unconsciously by the individual. From this standpoint we can ask whether one ever sees anything without seeing it *as* something. The central question of interest to us here is, if we do in some sense 'intend' our own reality, then is it perhaps possible to develop that faculty of intentionality so that reality is restructured in another and perhaps more illuminating way?

This turns on its head the usual view that the goal of clear-headed research is to free oneself from all preconceptions and prejudices. Hans-Georg Gadamer was perhaps the first to point out that while there are indeed bad prejudices, we must recognize "the fact that there are legitimate prejudices, if we want to do justice to man's finite, historical mode of being" (Gadamer, 1975, p. 245). To use the metaphor developed by Rorty (1979), we must free ourselves from the idea that the mind is a mirror-like glassy essence to be polished and freed of all imperfections. If we were truly to succeed in this undertaking, we would with the moment of success banish cognition or seeing from the psyche as well. Obviously this is not to imply that we may entertain prejudices without consequences. Quite the contrary, as we now realize that prejudices are, in fact, "the biases of our openness to

the world" (Gadamer, 1976, p. xv), one appreciates the power of 'bad' prejudices to create misunderstanding. Still, a 'tabula rasa' registers nothing. In this view, it is through our prejudices that we know the world at all. But let us drop Gadamer's dramatic use of the word prejudice and focus rather on man's 'historical mode of being.'

That we see is due to our historical mode of being: In other words, that we have lived as sentient beings in this world for 20 or 30 years is not without its consequences. In this facet of our nature, memory certainly plays an important role. But by memory different capacities can be meant. I may remember, for example, that the sum of any sequence of odd integers is a perfect square $(1+3+5+7=16)$. Certainly at one time at least, I thought about this fact even if was only to puzzle over what my mathematics teacher said.

I may also remember that my wife has red hair, but to do so presupposes that I noticed the color of her hair. Very few of us possess the faculty of eidetic imagery, photographic memory, which would allow us to recall details we have not thought about. Things thought about, whether percepts or concepts, are then one class of memories. They form one aspect of our historical mode of being. They do not, however, by any means exhaust it. Here we come back to the concept of 'tacit knowing' developed by Polanyi. When I sit down at the piano struggling to remember a Two-part Invention, I am certainly not calling forth a score into memory. I am not sure what happens, but musical memory translates immediately into actions — into will, without ever rising up into full consciousness. Examples can be multiplied easily: language learning, bicycle riding, writing and even more subtle abilities such as oratorical skill. Each of these faculties arises with practice, that is from work in or amongst the elements of that field. This is then a second aspect of our historical mode of being. It is like memory in that it connects past actions with the present, but is unlike memory in that it need not rise up into consciousness. To do so may in fact be fatal, as any good sports car driver will tell us.

It may be somewhat bolder to maintain that our normal faculty of sight arises in a manner analogous to this second aspect, but this has been cogently argued. What is of most importance for this discussion is the light it throws on the practice of Goethean science. From the preceding discussion we may recognize a concept familiar to us from the Romantic period, namely that of *Bildung* or the cultivation of faculities. The travels and apprenticeship of Wilhelm Meister provide him with much more than a head full of memories. The protagonist of a *Bildungsroman* deepens and matures through his travels. He sees the world differently for having passed through countless struggles. Odysseus returns home profoundly changed and it is that change, more than his specific conquests, which is of first importance.

Likewise for Goethe in his scientific writings, neither the eye nor the mind is viewed ahistorically. Rather each can be understood only in the context of historical development. Organs and faculties are shaped by their corresponding natural elements. The eye is shaped by the light:

> The eye owes its existence to the light. Out of indifferent animal organs the light produces an organ to correspond to itself; and so the eye is formed by the light for the light so that the inner light may meet the outer (*HA* 13, p. 323; Goethe, 1970, p. liii).

Very revealing in this regard is Goethe's uncompromising position taken in a conversation with Schopenhauer concerning the active nature of light:

> "What" he [Goethe] once said to me, staring at me with his Jupiter eyes, "Light should only exist in as much as it is seen? No! *You* would not exist if the light did not see *you*" (Goethe, 1901–1911, II, p. 245).

