settling presence of unchaperoned women, and of the flood of biomedical rhetoric on female inferiority that confronted them in official medical circles. There are sketches of the heroines of this generation, the Englishwomen Elizabeth Morgan and Elizabeth Garrett, the Americans Mary Putnam and Susan Dimock, and the Russian pioneers Nadezhda Suslova and Maria Bokova, most of whom returned to their homelands to found hospitals and clinics or campaign for legal reform.

Bonner's study provides a clearly written and comprehensive historical account of the evolving national legal and educational structures bearing on women's medical education and licensing. There is still much more to know, however, about the cultural and social incentives and disincentives that, for example, made Russian women the most numerous of the foreign students in European faculties or caused American women to fall so far behind their European counterparts in the course of the 20th century. Why, once legal obstacles largely disappeared, did the women of one society follow medical careers in larger numbers than those of another? Bonner only alludes to the marital and parental status of these pioneer students. They married less than the average, but was this a cause or a consequence of their determination to become physicians? And why have marriage rates increased among female doctors in recent times? As Bonner himself acknowledges, the informal barriers to full parity in medical education and practice have often been more effective than the legal and institutional ones in discouraging or channeling women's ambitions. Medicine and medical education were and still are largely male cognitive and discursive spaces that replicate the gendered structures of the larger society. Though "woman doctor" is no longer the oxymoron it was in the 19th century, the very fact that we continue to make this distinction suggests that we have much more to learn about the way culture has subtly persuaded women to make appropriately gendered choices in their medical educations, specialties, and professional activities.

Robert A. Nye
Department of History,
University of Oklahoma,
Norman, OK 73019

Functional Analysis

Ten Lectures on Wavelets. INGRID DAUBECHIES. Society for Industrial and Applied Mathematics, Philadelphia, 1992. xx, 352 pp. Paper, $37.50. From a conference, Lowell, MA, June 1990.

An Introduction to Wavelets. CHARLES K. CHUI. Academic Press, San Diego, CA, 1992. x, 264 pp., illus. $49.95. Wavelet Analysis and Its Applications, vol. 1.

Wavelet analysis is acquiring increasing popularity among workers in a wide variety of fields. These range from signal processing to video and image compression, feature extraction, and speech recognition to filterbanks, sub-band coding, geophysics, approximation theory, numerically oriented harmonic analysis, and several branches of mathematical physics. Most of these developments have taken place in the last five years, and the future looks very promising. Two collective volumes on the subject have appeared this year [see below], and an English translation combining the three parts of the French work *Ondelettes* (Hermann, Paris, 1990) by Y. Meyer with R. Coifman is due out soon from Cambridge University Press. The two books under review here come at a good time and are at a level that should make the subject more widely accessible.

The basic problem addressed by wavelet theory is that of analyzing a function. The expression "analyzing a function f," or decomposing it into elementary components, refers quite frequently to Fourier analysis, by which coefficients of f are computed by means of the inner product (f,e^{inx}) and the function f is recovered by adding the products of these coefficients multiplied by the exponentials e^{inx}.

The idea of decomposing a function into "harmonics" certainly owes a lot to the study of physical phenomena such as the vibrating string, but as often happens with deep mathematical concepts, the ideas that originate in one field become relevant in areas far removed from their source. Indeed, it is quite common to analyze a signal f for reasons that have nothing to do with vibrating strings, and in fact some research involves computing the coefficients of a signal f in terms of a "basis" of functions different from exponentials, transmitting these coefficients over a channel, and then trying to synthesize the function at the other end. An obvious problem is that of deciding which basis is appropriate for the problem at hand. In some cases there is no choice at all (as described below), and in others the freedom is almost mind-boggling.

Recent work in wavelet theory has provided workers in several areas of science and technology with a tool kit that has many of the advantages of the more established Fourier analysis and also offers a wide choice in picking and computing with an appropriate "wavelet basis." In many instances, these "coefficients" have a good deal of physical meaning, and occasionally they are the only objects that one can get one's hands on. For instance, in x-ray crystallography the (modules of the) Fourier coefficients of the periodic, three-dimensional structure are the intensities of radiation scattered in several directions. In the case of CAT scanning or x-ray tomography, the one-dimensional Fourier transform of the projection data gives sections of the Fourier transform of the higher-dimensional object of interest. The first example is one in which Fourier analysis is naturally tied to the physics of the problem and cannot be done away with. There are, however, other areas, such as Range-Doppler radar detection, where wavelet theory is more appropriate.

In instances where the choice of basis is wide open, questions arise as to whether Fourier analysis should be used, and if not, which of its advantages should be preserved. An obvious one that comes to mind is orthogonality of the basis functions, which makes the computation of the coefficients a very trivial task. But is this really necessary, or even a good idea, in all cases? Clearly an important point is the complexity of the resulting algorithms, as is how well they can take advantage of new computer architectures.

