of his life and after his death, Banneker was frequently invoked as an example of racial equality and as justification for the abolition of slavery. Thomas Jefferson responded to Banneker's first almanac (1791) by declaring that he had given proof "that nature has given to our black brethren talents equal to those of the other colors of men, and that the appearance of a want of them is owing merely to the degraded condition of their existence, both in Africa and America."

In the many years since Banneker's death, the retelling of his feats has led to what the author terms "erroneous exaggerations." The image of Banneker created in the last century and a half led Bedini to reexamine the few documents from Banneker's life which still remain and to attempt to put the early American scientist into the context of his own times. This life of Banneker is convincing and, unless substantial new material appears, definitive.

Traditional historical methods, such as using every ingenuity to uncover extant records, have been well employed, but the author's major contribution is the close examination of Banneker's mathematical notebooks which has permitted for the first time a solid determination of Banneker's place among his contemporaries. From this study, the author concludes that Banneker was "a man of modest ability and performance, who, by means of his efforts, contributed a tangible bit to the fabric of science in America."

Perhaps the most impressive features of Banneker's life were not his almanacs but his self-education and establishment of a dignified life in a society which surrounded him with legal sanctions because of his race. He lived alone on a farm; he was harassed by neighbors and even renters of his land. He grew to meet the approaches of others with a wariness and distance, but to those he trusted he showed generous hospitality. At several crucial moments in his life he was befriended by the Ellicott family, who served as his link with the American scientific community, such as it then was. His existence, in spite of his work and productivity, was always precarious.

Some of the information the author has gathered suggests that the psychological elements of Banneker's life might be worthy of further examination. A key person for him was his maternal grandmother, an indentured Scotswoman who, when freed, bought a farm which she worked. Later she added two slaves, but eventually freed them and married one of them. She taught her grandson to read, helped him with simple arithmetic, and gave him encouragement. His own isolated life was similar in many ways to the one she had led, although he never married. His family's experiences, its compromises with white society, may have been the reason his outlook never lost an underlying pessimism. It is no longer necessary to exaggerate Banneker's efforts in order to vindicate his life.

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Origins of Medical Cytology

Addison and the White Corpuscles. An Aspect of Nineteenth-Century Biology. L. J. RATHER. University of California Press, Berkeley, 1972. x, 236 pp. + plates. $8.50. Publications of the Wellcome Institute of the History of Medicine, new series, vol. 22.

Early efforts to understand white blood cells were clouded by doubt and debate. Historian Rather ably analyzes these efforts from their early-19th-century beginnings to the discovery of phagocytosis in 1883. This book gives an intimate and accurate insight into the struggle of a science (medical cytology) to be born.

At the time when the drama began, inflammation was regarded by many as a special form of nutrition—and nutrition theory itself was a battleground of opinions. According to an older idea, certain "globules" are separated from the blood and become intercalated into the fibers then thought to constitute tissue. A newer view, espoused especially by Schwann, held that what leaves the blood is a fluid in which, when it reaches the tissues, new cells arise (by processes which Schwann compared to crystallization).

In the midst of the debate, in 1842, William Addison, the central figure in Rather's account, proposed that neither globules nor cell-forming fluids separate from the blood. Instead, white blood cells (which Addison wrongly derived from red blood cells) leave the bloodstream. In nutrition, he said, these add themselves to the tissues (which were by now supposed, because of Schwann's work, to be built in large part of cells). Addison saw the extruded white cells as likewise able to participate in pus- and tubercle-formation, coagulation, and the like.

Rather details the antecedents and inception of Addison's partly correct idea, the many mistakes it contained, the reactions it evoked when published, the alternatives suggested by others, the impact upon it of the rapidly developing cell theory and the theory of the microcirculation, and finally the liberating discoveries of Recklinghausen (migration of "pus-cells," 1863), Cohnheim (diapedesis, 1867 [also described by Waller in an unnoticed paper of 1846]), and Metchnikoff (phagocytosis, 1883).

Rather's narrative is packed with details; it would not have been adequate without them. A mass of added information is wisely relegated to notes. The indexing of the book is complete, the documentation superb. This reviewer wishes that Rather had chosen inflammation—rather than the semi-meritorious William Addison (no relation to Thomas)—as the hero of the tale. But the book as it stands is an outstanding case study in early and middle 19th-century biology.

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Principles and Devices

Topics in Solid State and Quantum Electronics. Papers from a lecture series, Mar. 1970. W. D. HERSHBERGER, Ed. Wiley, New York, 1972. xvi, 506 pp., illus. $23.50. University of California Engineering and Physical Sciences Extension Series.

The federal government and industry provide support for research in solid state and quantum electronic phenomena. The research leads to a multitude of new electronic devices, exploiting solid state and quantum phenomena often complex and outside the experience of electronics engineers and technologists. University extension services attempt to repair the knowledge gap with extension courses and lecture series (perhaps a hopeless task). The collected lectures by assembled experts make a book, like this one. If the topics are carefully chosen and the author-lecturers conscientious about their work, the book can be a useful outcome, as is the case here.

