namics," deals with the important subject of traveling waves in the cochlea of the inner ear. These waves have to be taken into consideration in any analysis of signal processing in the auditory system, and the author draws interesting conclusions with respect to some puzzling effects in pitch perception.

If the book has any broad, unifying theme, it is the pitch perception—a classical problem that concerned philosophers and scientists through many centuries and is still with us. Two schools of thought exist with respect to pitch perception: one attributes it to temporal coding in the nervous system, the other to a spatial frequency analysis. Whereas the first two chapters go to great pains in demonstrating the necessity of temporal coding in order to account for some perceptual phenomena, the remaining chapters assume more or less explicitly the frequency analysis. This lack of coherence is disturbing, and perhaps a chapter devoted more explicitly to spatial mechanisms of frequency analysis should have been added. An included chapter under the title "Time and frequency analysis" seems to have run out of steam before reaching the frequency part.

Although the book is not what it promises to be and, in addition, is outdated in some of its parts, it should be worth having for those who are interested in the sense of hearing. It does contain some useful information and presents a few interesting points of view. The literature references are helpful also, but in several instances historically misleading.

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A Mathematical Idea

Lebesgue's Theory of Integration. Its Origins and Development. THOMAS HAWKINS. University of Wisconsin Press, Madison, 1970. xvi, 228 pp., illus. $12.50.

Classical and Modern Integration Theories. IVAN N. PESIN. Translated from the Russian edition (Moscow, 1966) and edited by Samuel Kotz. Academic Press, New York, 1970. xx, 196 pp., $12.50. Probability and Mathematical Statistics.

Mathematicians have often been the most curious of scholarly creatures in that they have seldom been curious about the history of their own subject. Normally they have been content with a few gossipy tidbits of folk history: a blend of garbled inaccuracies and apocryphal tales only occasionally stiffened by solid facts. Now there appears to be a rising interest in the history of mathematics, particularly of modern mathematics, as is borne out by recent publication of these two books on the development of integration theory, representing quite different approaches to mathematical history.

In *Lebesgue's Theory of Integration*, Thomas Hawkins has set out "to place Lebesgue's early work on integration theory (1901–10) within its proper historical context by relating it, on the one hand, to the developments during the nineteenth century that motivated it and gave it significance and, on the other hand, to the contributions made in the field by his contemporaries." He has succeeded brilliantly on both counts.

Hawkins begins by examining Cauchy's proto-theory of integration, which treated only continuous functions. He then goes on to Riemann's integral, which is the first true integration theory, and which also contains the germ of a measure theory. As background for Lebesgue's discoveries of the turn of the century, there is a discussion of the various controversies revolving around the nature of infinite sets and what should be meant by a function.

The book is especially interesting because Hawkins has been able to convey the excitement of discovery and groping that must attend the birth of any fundamental theory. The mathematical problems of the 19th century, arising primarily from Riemann's integrals and Fourier series, are placed before us as they then existed, complete with the confusion of concepts that followed after them. Hawkins shows how the differences between ordinary and uniform continuity, or pointwise and uniform convergence, were not fully understood until after Cauchy; ideas about infinite point sets were naive, and many fundamental questions were not settled until after Cantor. The notion that a function was an "analytical expression" was firmly embedded; the concept of a function as an assignment did not take hold until the turn of the century. Perhaps there is a lesson here for us: Should we expect more of our freshmen than of the best professional minds of less than a century ago?

Hawkins centers his treatment around what he calls the three fundamental theorems: I, the inverse derivative problem; II, the evaluation problem for the definite integral; and III, the problem whether, if the (perhaps generalized) derivative of a function vanishes on set, the function itself is a constant there. He shows that as functions grew more complicated in the latter half of the 19th century the problems posed by the fundamental theorems could not be solved by use of the Riemann integral. The author also sheds light on the arc length controversy and the question of general continuity versus differentiability.

There is also an interesting treatment of the interim period immediately preceding Lebesgue. It was at this time that attention began to be focused on measure theory, and there was a realization, even then, that it was strongly linked to integration. Hawkins treats this well, sorting out the various trends into coherent sequences of ideas.

The climax of Hawkins's book is the study of the works of Lebesgue. He shows how Lebesgue started from Borel's earlier ideas of what should constitute a correct set of axioms for a measure and built these ideas up to a complete theory, combining integration and measure. In addition to Lebesgue's well-known limit theorems he was able to show that theorems I, II, and III are in general (almost everywhere, one is tempted to say) solvable and have the expected solutions.

Hawkins as an author is kinder to his readers than most who write on mathematics. Definitions are clearly stated. The notation has been carefully selected for clarity, and there is a well-chosen glossary. His style is easy and comfortable. Perhaps best of all, when a definition or notation has not been used in some time its meaning is recalled. Altogether, Thomas Hawkins has written a book that is the epitome of what a mathematical history should be.

Pesin (or Kotz, since he is listed as editor as well as translator) has given us a different kind of book. Rather than a history, it is presented as "a detailed historical survey of the development of classical integration theory." Only the outlines of the theories, together with some of the proofs, are here. It is truly regrettable that "in view of limitations in space [the author] was unable to present adequately the interrelation between integration and other branches of mathematics, for example, the theory of trigonometric series, a subject in which problems

originated that stimulated the development of integration theory." Isn't that much of what history is all about?