As it happens, many of these issues are beautifully addressed by wavelet theory. Its basic point is that $\psi(x)$ (the so-called "mother wavelet") can be designed such that the collection of functions

$$\psi_{m,n}(x) = 2^{-m/2}\psi(2^{-m}x - n),$$

that is, translates and dilates of ψ, forms an orthonormal basis. If the value of m is kept, and

$$\Theta_m(x) = \sum_n \langle f, \psi_{m,n}\rangle \psi_{m,n}(x)$$

is combined into

$$f(x) = \sum_m \Theta_m(x)$$

then features of f may be observed at different scales or octaves.

The historical origin of this emerging field can be traced to several sources. Most notable among these are windowed Fourier transforms and the Wigner-Ville distribution in signal processing, the Paley-Littlewood-Calderón theory in harmonic analysis, the work of Morlet and Grossman in geophysics, Gabor's work in physics using coherent states, and the work of Marr in vision. Independently of these efforts, mathematicians working in approximation theory and in numerical solutions of PDEs had come up with ideas such as spline analysis and multigrid methods, which can now be seen as part of a larger picture, namely multiresolution analysis. This framework, thanks to the work of Mallat and Meyer, is now rich enough to incorporate and unify all of these areas of research.

These pioneering efforts all resulted from attempts to get around the inherent difficulty associated with the time-honored Fourier analysis of signals—the impossibility of localizing the analysis of a signal in both time and frequency.

Wavelet theory has combined some of the best ideas from many previously disparate fields, and in so doing has already rendered a useful service to science and technology by encouraging communication among the practitioners of several disciplines. As with any other successful merger of different traditions, however, it is natural that each group finds its own approach preferable to those of other groups. It is therefore noteworthy that both of these books do a good job of avoiding provincialism, thus providing the reader with a rather full picture of the field.

The book by Daubechies, who is one of the main developers of the theory, is the result of an intensive short course. The presentation is completely engrossing; it is like reading a good, thick Russian novel. Daubechies has a real knack for making the material appealing and lively, and there is a definite "slowing down for details" at the points that require further elucidation. The opening chapter gives a very readable overview of the main problems considered in the book without getting bogged down in details. Subsequent chapters discuss fully the theoretical and practical aspects of wavelet theory, including wavelet transforms, orthonormal bases of wavelets, and characterization of functional spaces by means of wavelets. The closing chapter presents several topics under active investigation, such as multidimensional wavelets, wavelet packet bases, and a construction of wavelets tailored to decompose functions defined in a finite interval. This book can be used for many different purposes, from individual reading to graduate-level coursework, and it will likely become a classic.

The book by Chui is more modest in scope and could serve as a textbook for a one-semester course at the senior undergraduate level or more likely at the beginning graduate level in engineering or applied mathematics programs. For this purpose, it would have been useful to include (as I understand the author plans for a forthcoming second edition) problems that are designed to ensure that the student gets a hands-on understanding of the subject. Topics covered in the book include Fourier analysis, wavelet transform and time frequency analysis, and scaling functions and wavelets. Chui is among the people responsible for making the previously existing theory of (cardinal) splines fit within the framework of multiresolution analysis, and so spline analysis is also prominently featured.

The two books should make it easier for workers in different fields to acquire the keys to this useful tool kit. In the hands of an insightful worker, wavelet theory should be of great benefit in the acquisition, manipulation, and interpretation of data. It certainly provides a fertile ground for interactions among the fields of mathematics, the sciences, and technology.

F. Alberto Grünbaum
Department of Mathematics,
University of California,
Berkeley, CA 94720

Recent Collections on Wavelets

Wavelets and Their Applications. Mary Beth Ruskai, Gregory Beylkin, Ronald Coifman, Ingrid Daubechies, Stephane Mallat, Yves Meyer, and Louise Raphael, Eds. Jones and Bartlett, Boston, 1992. xiv, 474 pp., illus. $48.75. Books in Mathematics.

Eighteen papers covering the topics Signal Analysis (six papers), Numerical Analysis (three papers), Other Applications (four papers), and Theoretical Developments (five papers). Contributors include M. Vetterli, B. K. Alpert, A. Arneodo, and H. G. Feichtinger.

Wavelets. A Tutorial in Theory and Applications. Charles K. Chui, Ed. Academic Press, San Diego, CA, 1992. x, 723 pp., illus. $69.95. Wavelet Analysis and Its Applications, vol. 2.

Twenty-two chapters arranged under the headings Orthogonal Wavelets (three papers), Semi-orthogonal and Nonorthogonal Wavelets (four papers), Wavelet-like Local Bases (three papers), Multivariate Scaling Functions and Wavelets (three papers), Short-time Fourier and Window-Radon Transforms (two papers), Theory of Sampling and Interpolation (three papers), and Applications to Numerical Analysis and Signal Processing (four papers). Contributors include D. Pollen, G. Battle, B. K. Alpert, W. R. Madych, H. G. Feichtinger, J. J. Benedetto, and S. Jaffard. Bibliography included.

