research in the early 1930s, Holmes reveals in exquisite detail the workings of a creative mind on recalcitrant problems. His scrutiny allows us to follow the ebb and flow of Krebs's work, to see its multiple lines as they sometimes interacted and sometimes diverged, to trace his relations with colleagues and assistants, to appreciate the uncertainties he faced, and to feel something of the confusion that accompanies inquiry—the "fog of research," one might say.

If any readers still need be disabused of the idea that some singular method explains scientific change, this account should accomplish the job. It is equally corrosive, however, of platitudes about the determinative role of community structure in science. The traditions of his discipline, the precepts of his teachers, the results of his predecessors, local circumstances, and the nature of his tools all helped define, but did not fully specify, Krebs's path. At crucial junctures, Krebs was carried along by persistence, an ethos of constant optimistic labor, and, more than once, sheer luck. Krebs had an abiding "confidence that unexpected leads really would turn up, and that they would guide him toward goals he could not foresee in advance" (p. 384). His capacity for the routine work that produced such leads, his alertness to unanticipated results, and his energy in exploiting them depended as much upon temperament and upbringing as upon any formal training. This magnificent biography demonstrates, as few books do, the intimate relations between personality and science.

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Translocations

To the Ends of the Earth. Women's Search for Education in Medicine. THOMAS NEVILLE BONNER. Harvard University Press, Cambridge, MA, 1992. xvi, 232 pp. + plates, $34.95.

In the 50 years before World War I European and American women bent on medical careers managed to overturn most of the legal and educational obstacles that had denied them full admission to the profession. Since the conditions for this achievement were (grudgingly) established by male doctors and politicians, however, women's right to practice medicine continued to be hedged around in various ways that pertained directly to their sex. Even friendly voices acknowledged these strictures, as in the praise delivered in 1871 by the Zurich medical professor Hermann von Meyer to his university's first woman graduate, the American Susan Dimock: "You have shown by your example that it is possible for women to devote themselves to the medical profession without denying your female nature." As Dimock's example also indicates, it was easier for women to earn medical degrees abroad than in their own countries. Any account of this fascinating and complex story must therefore consider the remarkably international nature of women's medical education in these years. At the same time, women's accomplishments in the age of the nation state may be fully assessed only in particular national settings, and the chief virtue of Thomas Bonner's succinct history of these developments is the comparative perspective he brings to it.

In 1870 there were 525 women physicians in the United States, more than in the rest of the world combined, but as recently as the 1960s women made up a smaller proportion of students in medical schools here than in virtually any other industrialized nation, constituting only about 5 to 8 percent while Germany graduated women at a rate of 30 percent, Great Britain 25 percent, and France and Holland 20 percent each. As Bonner explains, the free market in education and licensing that prevailed in the United States encouraged the early growth of women's medical colleges as well as minimal certification procedures, whereas state control of education and licensing on the European continent acted effectively to exclude women until very late in the century. But once European political and medical authorities became convinced of the benefits, if not the justice, of training more women physicians, enrollments increased steadily under the umbrella of state sanctions, whereas in America the hit-or-miss patchwork of local and federal regulations permitted discrimination and practical obstacles to remain partly in place. Uniform legal reform in Europe often swept away all barriers to women within several years, whereas American laissez-faire created a situation where women might join co-ed classes in prestigious schools but continue to be denied access to internships in private hospitals or membership in medical societies, a characteristic aspect of the double-edged nature of "freedom."

"A caricature of women students in Zurich. Above: How they are! Below: How they should be!" [From *To the Ends of the Earth*; Medizin-historisches Institut, University of Zurich]

Depending on their nationality, the choices for female medical aspirants in the last half of the 19th century were different but everywhere limited. American and British women could attend private women's medical colleges, some of which offered degrees for a course of study (without clinical experience) as short as a year, but even the best of these, like the Women's Medical College of Pennsylvania, provided an education far beneath the standards of the best European and American faculties. On the Continent, German, French, and Russian women agitated for equality of education, but until the end of the century they gained only token access to the state system or made do with lesser titles such as "learned midwife." For women with the means and the drive, the preferred alternative was to seek out those few places in Europe where foreign women were permitted to study alongside men in respected medical faculties. The first institutions to graduate women in the late 1860s were the medical faculty of Zurich, joined shortly thereafter by other cantonal universities in Bern, Geneva, and Lausanne, and that of Paris, which waived for foreigners the rigorous admission standards it maintained for Frenchwomen.

Bonner tells us much of interest about women of several nationalities who followed this challenging option, based on a study of the archives of many of these faculties. He has found evidence of their networks of mutual support, of the often fierce resistance of townspeople to the un-

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.

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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.