Classical and Modern Integration Theories starts with Cauchy and goes on through Riemann to the early stages of measure theory. Here there is an outstanding formulation of the differences and connections between the several measure theories. After a good presentation of Lebesgue's integral measure theory, Pesin continues on to outline the theories of Denjoy, Perron, and Daniell.

The English edition of *Classical and Modern Integration Theory* sets four aims for itself. It succeeds in only two. As a book for a student already knowledgeable in Lebesgue's theory who wishes to see where and how it connects up with Riemann integration it is excellent; it would also be useful as a refresher for a former student who has not looked at the topic for a long time. Unfortunately, it does not succeed as a text for a novice; there are too many barriers. The book has some crucial misprints; the notation is often special and nonintuitive. True, there is a glossary of terms, but not all necessary items are included. In fact, the selection of terms is baffling; for example, continuity is defined, but absolute continuity is not. Finally, the two indexes specially prepared for the English edition are, admittedly, only partial. In sum, we have a right to expect a better job both of bookmaking and of history.

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Operations on the Heart

The History of Cardiac Surgery, 1896–1955. STEPHEN L. JOHNSON. Johns Hopkins Press, Baltimore, Md., 1970. xviii, 202 pp., illus. $9.50.

The Scalpel and the Heart. ROBERT G. RICHARDSON. Scribner, New York, 1970. x, 326 pp. + plates. $8.95.

Since the time of the ancients the heart has been accorded a place of predominance as well as mystery. At one time or another it was thought to be the seat of life, the source of vital spirits, the site of heat production in the body, and the repository of sentiments such as love. As recently as the presidential campaign of 1964 Americans were urged to vote with their hearts, not their minds. No wonder then that when heart transplantation became a reality in South Africa in late 1967 the world's imagination was immediately captured. These two books will explain much of the work that led up to our current phase of cardiac surgery, and they complement one another nicely.

Johnson, a member of the biomedical engineering faculty at the Johns Hopkins Medical School, has carefully shown the slow progress of the story, beginning with the successful suture of cardiac wounds in the 1890's, to the open-heart surgery of the 1950's. The value of his book lies in his approach to the story and in the superb illustrations so necessary to a nonsurgical reader. Much of this all too brief book is devoted to the necessary developments in physiology that were prerequisites to successful thoracic and cardiac surgery. The sections on electrocardiography, cardiac resuscitation, and cardiac catheterization, and the final chapter devoted to the heart-lung machine are particularly noteworthy. The inclusion of numerous drawings and diagrams makes for much easier comprehension of both problems and solutions. Johnson, moreover, brings to life a few of the contributors to the story, although he makes no attempt to assess their general work.

Robert Richardson, a London surgeon who is now a writer and editor, has the pleasing facility for making the complex technical and scientific problems more understandable to the nonspecialist. In this, his second book in the history of surgery, he describes the events surrounding the surgery of the heart and major thoracic blood vessels, as well as some of the physiological developments in anesthesia, hypothermia, and open-heart surgery also discussed by Johnson. Richardson's is the more elegantly written book, and it has a wider audience in mind. For all its information, however, it is less broad in historical perspective than *The History of Cardiac Surgery*. Richardson supplies a wealth of detail for the many advances made since 1955, when Johnson ends his story. Richardson's book supplies only a few references at the end whereas Johnson's book is fully documented. It is to Richardson's credit that he utilizes the important, but generally neglected, book by V. P. Demikhov, *Experimental Transplantation of Vital Organs*, published in Russia in 1960 and translated into English in 1962. The Russian contributions to cardiac surgery are extensive, and they must be taken into consideration.

Richardson's book is exciting reading, yet it suffers from severe defects. It is inadequately illustrated (especially when compared to Johnson's book), and it really is an extensive review of the literature without bringing to life the principal characters.

Surgery, especially cardiac surgery, has so captured public interest that these books should find a ready audience. Yet the question remains why the quality of the history of surgery as a whole has not improved much since the time of Gurlt, Fischer, and Billings, all writing more than 70 years ago. One problem has been, as Richard Meade noted recently in his *Introduction to the History of General Surgery*, that we have focused too much attention on the surgeons, to the neglect of the operations they performed. These two books do much to swing the balance the other way. Still, we are left with a feeling, especially from Richardson's book, that we are reading a catalog of operations, their dates, successes, complications, and failures, all piled on one after another. Do we not have to look for the development of cardiac surgery within the history of general surgery and within the history of 20th-century medicine as a whole? Do surgeons only operate or devise ingenious equipment to enable them to operate more safely or in more complicated situations? Do they not have some guiding principles, some philosophy, some thoughts about solving scientific and technical problems? Stereotypes aside, I think the answer is an unqualified yes; yet no one seems able to come to grips with these aspects of the history and development of surgery. Perhaps it is foolish to expect either a surgeon or a historian working alone to accomplish the difficult task of synthesis. A joint effort may be the solution.

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Food in the Sea

Marine Food Chains. Proceedings of a symposium, Aarhus, Denmark, July 1968. J. H. STEELE, Ed. University of California Press, Berkeley, 1970. viii, 552 pp., illus. $13.50.

The advent of the computer has begun to make the prediction of events taking place in our biosphere a practical reality. Yet simulation of the environment cannot proceed without basic