Book Reviews

The Anthropology of Mathematics

Evolution of Mathematical Concepts. An Elementary Study. RAYMOND L. WILDER. Wiley, New York, 1968. xx + 234 pp., illus. $8.

A mathematician all too frequently is regarded by the man in the street as one who has exceptional number facility—a counter-caster, as Shakespeare has Iago meanly call Cassio. Psychology has shown, however, that mathematical ability has more subtle and more elusive facets; and Jacques Hadamard in 1949 sought to identify, in *The Psychology of Invention in the Mathematical Field,* the factors at work in the creative process. The volume under review deals with a complementary aspect of the problem, one which might be described as the anthropology of invention in the mathematical field, for it concerns chiefly "the evolution of mathematics as a cultural organism." Forces operating on an individual are not generally discussed, for serendipity, while also important, belongs more properly to psychological studies. Unlike the efforts of the individual, the author argues, cultural change, such as that which mathematics is undergoing at the present time, may gain such impetus that it cannot be diverted from its course. The book is motivated by "the desire to determine, if possible, how and why mathematical concepts, such as *number* and *geometry*, were created and developed"; and despite the eminence of the author in mathematical research, the material is presented from "the standpoint of an anthropologist, rather than that of a mathematician." Appropriately, the only portrait in the volume is a frontispiece likeness of E. B. Tyler, the English anthropologist.

Attempts to account for the development of mathematics are not exactly new, for Herodotus in the 5th century B.C. attributed the origin of geometry to the practical need in Egypt for redrawing boundaries following each annual flooding of the Nile. Wilder avails himself of the tools of modern social science to probe with more sophistication into the interactions of mathematicians with the society in which they operate and into the internal pressures within the subject itself; but here too one suspects occasionally a modicum of oversimplification. Citing with approval the thesis of L. A. White that the use of symbols distinguishes man from other animals, he tells us that "It is *symbolization* that not only makes cultures possible, but furnishes the means for their continuity and growth," and that "Counting is, then, a *symbolic process* employed only by man, the sole symbol-creating animal." Modern mathematics does confirm the importance of good notations, but haunting suspicion that the role of symbolism may have been hyperbolized rises when one recalls the glorious nonsymbolic achievements of Greek geometry, the Arabic development of a rhetorical algebra, and evidence that animals do indeed count. Again the facile suggestion that the decline in Hellenistic mathematics may have been due to failure to advance in symbolism begs a counter suggestion that perhaps this same "failure" could account also for the earlier rapid rise in Hellenic mathematics.

The author describes his volume as a book *about* mathematics, rather than a contribution *to* the subject; and in order to avoid technicalities he has focused attention on two elementary aspects, the concept of number and the role of geometry. Almost a full chapter is devoted to the clarification of the idea of a real number, but the cultural foundations of negative and imaginary numbers are barely touched upon. The evolution of geometry receives less ample treatment than that of number; and one regrets that, perhaps influenced by the level of the exposition, the author did not apply his principle of internal (hereditary) and external (environmental) stresses to the problem of why mathematics in the 17th century exhibited so inhospitable an attitude toward projective geometry. Incidentally, the suggestion that the solution of the problem of the parallel postulate in geometry was the result of insight gained through the formal character of axiomatic systems in algebra appears parlous, in view of the fact that non-Euclidean geometry appeared in Germany, Russia, and Hungary *before* postulational algebra arose in England.

Wilder's book is not intended to be a definitive treatment of its subject—to determine how and why mathematical concepts were created and developed—for it represents something of a pioneering effort in this direction. Few readers will accept every statement as firmly established; but fewer still will fail to enjoy the novel approaches, the suggestive insights, and the penetrating views concerning the forces which have brought mathematics into being. The author writes with exceptional clarity, with wide historical acquaintance, with thorough mastery of the mathematical material, and in an attractive style. His keen perception and judgment in emphasizing what is important makes the book particularly rewarding reading, and additional pleasure is afforded in that proofreading has come as close to perfection as is humanly possible. For those who insist on a happy ending, the book closes on an optimistic note: "The present-day situation in mathematics is made all the more interesting by the realization that there cannot, because of the cultural nature of mathematics, ever be an end to its evolution."

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Renaissance Essays

Reflections on Men and Ideas. GIORGIO DE SANTILLANA. M.I.T. Press, Cambridge, Mass., 1968. xiv + 381 pp., illus. $15.

In this handsome book, Giorgio de Santillana has brought together the scattered articles and occasional papers he has published during the past quarter century. Santillana is perhaps best known for his *Crime of Galileo*; these assembled pieces disclose the range of his interests and—as Hugh Trevor-Roper admiringly says in his foreword to the book—the extraordinary range of

his humane culture. Santillana is both historian of science and man of letters. For the most part these are essays in interpretation—imaginative, suggestive (if not always convincing), and sometimes polemical, written with wit and irony and that sort of throw-away audacity so typical of his conversation and, I suppose, of his teaching.

