spect to the phylogenetic relatedness of rotifers to other lower metazoa. An additional paper by Wurdak and Gilbert describes the glycogen energy reserves of the reduced intestine in nonfeeding males. The second series of papers, on in situ feeding studies of rotifers (Bogdan, Gilbert, and Starkweather) using Haney's incubation chambers, emphasizes the high rates of feeding relative to other zooplankton and describes selective feeding, including an apparent preference for dead algae. Other papers describe culture techniques, aging studies, the stimulus for mictic egg production and hatching, cyclomorphic changes, selective predation, the ecology of the mobile larvae of sessile species, and biogeography.

This was a small symposium with 51 attendants. It must have been fun to be at the meetings; I found reading the resultant papers both enlightening and enjoyable.

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Pioneer Seismologist

John Milne. Father of Modern Seismology. L. K. HERBERT-GUSTAR and P. A. NOTT. Norbury, Tenterden, Kent, 1980. xvi, 200 pp., illus. + plates. £10.

In 1893, the first modern seismograph capable of detecting earthquakes in any part of the world was invented by John Milne in Japan. The debt of modern seismology to Milne is great, yet he has always been a personality in the shadows. It is thus fortunate that we now have this illuminating and well-written biography.

Milne was born in 1850 in Liverpool. Whether tramping through Ireland in his early youth (he existed by playing the piano at wayside inns) or later canoeing along the rivers and canals of southern England, he displayed a wandering spirit that was to dominate his life. His studies at King's College, London, were centered on mechanics and geology, and he immediately put his knowledge of these subjects to work during an expedition to Iceland. After this expedition he studied mining at London and did extensive fieldwork in western Europe. Milne's first job as a consultant at the age of 22 was to assess the mineral resources of Newfoundland, and during the course of this work he became interested in icebergs and the mechanical aspects of ice abrasion on rock. After a short while back in England, his restlessness was eased by an invitation to join, as a geologist, an expedition to the Middle East in search of Mount Sinai. This exploration promoted Milne's growing reputation as a competent geologist who, like many Victorians, was prepared to travel for the sake of science.

In 1874 came the offer that was to be crucial for seismology—an appointment as professor of geology and mining at the Imperial College of Engineering in Tokyo. When traveling to Japan, Milne typically elected to go overland through Russia and Siberia to Vladivostok, from where he could make the short sea connection to Japan. The journey was a feat of endurance in those days, taking seven months, including a Siberian winter. Milne wrote copiously of all his travels and left a vivid record of his observations, including some pointed advice for would-be travelers ("a strong constitution is needed").

Milne's appointment in Japan was part of a program to use foreign specialists to train Japanese nationals in Japan's quest for parity with Western industrialized nations. Milne was to stay in Japan for 20 years, during which time he fostered the new science of seismology and became its world authority. His first obligations were to mining exploration, but his work in this field is not well known outside Japan because his reports to the government were largely confidential. Nevertheless his "Miners Handbook" proved invaluable to several generations of Japanese mining engineers, largely because the mining industry in Japan when Milne arrived in 1875 was in a primitive condition. In addition, during the early years of his appointment, he made geological observations and detailed sketches of more than 50 volcanoes that he climbed. That his scientific achievements continued to be recognized in Europe is shown by his election as fellow of the Royal Society in 1887.

On Milne's first night in Japan he experienced his first earthquake. The phenomenon intrigued him and the rest of his British staff (Ewing, Gray, Ayrton, and Perry). They felt that the key to understanding earthquakes was an instrument that could adequately record the nature of the seismic energy, not just the fact that an earthquake had taken place (seismoscopes had existed for 1700 years). Here was a challenge that could not be ignored. ("We had earthquakes for breakfast, dinner, tea, and supper.") One of Milne's Japanese colleagues later remarked that "he threatens to exhaust all that there is for workers in seismology to investigate." When not occupied with his official duties, Milne would sit for hours writing copious notes and compiling lengthy reports. According to the authors of this biography, his writings on seismology exceeded 2 million words: he was responsible for two-thirds of the contents of the publications of the Seismological Society of Japan during his stay in that country. His own enthusiasm and drive were obviously the stimulus to the group at the Imperial College, Tokyo.

Milne's contribution to seismology was due to his having the acumen to identify the necessary crucial experiments on earthquake motion. His early instrumental work was dominated by experiments on pendulums, because he strongly believed that simplicity in design was a key factor. He also experimented with microphones in recording earth tremors—thus anticipating by 50 years the standard use of geophones in seismic surveys—and investigated simulated ground motion in the laboratory, using concrete balls weighing about 2000 pounds, as well as explosive charges.

Realizing that the study of individual earthquakes would require the services of many people, Milne proposed that a society be formed of specialists who could pool their knowledge. Thus, in 1880, the Seismological Society of Japan was formed. In the society's opening address, Milne described the first seismograph network, in which 15 Gray-Milne pendulum instruments were to be deployed in Japan. As the work of the Seismological Society of Japan was superseded by that of the National Earthquake Investigation Committee in 1892, Milne became more and more involved in recording teleseismic earthquakes. This required an extremely sensitive seismograph. Stimulated by Zöllner's design for pendulums to detect the lunar disturbance of gravity, Milne constructed in 1893 the well-known horizontal-pendulum seismograph that bears his name.

Whether because of a fire in his home that destroyed many of his writings as well as much of his reference library, or because he felt out of the mainstream of Western science, or because he sensed the growing reaction against foreigners because of a resurgence of Japanese nationalism, Milne decided to return to England in 1895. He wanted to set up his new seismograph at a permanent observatory and finally chose Shide Hill House on the Isle of Wight.

