geochemistry are more or less ignored. Overall, the book carries a strong flavour of the 'school' of Garrels and Mackenzie, innovative and interesting at one time, but that time was nearly 20 years ago.

Consequently, several evenings of rather laborious reading failed to provide this reviewer with much additional insight into the subject. I make an exception for the final chapter, as yet unmentioned, an interesting and usefully controversial comment by Jan Veizer on the evidence for cyclicity as he sees it manifested in detrital sediments. The treatment here is lively and accessible, although somewhat vitiated by an unfortunate and rather unhelpful insistence on a division between evolutionist and cyclist perspectives on the matter.

Still, no coherent overview emerges of the magnitude of geochemical cyclicity in the history of the Earth, nor does the book necessarily persuade the sceptic that the concept is worth taking seriously. It is also far from clear what the intended audience is, as is so often the case with the multi-authored 'syntheses' that are springing up across the literature like toadstools in the autumn. The contributions are either too short and obscure to be introductions to the field for outsiders, or are too elementary to spark an interest in the specialist.

The test of a volume such as this is whether its whole is better than the sum of its parts; I would argue that in this case we would have been better served if the few segments of original writings had been presented in suitable journals (which, incidentally, also would have ensured better editorial quality control). As it is, the book will rest on many a library shelf after having consumed monies that might have been used better for other works. I doubt that it will be widely consulted, or will be found to have been a source of inspiration after another decade of research has passed. □

T.H. van Andel is in the Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK.

Clash of cultures

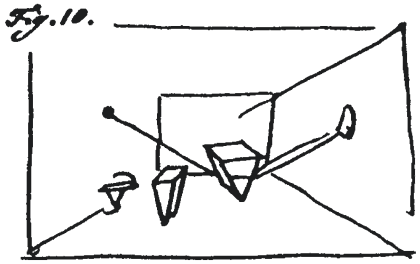
J.D. Mollon

Goethe contra Newton: Polemics and the Project for a New Science of Color. By Dennis L. Sepper. *Cambridge University Press: 1988. Pp. 222. £27.50, $39.50.*

How astonished I was, then, when the white wall, observed though the prism, remained white just as before; that only there, where darkness adjoined on it, did a more or less distinct color appear. . . . It did not take much reflection for me to recognize that a boundary is necessary to produce colours, and I immediately said to myself, as if by instinct, that the Newtonian teaching is false.

IT IS this unashamed admission, placed at the end of the *Farbenlehre*, that has always coloured the response of the scientific establishment to what Goethe himself saw as his greatest contribution. Under pressure to return the borrowed prism, Goethe made the most casual and hurried observations, wrongly supposed that newtonian optics were contradicted by what he saw, and set out on a vast, vain attempt to build a rival synthesis of colour science. For the poet and *Literat*, white could not be a composite: nature is not to be rent by torturing experiment and abstraction, just as a work of art should not be subjected to an analysis that destroys it.

Sepper's purpose is to show us that this caricature is inadequate. Goethe, he argues, had a subtle and well-considered view of the nature of scientific method, had good grounds for questioning Newton's implicit presuppositions, and had even better grounds for criticizing the



A drawing from Goethe's notebooks showing what he called the "objective" and "subjective" ways of using the prism: a newtonian spectrum is being formed objectively and is here being viewed subjectively through another prism.

degenerate accounts of newtonian optics that are found in eighteenth-century compendia of physics. To illustrate Goethe's method, Sepper gives a detailed summary of the first of the *Beiträge zur Optik* (1791), which describes an ordered sequence of experiments on the appearance of edges when viewed through prisms. For Goethe, the purpose of experiments is to allow the phenomena to show themselves, in a way that is controlled but is uncontaminated by hypothesis or by the observer's more general *Vorstellungsart*. A single experiment cannot stand on its own: the conditions must be systematically varied — contrasted, simplified, recomplicated — to show the relationship of one phenomenon to another. This is the manifolding of experiments that Goethe calls *Vermannigfaltigung*. Sepper draws our attention to the essay *Der Versuch als Vermittler von Objekt und Subjekt* (1793), which makes explicit the scientific method mostly only implicit in the earlier *Beiträge*.

One large section of Sepper's book does seem out of place, and that is the part given over to knocking Newton. The points that Sepper makes against Newton (for example, the ambiguous status of the ray — as an observed phenomenon and as a theoretical construct; and the inadequacy of the *experimentum crucis* as a refutation of Hooke) are indeed in the spirit of Goethe, but in their detail they owe more to the analyses published by newtonian scholars since 1960.

Sepper explicitly sets up Newton and Goethe as contemporary rivals, and this is artificial. Colour science did not stand still during the eighteenth century, and many concepts and observations were available to Goethe at the publication of the *Farbenlehre* in 1810 that were not available to Newton in 1672. Goethe is given much credit by Sepper for his survey of 'physiological' colours (for example successive and simultaneous contrast); but these phenomena are richly described in the eighteenth-century literature, and by 1810 the better commentators had firmly made the categorical distinction between those aspects of colour that needed physical explanation and those that needed physiological explanation. (It was a newtonian physicist, Lichtenberg, who first clarified the distinction for Goethe — see H. Lang *Photorin* **6**, 12–31; 1983.)

Against Newton and in favour of Goethe, Sepper cites (pp. 14 and 156) the modern demonstrations of colour constancy by Edwin Land, which show us (or rather, remind us) that there is no fixed relationship between the refrangibility of light and the hue perceived. But as I have related in *The Listener* (**113**, No. 2891, 6–7; 1985) the latter observation had already been made, and the nature of colour constancy lucidly explained, by the establishment scientist, Gaspard Monge, two decades before the publication of the *Farbenlehre*. Monge grasped the relationship between colour constancy and coloured shadows, and he proposed, as Land did a long time later, that hue depends on the ratio of different components in the spectral flux, rather than upon their absolute values. The paper that Monge gave to the Royal Academy of Sciences in 1789 was well known to his contemporaries; and we know, from a reference in Goethe's notebooks, that Goethe was aware of it (*Goethes Werke, Abtheilung II: Naturwissenschaftliche Schriften Band V: Paralimpomena*, p.132; Weimer, 1906).

. . . and one does not stop to wonder, through what incredible lapse of thought so outstanding a man not only deludes himself at the outset, but lets the error so take root, that against all evidence, indeed against all conscience, he clings to it thereafter and invents one unseemly experiment after another, in order to hide his initial inattention from his inattentive pupils [Goethe, *Farbenlehre, historischer Teil, achtzehntes Jahrhundert: "Isaak Newton"*].

J.D. Mollon is in the Department of Experimental Psychology, University of Cambridge, Downing Street, Cambridge CB2 3EB, UK.