The topics covered here ranged over

various microwave solid state devices, superconductivity (briefly), lasers, image devices, integrated-circuit technology, and magnetic materials (again briefly). For each topic the pattern is to describe the background phenomena and physical principles, the kinds of devices that result, the present state of the art in device performance, and some of the practical applications and possible future trends for these devices, concluding with brief but carefully selected lists of references.

Microwave semiconductor devices, using bulk negative-resistance effects (the Gunn effect, LSA mode) and avalanche negative-resistance effects (Impatt, Trapatt), can now generate kilowatts of pulsed power at a few Ghz, watts of continuous power at tens of Ghz, and useful oscillations up to a few hundreds of Ghz. Two separate and authoritative sections cover these devices, whose impact on microwave and millimeter-wave device technology will be truly revolutionary. Another strong section describes the varied device possibilities of microwave elastic or acoustic waves (bulk and surface) at frequencies from 100 Mhz to 100 Ghz. These waves can now be generated, guided, modulated, amplified, convolved, diffracted, and detected, all inside (or on) tiny chunks of crystal.

A brief chapter reviews superconductive electronic devices, mostly still rather exotic, based on Josephson phenomena. The two following lectures review the present status of solid state and semiconductor lasers, and the physics and device applications of nonlinear optical polarization in optical parametric oscillators and harmonic generators. The following chapter on laser systems falls rather outside the device-and-phenomena-oriented pattern of the rest of the book, being concerned primarily with optical communications system calculations, rather than with the numerous laser applications in science and technology that might better have been included.

The remaining lectures give a useful survey of image pickup and display devices, vacuum and solid state; an authoritative survey of the battery of competing, still evolving technologies that produce integrated circuits with thousands of transistors per chip and millions of circuits per week; a similarly well done survey of microwave circuit elements, passive and active, fabricated in miniaturized integrated-circuit and microstrip form: and a brief but carefully selected review of some new advances in magnetic materials.

By its nature this book will have a limited useful lifetime. But for the next several years this collection of fairly up-to-date, generally well illustrated, conscientiously prepared survey articles can serve as a good starting point for exploring most of the topics covered.

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Motion Calculation

Astrodynamics. SAMUEL HERRICK. In two volumes. Vol. 1, Orbit Determination, Space Navigation, Celestial Mechanics. xxvi, 540 pp., illus. $34.50. Vol. 2, Orbit Correction, Perturbation Theory, Integration. xiv, 348 pp., illus. $24.50. Van Nostrand Reinhold, New York, 1971–72.

Herrick has won respect as educator, researcher, and consultant. Sets of his notes on orbital computations have been used almost since the start of the "space age," and rumors of a textbook have circulated for almost as long. The two volumes under review constitute that textbook; they reflect the author's skills, interests, and enthusiasms, and his opinions.

The first volume is principally concerned with the problem of two bodies: computations and applications. There are chapters on the preliminary determination of orbits (from three observations) and on orbit design, and thorough discussions of units and coordinate systems. There is also a chapter on perturbed equations of motion and their treatment. Finally, there are appendices dealing with reference formulas and terminology. In the second volume heavy emphasis is laid on the application of numerical methods for integrating second-order perturbed equations of motion (essentially as devised by Gauss) and on perturbation procedures in which the author's "perturbed variation" ideas and notation are used. The volumes contain throughout detailed listings of formulas and worked numerical examples.

The volumes represent a monumental amount of meticulous work, and form a monument to the author. But I fear that the greatest need for them has passed. Within limits they are valuable and stimulating references on the rich variety of methods available for treating some problems; but these volumes cannot stand alone. Important topics—statistical methods for data processing, for example, or analytical theories that are used to calculate orbits of artificial satellites—are omitted. In spite of his emphasis on computation, the author seems to be wedded to the usage (under his heading "QUICK-WIT") of the desk calculator and seems to be not at ease in referring to high-speed computers (FORTRAN and the like are referred to as "machine languages" and put into the category "NITWIT"!).

The author is, of course, under no obligation to be encyclopedic, and is entitled to a little nostalgia. But these are expensive volumes; the reader whose pocket has been touched may grudge, for instance, the devotion of four pages to a special method for solving Kepler's equation with a desk calculator; to learn how to solve this equation efficiently on a high-speed computer he will have to look elsewhere. I gained little from the sections on analytical methods. In the chapter entitled "Hamiltonian mechanics," I was baffled, for instance, by the sentence: "The implied osculating reference orbit is sometimes described by one or more of the following terms (in ascending order of mathematical generalization): separable, scleronomic, holonomic, and non-esophageal." The author seems not to be at home here.

The title reflects the author's wish to define a distinct discipline, and also his enthusiasm for some newly coined words. A lot of space is taken up by discussion of vocabulary, and the author has a lot of fun. To me, much of the spirit of the work is exemplified in the following definition, which I quote in full: "Algorithm: Algorism, misspelled because of mistakenly assumed association with the root of *arithmetic*; correctly applied to arithmetic using concept of zero; incorrectly substituted for *collection of formulae* by programmers who have been buffaloed into believing existence theorems were important, good programming not, contrary to fact; has gained considerable currency among persons too kindly to recognize arrant pedantry." Characteristic and amusing: but behind the times.

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