Milne had repeatedly called for international cooperation in recording earthquakes. He realized that unless seismographs were of a standard design the

comparison of earthquakes would be impossible, and at Shide he enthusiastically promoted this concept. In all, Milne was to establish 80 of his horizontal-pendulum instruments at more than 60 stations throughout the world. The catalogues of earthquakes that resulted from this world seismic net—the "Shide Circulars"—published with the encouragement of the British Association for the Advancement of Science, were to be the forerunners of the International Seismological Summary.

Milne's retirement years in England produced no major advances of the kind that in Japan had won him international fame. He did write two textbooks on seismology as well as a "Catalogue of Destructive Earthquakes AD 7 to AD 1899." After 1900, the progress of modern seismology was so rapid that one man working alone probably could not keep abreast of all the advances. Milne did not live to see the arrival at Shide of the Milne-Shaw instrument—designed to overcome the two major drawbacks of his earliest seismograph, low magnification factor and lack of satisfactory damping. Curiously, despite all the earthquake records that Milne collected, he never attempted to devise a magnitude scale—preferring to classify earthquakes by three simple degrees of intensity based on the radius of the area affected. Nor did he successfully investigate the question of travel-time curves, something that was eventually solved by Mohorovičič in 1910. Nevertheless, Milne was still in the mainstream of scientific life at Shide. Among his many visitors were Prince Boris Galitzin, who had developed the first electromagnetic seismograph, and H. F. Reid of Stanford University, who visited Milne after the 1906 San Francisco earthquake. A frequent guest was H. H. Turner, professor of astronomy at Oxford, who, after Milne's death, was to encourage the continuation of the "Shide Circulars," the project being transferred to Oxford in 1919.

Milne was undoubtedly a pioneer—adventuresome, unable to resist a challenge, and having a fanatical interest in his chosen field. That his life and work are unknown is largely because his major accomplishments were in Japan, where earthquakes are frequent, whereas in the English-speaking world they are not. It is important to have such a well-researched biography available, not only as a reminder of his immense contributions to modern seismology but as a legacy of one of the last great Victorian pioneers.

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Psychophysiology

Biofeedback and the Modification of Behavior. AUBREY J. YATES. Plenum, New York, 1980. xii, 512 pp., illus. $24.50.

Yates defines biofeedback as referring to "the display of some aspect of the physiological functioning of the individual with the expectation that observation of the characteristics of the display will enable the individual to attain increased voluntary control over the physiological function being displayed." Research on biofeedback has many origins, among which are developments in information and control system theory and the technology of electrophysiology. However, its beginnings may be found in the fumblings of clinical electromyographers who learned that they could turn their oscilloscopes around and let their patients use the visual tracings of their own recorded muscle potentials (or amplified auditory equivalents) to reeducate their damaged muscles. Other psychophysiologists were simply curious about their own ability to control or detect changes in their brain waves, skin temperature, heart rate, or palmar sweating. It is well recognized that the concept of feedback is critical to our understanding of the regulation of biological and learning processes. Moreover, the deceptively simple idea of making physiological information directly available to the individual generating it quickly caught the imagination of lay persons, researchers, and clinicians.

As a serious concern in psychophysiology and behavioral sciences, biofeedback is now more than two decades old. It may be showing its age, if not its maturity, with the publication of this first comprehensive account of the field.

Previous books on biofeedback have ranged from sensationalized popularizations to grandiose personal statements to "how-to-do-it" guides for clinicians to surveys and evaluations of clinical applications. The most serious books have been collections of empirical research papers or theoretical overviews by leading individual investigators in the field.

What Yates has done is to take the 1500 or so papers published on biofeedback and related topics and neatly summarize and integrate them. His account includes a survey of historical antecedents, a detailed examination of issues of instrumentation and methodology, and an exhaustive coverage of biofeedback research on the control of muscle activity, autonomic functions, electrical activity of the brain, and other physiological processes. The great variety of applications of biofeedback in medicine, psychiatry, psychology, dentistry, and education are given careful coverage. A special chapter is devoted to theoretical issues. A concluding chapter presents an overview and evaluation of the past, present, and future of biofeedback. Just in providing the information and bibliography Yates has performed an enormous service for students and investigators. He assures the reader that he has obtained and read virtually all the references cited in the book, and that is no mean feat. The painful detail may frustrate the impatient reader.

Although he is not at all a novice in behavioral and psychophysiological research, Yates's own work has not been directly concerned with biofeedback. (He has studied the effects of delayed auditory feedback on speech, and this may explain his interest in the topic.) This inexperience permits a certain freshness of outlook. Yates can examine methods, findings, and interpretations without undue skepticism or special bias.

Yates's dissection of the independent variables involved in biofeedback results in a new attempt at classifying feedback displays. They may be visual, digital, auditory, or tactile. The information may be presented within a trial or at the end of a trial; it may be proportional or binary; it may be continuous or noncontinuous. Although such a taxonomy may strike one as sterile, it can guide us in the evaluation and integration of completed research and in the search for more effective displays and a definition of the critical features of feedback per se. On the other hand, Yates's repeated complaints about inadequate controls and confounding variables reflect a failure to put the phenomena of biofeedback into the broader context of psychophysiological research. For example, his discussion of the "drift effect" (changes in physiological function resulting from "naturally occurring changes over the passage of time") would have greatly profited from a close consideration of the vast psychophysiological literature on habituation, sensitization, and adaptation. In addition, understanding the rationale for the use of biofeedback for various specific medical disorders requires a more thorough consideration of the particular physiological as well as behavioral factors involved. It would have also been useful to have more extensive coverage from Yates's behavioral standpoint of the issues of generalization and maintenance of treatment effects in clinical applications of biofeedback.