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Air Pollution. With contributions by C. Gries *et al.* Springer-Verlag, New York, 1992. xii, 185 pp., illus. $98. Handbook of Environmental Chemistry, vol. 4, part c.

Air Pollution Modeling. Theories, Computational Methods and Available Software. Paolo Zannetti. Van Nostrand Reinhold, New York, 1992. xii, 444 pp., illus. $62.95.

Airpower in the Gulf. James P. Coyne. Air Force Association, Arlington, VA, 1992. viii, 224 pp., illus. Paper, $21.

America's Renewable Resources. Historical Trends and Current Challenges. Kenneth D. Frederick and Roger A. Sedjo, Eds. Resources for the Future, Washington, DC, 1992. xvi, 296 pp., illus. $22.95; paper, $19.95.

American Physicians in the Nineteenth Century. From Sects to Science. William G. Rothstein. Johns Hopkins University Press, Baltimore, MD, 1992. xxii, 362 pp. Paper, $18.95. Reprint, 1972 ed.

The Amygdala. Neurobiological Aspects of Emotion, Memory, and Mental Dysfunction. John P. Aggleton, Ed. Wiley, New York, 1992. xii, 615 pp., illus. $125.

Analysis with Local Census Data. Portraits of Change. Dowell Myers. Academic Press, San Diego, CA, 1992. xii, 369 pp., illus. Paper, $42.50.

Bioprocess Monitoring and Control. Marie-Noëlle Pons, Ed. Hanser, Munich, Germany, 1992 (U.S. distributor, Oxford University Press, New York). xviii, 365 pp., illus. $95. Hanser Series in Biotechnologie.

Biosensors and Chemical Sensors. Optimizing Performance Through Polymeric Materials. Peter G. Edelman and Joseph Wang, Eds. American Chemical Society, Washington, DC, 1992. xii, 332 pp., illus. $79.95. ACS Symposium Series, 487. From a symposium, Atlanta, GA, 1991.

Biotechnology of Cell Regulation. Roberto Verna and Yasutomi Nishizuka, Eds. Raven, New York, 1992. xii, 472 pp., illus. $150. Advances in Experimental Medicine, 4. From a symposium, Siena, Italy, June 1991.

The Bronchial Circulation. John Butler, Ed. Dekker, New York, 1992. xx, 806 pp., illus. $185. Lung Biology in Health and Disease, vol. 57.

Butterflies of the Bulolo-Wau Valley. Michael Parsons. Bishop Museum Press, Honolulu, HI, 1992. viii, 280 pp., illus., + plates. Paper, $34.95.

Catalysis Looks to the Future. National Research Council. National Academy Press, Washington, DC, 1992. x, 86 pp., illus. Paper, $19.

The Chemical Bond. Structure and Dynamics. Ahmed Zewail, Ed. Academic Press, San Diego, CA, 1992. xviii, 313 pp., illus. $49.95. Based on a symposium, Pasadena, CA, Feb. 1991.

Codes, Puzzles, and Conspiracy. Dennis Shasha. Freeman, New York, 1992. xiv, 241 pp., illus. $17.95; paper, $11.95.

Cognitive Psychology. An Overview for Cognitive Scientists. Lawrence W. Barsalou. Erlbaum, Hillsdale, NJ, 1992. xii, 410 pp., illus. $79.95; paper, $36. Tutorial Essays in Cognitive Science.

Colloidal Dispersions. W. B. Russel, D. A. Saville, and W. R. Schowalter. Cambridge University Press, New York, 1992. xviii, 525 pp., illus. $110; paper, $39.95. Reprint, 1989 ed.

Color in Electronic Displays. Heino Widdel and David L. Post, Eds. Plenum, New York, 1992. x, 335 pp., illus. $85. Defense Research Series, vol. 3.

Colour Atlas of the Surface Forms of the Earth. Helmut Blume. Andrew Goudie and Rita Gardner, Transl. Eds. Harvard University Press, Cambridge, MA, 1992. iv, 140 pp., illus. $75. Translated from the German edition (Stuttgart, 1991) by Björn Wygrala.

Combination Therapies. Biological Response Modifiers in the Treatment of Cancer and Infectious Diseases. Allan L. Goldstein and Enrico Garaci, Eds. Plenum, New York, 1992. xvi, 313 pp., illus. $75. From a symposium, Washington, DC, March 1991.

Compendium of Organic Synthetic Methods. Vol. 7. Michael B. Smith. Wiley, New York, 1992. xx, 547 pp., illus. $59.95.

The Complete C++ Primer. Keith Weiskamp and Bryan Flamig. 2nd ed. Academic Press, San Diego,