The most sober-sided of these papers are the two earliest in date: his discussion of "Scientific Rationalism," originally published in the *International Encyclopedia of Unified Science* in 1941, and his "Eudoxus and Plato" (1949). Among the more recent articles are the sympathetic portrait of Leonardo da Vinci and an admirable piece on Paolo Toscanelli seen in the milieu of Florentine artists and architects. This important theme—the relation of the Italian Renaissance to the rise of early modern science—Santillana had earlier treated in a study reprinted here on the role of art in the scientific renaissance.

In one of his essays Santillana borrows a phrase from Nietzsche: "every mold of our thought was created in Greece during the earliest centuries." True or not (this is the sort of challenge he likes to throw out), it is true of Santillana's way of looking at the history of thought. For him, Greece is the touchstone; and the Italian Renaissance (its reincarnation) is his second love. Galileo is the central symbolic figure linking the Ancients with the Moderns. Of course this way of viewing the rise of modern science is no longer fashionable—indeed, it was the interpretation of men of the 18th-century Enlightenment. But there are signs that historians of science are having a change of heart, and Santillana may help free us from too exclusive a dependence upon the schools of Duhem and of Thorndike.

These essays, in Santillana's typical manner, defy the chronological and subject boundaries of the great men and great ideas he treats. Niels Bohr appears in a discussion of Bruno and Leibniz; Valéry and Heraclitus in the paper on Einstein; and, of course, the Oppenheimer affair is compared (point by point) with the Inquisitional trial *de vehementi* of Galileo. For Santillana unity of thought is a unity in time as well as between disciplines.

The Renaissance had its powerful rhetorical current, where verbal *persuasio* and the arts of language meant more than syllogistic logic or the concern with prosaic fact. And this, one feels, is true of Santillana. He has an amused disdain for pedantry and the more fusty kinds of scholarship, indeed sometimes for facts. This is true not only in the funny takeoff on Diogenes Laertius (a sketch of his one-time colleague Norbertos Vindobonensis) but even in his other pieces, which, I suspect, should be viewed sometimes as satires on the more "square" forms of scholarly writing. Santillana's purpose more often than not is to suggest a mood, an attitude toward his subject. This he does by an impressionistic approach, a beguiling style, marked by deliberate bits of mystification, verbal sorties, and swift evasive action. These, I repeat, are the essays of an amusing, thoughtful man of letters. They should be read *cum grano salis* for the sheer pleasure they give, but not by the uninitiated.

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Plant Pigments

Comparative Biochemistry of the Flavonoids. J. B. HARBORNE. Academic Press, New York, 1967. vii + 383 pp., illus. $16.

When an acknowledged expert writes a book on his subject, it is almost certain to be a good book. This is particularly true when no comparable treatment of the subject has appeared for 40 years. Considering the great interest in the flower pigments from the viewpoints of genetics, horticulture, and chemical taxonomy, it is indeed remarkable that no one has attempted to treat the biochemistry of this group of substances since the late Mrs. M. W. Onslow, the second edition of whose book on the anthocyanins appeared in 1925. In the interim there have of course been a number of reviews, and the purely chemical side was treated by Dean and by Geissman in the early 1960's, but the biochemical and biological viewpoint has waited an unconscionably long time for incorporation into a full treatment. Unlike Mrs. Onslow, furthermore, Harborne covers all the members of the group—flavones and flavonols, isoflavones, the curious *C*-glycosyl derivatives, and even the unrelated "nitrogenous anthocyanins" or betacyanins, with indolic and other bases.

Thoroughness is the keynote. Not only the formulas but the occurrence in plants is given *in extenso*. The fantastic Table 1.6 has the modest heading "*Rf* Values and Sources of All Known Anthocyanins" and gives R_f's in four solvents and the genus and species of the principal source for each substance; it is five pages long. A page of spatial formulas gives the structures of all the known carbohydrates found in flavonoids. Absorption peaks are listed wherever they are known. Literature references from 1835 to 1966 cover 21 pages.

Chemical taxonomy provides a second major part of the book's interest, and many pages of tables list the red, blue, purple, and yellow pigments of dicotyledons, monocotyledons, and gymnosperms wherever they have been identified. It is notable how many plants have leucoanthocyanidins in their leaves, and since these are converted readily to anthocyanidins on being warmed with acid the chemical taxonomist can be easily confused by them. Horticultural varieties, of course, provide other sources of complication, as the Robinsons long ago found.

The least satisfactory part of the book is that dealing with physiology. Although light is a major factor in the formation and interconversion of flavonoids, the role of light in controlling anthocyanin formation is given brief and rather superficial treatment. The numerous action spectra—different in different plants—are neither presented nor discussed. Although the author notes that the application of probable precursors (other than sucrose) almost never increases anthocyanin formation, he does not make the obvious deduction, namely that substrate is not the limiting factor. The corollary, that one or more enzymes are the limiting factors, is the key to understanding all the experiments with purine antagonists, antibiotics, and ribonuclease, for these all point to the generalization that control is exercised primarily at the level of *enzyme formation*. A grasp of this point could have given the physiological discussion a unity which it does not possess.

The book has no fewer than four indexes—of subjects, authors, plant names, and plant families—a feature which makes it excellent for reference and which one could wish to see more often, for good indexing is some indication of the care and thought which have gone into a book's preparation.

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