

this reflects the author's special interests, a historiographic tradition, a judgment about the book's readers, or the actual history of zoological publishing.

Knight's special concern is not with bibliophilic matters, however; rather, he wants to investigate the place of these books within the history of the science of zoology. How do the texts and pictures of these books fit together? What scientific attitudes and theories do the pictures embody? What can these sumptuous publications tell us about the social organization of zoology in a given period? How have their scientific functions changed over the past 500 years? These are certainly the kind of questions "an essay towards a history of printed zoological pictures" ought to take up. And Knight makes many astute observations about the ways pictorial works exemplified the zoology of their times: how, for instance, the high cost of plates in books was subsidized by their prior publication in journals, how the grouping of animals in a single illustration displayed the author's ideas about classification, how Darwinian theory encouraged artists to show animals against the background of their natural habitat and to record individual variations within a species. It is unfortunate but excusable in "an essay towards a history" that the author has not drawn together these observations into a more general argument about the scientific functions of zoological illustrations.

What is harder to forgive, though, is his neglect of the artistic content and context of zoological illustrations. The point here is not the beauty or ugliness of these pictures—Knight disclaims any intention of assessing them "by purely aesthetic criteria," although in fact he often does rate them on their attractiveness—but rather the decisions that determined the final composition and rendering of the image. In the introductory chapters, he raises some pertinent questions about the constraints imposed on the artist by prevailing artistic conventions, by the zoologist and publisher, and by the printing process; but he does not go on to consider how the artist dealt with these constraints in practice and solved the tricky problems of presenting complex scientific information visually.

As a rule, we realize how much these matters determine our response to a picture only when the artist's solution has been especially incongruous or especially apt. Consider, for example, the romantic choice of a moonlit ruined castle as the background for the picture of bats in Buffon's *Histoire naturelle* (figure 56), or the deft use of cast shadows to create

the illusion of scarabs walking across the page of Martyn's *English Entomologist* (figure 68; reproduced here), or the ingenious folding of a long, sinuous eel to tuck it into a small space in Playfair and Günther's *Fishes of Zanzibar* (figure 23). The general naïveté of non-artists about the construction of convincing visual images makes it all the more important that a book on the history of zoological illustrations pay attention to these sorts of issues. Moreover, it can be done very well: see, for example, Robert Herrlinger, *History of Medical Illustration to 1600*; David Woodward, Ed., *Five Centuries of Map Printing*; and Ann Blum and Sarah Landry, "In loving detail," *Harvard Magazine*, May–June 1977, pp. 39–51.

Finally, an illustrated book about illustrated books invites comment on its own appearance and production. This book comes off very badly in comparison to the works it describes. The index is wholly inadequate, the bibliographic entries idiosyncratic in form, the text marred by a great many typographical errors. Knight's disregard for the visual aspects of illustration seems to have carried over into the handling of the figures. The pictures are not keyed to the text. The captions are uninformative: even in the chapter on techniques of zoological illustration, the captions do not specify how the drawings were reproduced. A still more striking sin of omission is the failure to name the artists of the pictures in the captions. Worst of all, the pictures themselves are printed here in muddy grays and exaggerated blacks and show through the thin paper. What should have been a delight to see and read is, as a result, a sad disappointment.

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French and British Studies

Essays and Papers in the History of Modern Science. HENRY GUERLAC. Johns Hopkins University Press, Baltimore, 1977. xx, 540 pp. \$20.

Historians of science will be happy to have these papers conveniently collected in a single volume, though few if any of the essays will be new to them. Word of the publication of a paper by Guerlac has regularly sent historians to seek it out, even in the most recondite of places. Urbane, literate without ostentation, occasionally enlivened with wit barely con-

cealing a sharp needle, Guerlac's work was a school in which many of us learned the art of marshaling evidence to bring to bear on carefully defined historical problems.

Here there are brought together 33 of the more than 50 articles Guerlac has written, one as early as 1943 and the remainder dating from 1950 through 1976, ranging in subject from general aspects of the history of science through Newtonian science and Lavoisier and the chemical revolution to science in French culture. Whatever their subject, the majority of the papers illustrate the author's inclination to work "in small form," as a kind of historical detective piecing clues together to solve some persistent interpretative puzzle. There is inevitably some repetition, and, as is exemplified by the difference between the biographical sketch of Stephen Hales (of 1972) and the earlier (1951) "The Continental reputation of Stephen Hales," there are some minor corrections of fact as other investigators added their meed of information to Guerlac's own studies.

Each reader will have his or her own favorite selections. Among mine are "Francis Hauksbee: Expérimentateur au profit de Newton" combined with "Newton's optical aether: His draft of a proposed addition to his *Opticks*," where one goes from a reasoned inference, in the first, to demonstration by documentation, in the second, of the influence of Hauksbee's work in returning Newton to aetherial hypotheses. Another set is "The origin of Lavoisier's work on combustion" combined with "A curious Lavoisier episode," showing the influence of Guyton de Morveau's experiments on Lavoisier's and on the original phrasing of his famous "sealed note," changed in publication to conceal competition with his French contemporaries. And, in a different and more reflective mood, there is the discussion of Montesquieu and natural laws of society in "Humanism in science" combined with "Three eighteenth-century social philosophers: Scientific influences on their thought," which deals with Montesquieu, Voltaire, and the Baron d'Holbach.