The active character of light or of phenomena more generally is central to a proper understanding of Goethe's *Weltanschauung*. Although in a distant past light may have called forth from passive animal organs the organs of sight, in the present day we must be active ourselves in the development of new faculties. We may possess innate talents, but these must be developed and schooled. The organs of human cognition so created move through the world as a magnet drawing forth from isolated natural phenomena their hidden unity:

> The faculties [*die Organe*] of man freely and unconsciously combine the acquired with the innate through practice, teaching, reflection, successes, failures, challenge and opposition and always again reflection, so that they bring forth a unity which astounds the world (Hiebel, 1961, p. 246).

The development of such organs of cognition demands profound transformations of the human psyche. Such transformations are effected precisely through scientific investigation. Goethe stands in awe before the magnitude of the change. In a letter to F.H. Jacobi he writes:

> To grasp the phenomena, to fix them to experiments, to arrange the experiences and

> know the possible mode of representations of them — the first as attentively as possible, the second as exhaustively as possible and the last with sufficient many-sidedness — demands a moulding of man's poor ego, a transformation so great that I never should have believed it possible.

The transformation of the human psyche occurs through concourse with natural phenomena. Just as the eye as 'sunlike organ' is created by the light, so organs of the mind may be created by each and every object about us. "Each new object, well contemplated, opens up a new organ within us" (*HA* 13, p. 38; Goethe, 1952, p. 235). Moreover, the pedagogical task which nature constantly enacts can be imitated and furthered in human creations. The formation or cultivation of human sensibilities becomes then the task of the arts, as Shelley will argue in his essay "Defense of Poetry" (1965).

Hence the boundaries of natural knowledge are pushed back in Goethe's science not by prosthetic devices such as telescopes, microscopes, photomultipliers and the like, but by the transformation of the individual human psyche. The most important business of education then becomes the schooling of faculties, not the mastery of information (Broudy, 1979, p. 446). Long after facts as explicit knowledge have disappeared from active memory, we will continue to perceive patterns, solve problems, and make discoveries by means of the faculties we have acquired. Polanyi will go so far as to declare that "all knowledge is *either tacit or rooted in tacit knowledge*. A *wholly* explicit knowledge is unthinkable (Polanyi, 1969, p. 144). The profound similarity between perception and scientific discovery which I have attempted to elaborate with regard to Goethe's struggle toward archetypal phenomena has been developed at great length in an independent context by Polanyi:

> I maintained that the capacity of scientists to perceive in nature the presence of lasting shapes differs from ordinary perception only by the fact that it can integrate shapes that ordinary perception cannot readily handle (1969, p. 138).

The recognition that scientific discovery proceeds by cognitive acts essentially similar to perception opens up a new route for the understanding of Goethe's archetypal phenomenon. It is what Polanyi would call a perceived coherence. Goethe would perhaps go further and call it the universal in the particular, the ideal in the real.

The German poet Novalis — who, we must recall, was also a mining engineer — writes eloquently concerning the organs needed for a full and profound vision of nature:

> But it is vain to attempt to teach and preach Nature. One born blind does not learn to see though we tell him forever about colors, lights and distant forms. Just so no one will understand Nature who has not the necessary organ, the inward instrument, the specific creating instrument, no one who does not as if spontaneously recognise and distinguish Nature everywhere in all things, nor one who does not with an inherent lust of Creation mingle himself by means of Sensation in manifold relationships with all bodies, and feel his way into them simultaneouly (1903, pp. 137, 108).

Although atrophied, the needed organs can be developed so that one may become "a sentient instrument of nature's secret activities" because, as Novalis writes, "Association with the forces of Nature, with animals, plants, rocks, stones, and waves must of necessity mould man to a resemblance of these objects" (1903, p. 141).

