Form in the Mineral Kingdom

The Scientific Reinterpretation of Form. NORMA E. EMERTON. Cornell University Press, Ithaca, N.Y., 1984. 319 pp., illus. $29.95. Cornell History of Science Series.

That the organization and individuality of every species of matter were due to something other than the matter itself was a fundamental tenet of ancient philosophy. Transcendent, as with Plato, or immanent, as with Aristotle, that something was known most generally as "the form." The form was so inextricably bound up with matter in perceptible bodies that it could never be isolated except by philosophical analysis; nevertheless its independent existence was hardly questioned for two millennia. Matter was passive, and without form it could have no shape, purpose, meaning, direction, or any other specific characteristic.

The concept of form is most easily grasped in the organic realm. If we are without specialized knowledge, even now common sense still assures us that the form of the oak tree, for example, is in the acorn, just as common sense still assures us that the sun rises and sets. Emerton has wisely left most discussion of organic form aside, however, in order to focus on the somewhat simpler case of mineral form.

Even so the story is a complex one. In his *Metaphysics* Aristotle had defined form as "that by reason of which the matter is some definite thing." Aristotle strove to maintain an ontological balance between matter and form and "criticized both the materialistic atomists who ignored the form and the Platonists who overemphasized it" (p. 49). But in the long centuries of Aristotle's philosophical dominance the views he had promulgated were more often than not modified by influences external to his own system: the preeminence of light as first form from Platonizing Augustinian theology, forms as the seminal reasons (*logoi spermatikoi*) of the Stoics, form as the geometry of the world-shaping Platonic solids, form as world soul—be it conceived as Plato's Demi-Urge, as an alchemical Archeus, or as the astrological "power of the heavens." In the Lovejoy tradition of the history of ideas, Emerton's work presents a rich panorama of the uses to which the concept of form was put in the Middle Ages, Renaissance, and early modern period.

Although some philosophical variants involved a "low" view of form that associated it very closely with matter, more often the thinkers discussed by Emerton preferred an "exalted" concept of form that associated form with divine activity. The scientific reinterpretation of form, however, which is the primary focus of the book, required that form come to be identified with particular aspects of matter itself. Of importance in this process was Aristotle's "mixtion" theory (for what we would now call the formation of chemical compounds), and also the concept of "minima" associated with it. Minima were conceived as the smallest "parts" of a substance that still possessed the form of the whole—a concept not very different in some ways from that of the modern chemical molecule.

To a certain extent minima proved to be more useful in the scientific reinterpretation of form than did atoms. "Atoms were the ultimate building blocks of all matter, solid and indestructible, whereas minima were not fundamental particles but a temporary state of matter enabling change to take place, and their function was to be the vehicle of the form—a conception that was meaningless in atomistic terms" (p. 90). Given various reinterpretations from the 16th to the early 19th century in terms of corpuscles and in terms of form-bearing chemical or geometric "seeds," "spirits," and the like, minima eventually became the "integrant molecules" of the crystallographers—those smallest parts of a crystalline substance that have the "primitive form" of the whole.

Omitted from Emerton's account of the scientific reinterpretation of form, however, is any serious discussion of the long parallel evolution of the chemical concept of the element that culminated in the work of Lavoisier. The chemists had effectively destroyed the ancient concept of one common matter, the concept of matter that had required the concept of form for its differentiation in the first place. In their lists of differentiated and nontransmutable substances the chemists had already coalesced matter and form by insisting that the matter of each element was distinctive. It was then possible to coalesce the concept of minima with the concept of atoms, which is what Dalton did in describing the atoms themselves as differentiated—as the smallest form-bearing parts of the differentiated elements. But even if those aspects of late 18th- and early 19th-century chemistry should be included in a more comprehensive reconstruction of the scientific reinterpretation of form, Emerton's book offers an excellent account of the transition from philosophy to science in the development of mineralogy and crystallography. Her way of conceptualizing the problems involved is significant and may well prove useful to others attempting to define the rise of modern science.

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