Rereading "Lavoisier and his biographers" makes one wish that Guerlac would just once transcend his preference for articles over books to write the biography of Lavoisier that only he could write. And of course one does not always agree with his interpretations. Although Guerlac admits that the French "mathematical positivists" probably understood Newton less than the British experimentalists, he is himself too much

the admirer of the French to escape their positivism, as is revealed in his description of Newtonian ontological views as "a psychological prop" and a "heuristic aid." Nor, in view of Black's explicit rejection (in his *Lectures*, vol. 1, pp. 282–283) of attraction as a means of explaining chemical combinations, can I accept Guerlac's arguments in "The background to Dalton's atomic theory" for the importance to Cullen and Black of Newtonian force concepts.

For all one's minor objection to some of the conclusions of these papers, together they constitute an instructive and

readable introduction to some of the problems of 17th- and 18th-century science and to the range and subtlety of mind of one of the major practitioners of the history of science. My only strong objection to the book is the autumnal flavor of the foreword and introduction. I must protest their implication that we are not to continue to be instructed and goaded in our research by a continuation of papers by Guerlac.

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Struggles and Success

Lunar Impact. A History of Project Ranger. R. CARGILL HALL. National Aeronautics and Space Administration, Washington, D.C., 1977 (available from the Superintendent of Documents, Washington, D.C.). xviii, 454 pp., illus. \$6.25. NASA History Series. NASA SP-4210. Stock No. 033-000-00699-3.

The first close-up photographs of the lunar surface, obtained in mid-1964, opened a new era by bringing the moon into the purview of experimental science. The photographs almost to the last appeared to be unattainable. Many advanced machines had to be designed to provide them, and the difficulties encountered in the task were not only ones of engineering, but ones of management as well. This is the theme of Hall's well-researched and excitingly written history of Project Ranger, conducted by NASA and the Jet Propulsion Laboratory (JPL) of the California Institute of Technology in the years 1959 to 1965.

The design of Ranger began as the Explorer and Mercury projects attained their successes and during the Army's Pioneer and NASA's Atlas-Able programs. The stated mission of the Ranger project emphasized sending a satellite to the moon and conducting some experiments during the flight, but the question of what experiments it would do along the way and before impact gave rise to much perturbation before the first successful flight. NASA, being a civilian agency, was more susceptible than the military to outside influences, and early planning for Ranger involved many tensions. One major tension existed between the designers, who wanted a fail-safe system with redundant backup, and

the experimenters, who wanted to load as much scientific apparatus as possible on the capsule, even if backup had to be sacrificed. Another tension came from the differences between the points of view of sky and planetary scientists. The former desired information about the region above the earth's surface and the latter saw the project as an opportunity to learn more about the moon and other bodies of the solar system. The two groups argued for different experiments. Compromises were designed to placate both sides. The problems multiplied when the Air Force insisted that because it developed the Atlas rocket and commanded the launch facilities it should control launches.

Other factors, too, affected decision-making, and Hall effectively integrates these into his narrative. For example, NASA, then a fledgling agency, found it desirable to oversee the early work of contractors by committee; the armed services conducted programs for research on missiles and rockets and created confusion because of inter-service rivalry; and, not least, the times were highly charged with a competitive spirit, stimulated by Sputnik, that made many conclude that the United States must reach the moon before the Soviets. For the first five Rangers these problems were not satisfactorily resolved. Consequently, designs were weak and the missions failed—at first owing to Atlas failures.

After Ranger 5 failed the program was overhauled, with great distress for JPL, which had to bear the brunt of everyone's discontent. Fortunately, by that time NASA had resolved its manage-

ment difficulties, and subsequent activities were directed in a more hierarchical fashion. And along the way a new view of the space program was taken by the Kennedy administration, and manned lunar missions received first priority. These developments helped to rigidify Ranger's mission, and engineering became uppermost because of its importance in ensuring the return of information that would be valuable in making Apollo flights safe. In this way planetary scientists won a partial victory in that a few of their experiments were included. Of course, this offered the potential for a new set of tensions, but they were avoided by good management practices.

Although the increasing accomplishments of the Ranger program could not be appreciated during the stress of trying to achieve success, Hall notes that they were many and varied. Pointing to the greatest value of Ranger, he writes,

Perhaps more than any other flight project, Ranger proved the technologies and the designs for the automatic machines NASA would use for deep space exploration: attitude stabilization on three axes, onboard computer and sequencer, directional scientific observations, midcourse trajectory and terminal maneuver capability, and steerable high-gain antenna.

In addition, Ranger scientists developed the Deep Space Network, using a two-way Doppler tracking and communication system that aided accurate trajectory computation. And, most impressive, the last three Rangers returned excellent photographs of the lunar surface made with the use of a camera developed by RCA.

Hall presents all these events in an engaging manner, and he portrays warmly the struggles with design, construction, and preparation for launch, the complete and partial failures, and the attainment of success. Hall has been careful not to let himself be deflected from his main theme by effects on the project that were generated by persons or institutions beyond NASA. There are instances, however, when some further information or slight repetition would aid the reader. The number of offices and companies involved in the project increases as the story unfolds, and their various roles are not always made clear. The central role of JPL in the story tends to minimize the contributions of others, but at the same time we receive only occasional glimpses of how work on the Ranger program affected other JPL activities. Even so, the book resembles a mystery story to which you know the ending but which you feel compelled to complete in order to learn how the obstacles were overcome.