By refusing to translate seen phenomena into a hypothetical or abstract theory, the full value and content of the phenomenal world remains. The Ideal is not projected onto a limited conceptual grid which stands ready to hand. Rather, faculties adequate to the Idea are formed by reflection, practice and observation in the phenomenal field itself. The retention of the full value or content of phenomena was essential for Goethe who, we must always remember, comes to the arena not only as scientist but also as artist. For the artist is interested not only in 'conditions of appearance,' but also in the psychological value of colors, their effect on the soul, both individually and more especially in combinations. The seen archetype still possesses that value. It is a phenomenon and as such we need only shift our center of interest from the sensory to the 'moral' [*sittlich*] aspects of color. The dynamic polarity of light and darkness then becomes a metaphor for the vacillations and struggles of the soul. In this sense the final chapter of Goethe's *Theory of Colors* connects with the introduction in which he tells us that "Colors are the deeds and sufferings of light."

NOTES *

* Originally read at a joint symposium sponsored by the Boston Colloquium for the Philosophy of Science and the Departments of Germanic Languages and History of Science at Harvard University, 3—4 December 1982. It is a pleasure to acknowledge the very considerable assistance which Professor Frederick Amrine so willingly provided in matters of both content and style. His criticisms served always to clarify and strengthen this essay. I owe much also to conversations with Professors Ron Brady, Alan Cottrell and Mr. Christopher Bamford.

1 On Aristotelian and corpuscular physics, see J. L. Heilbron (1982), pp. 11—38.
2 Goethe, quoted by A. Wachsmuth (1966), p. 6.
3 Mayer (1893), p. 181, quoted by Duhem (1974), p. 52.
4 Cf. Gernot Böhme's piece in this volume.
5 Goethe, from a letter to Soret, 30 December 1823, quoted by Rike Wankmüller (*HA* 13, p. 616).
6 Eckermann (1964), 13 Feb. 1829, p. 144.
7 Goethe (1846), p. 198.

BIBLIOGRAPHY

Broudy, H. S.: 'Tacit Knowing as a Rationale for Liberal Education'. *Teachers College Record* **80** (1979) 446—462.

Cassirer, E.: *Platonic Renaissance in England* (trans. by J. P. Pettegrove), Gordian Press, New York, 1970.

Descartes, R.: *Discourse on Method, Optics, Geometry and Meteorology* (trans. by P. J. Olscamp), Bobbs-Merrill, Indianapolis, 1965.

Duhem, P.: *The Aim and Structure of Physical Theory* (trans. by P. Wiener), Athenaeum, New York, 1974.

Duhem, P.: *To Save the Phenomena* (trans. by E. Doland and C. Maschler), Univ. of Chicago Press, Chicago, 1969.

Eckermann, J. P.: *Conversations with Goethe* (trans. C. O'Brien), Ungar, New York, 1964.

Fontenelle, B. de: *Entretiens sur la pluralité des mondes*, Marabout Univ. (Gerard and Co.), Marabout, 1973.

Furley, D. J.: 'Aristotle and the Atomists on Motion in a Void', in *Motion and Time, Space and Matter, Interrelations in the History and Philosophy of Science* (ed. by P. K. Machamer and R. G. Turnbull), Ohio State Univ. Press, Columbus, 1976, pp. 83—100.

Gadamer, H.-G.: *Philosophical Hermeneutics*, Univ. of California Press, Berkeley, 1976.

Gadamer, H.-G.: *Truth and Method* (trans. by G. Barden and J. Cumming), Seabury Press, New York, 1975.

Galilei, Galileo: *Dialogues Concerning Two New Sciences* (trans. by A. de Salvio), Dover Publications, New York, 1954.

Goethe, J. W. von: *Briefwechsel zwischen Goethe und F. H. Jacobi* (ed. by M. Jacobi), Weidmann, Leipzig, 1846.

Goethe, J. W. von: *Goethe's Botanical Writings* (trans. by B. Mueller), Univ. of Hawaii Press, Honolulu, 1952.

Goethe, J. W. von: *Goethes Gespräche*, Biedermann, Leipzig, 1901—1911.

Goethe, J. W. von: *Theory of Colours* (trans. by C. L. Eastlake), M. I. T. Press, Cambridge, Mass., 1970.

Hanson, N. R.: 'The Logic of Discovery', *Journal of Philosophy* **55** (1958) 1073—1089.