the sound spectrograph: that the vocal tract of the nonhuman primate is similar to that of the human newborn in not being able to generate the range of formant frequencies characteristic of an adult human being.

Implicit, at this point, is a resurrection of the principle that ontogeny recapitulates phylogeny. Although most scientists stopped thinking this way decades ago, the principle is occasionally heuristic, and Lieberman, perhaps with it in mind suggests that a development similar to the descent of the larynx in human ontogeny must have taken place during the evolution of the hominids. At this point the book turns to an investigation of the development, in the hominid lineage, of a supralaryngeal vocal tract capable of fully articulate speech.

Lieberman describes reconstructions, based on the positions of anatomical features on the basicranium, of the vocal tracts of various fossil hominids. Measurements of the reconstructions provide data for the computer-implemented analog, which Lieberman then claims can reveal the articulatory capacity for the fossil in question. Here Lieberman's method is both at its most exciting and at its weakest. It is probably one of the most interesting developments of the last decade in the study of the evolution of the communication capacities of the Hominidae. For the vertebrate paleontologist, who is already reluctant to reconstruct soft body parts from fossil bone, it is unthinkable to reconstruct such parts when the bone is absent. Nevertheless, the method is useful as one source of evidence among many. Even if the reconstructions are not completely accurate, they can indicate a trend toward an increase in capacity for generating formant frequencies in the last 300,000 years of human evolution.

To this point the book is fun. It is an instructive, very useful introduction to the kinds of problems that must be dealt with if we are to understand the origins of human language. It is packed with information and demonstrates, in places elegantly, the appropriateness of an interdisciplinary approach.

Some of the book's conclusions are less useful. Using whether or not a fossil hominid had a vocal tract suitable for the production of fully articulate speech as a taxonomic indicator, Lieberman tries to unscramble the classification of archaic *Homo sapiens*. He concludes that "fossils like Es-Skūhl V and Djebel Kafzeh are functionally distinct from Neandertal fossils; they exhibit the anatomical specializations necessary for human speech. Neandertal fossils lack these specializations." He surmises, then, that some archaic hominids could speak articulately while others could not.

On the morphological criteria Lieberman uses, the fossils he discusses do cluster into the two groups he postulates. But it is not clear how anatomy relates to function here. For instance, if the reconstructed formant frequency data for Neandertal vowel production found on p. 141 are compared with the data Lieberman cites from a sample of modern human beings, it is found that the range of formant frequencies for Neandertal fits into the modal class of the modern sample. Following Lieberman's logic, one could say that the modern human population falls into two taxonomic groups.

This anomaly calls attention to the fact that production of speech sound is not the sole function of the anatomical region in question. The structure of the head and neck, particularly the components of the basicranium and craniofacial skeleton, is a compromise among a number of functions: speech, respiration, mastication, and others. The approach based on production of speech sound is appealing because it tends to quantify shape. But it is useful only to the extent that conclusions reached are integrated with the total functioning of the head and neck. Though Lieberman recognizes functions other than speech, he does not undertake such an integration. The research he reports is, nevertheless, well worth considering, and the book is important for anyone interested in the evolution of the more recent hominids.

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Richard Courant

Courant in Göttingen and New York. The Story of an Improbable Mathematician. CONSTANCE REID. Springer-Verlag, New York, 1976. iv, 314 pp. + plates. $12.80.

Courant the man is at least as interesting as Courant the mathematician. That is fortunate, for the author of this book is strongest in the biographical line.

Courant was born in 1888 to German Jewish parents in Silesia. His father failed in several businesses, including selling obscene postcards; Richard cut himself adrift financially at the age of 16, when his family moved to Berlin. He remained at Breslau, studying for the final gymnasium examination and tutoring others for his living.

After trying other universities, Courant settled at Göttingen, capital of the mathematical world. His ambition, soon realized, was to become the assistant of David Hilbert, for which he received 50 marks (perhaps $100 in present purchasing power) and access to the prince of European mathematicians. Reid is at her best in describing the inner circle of professors and favorite students, the conduct of the seminars and the various stimulants to mathematical work.

Courant was caught up in World War I before he could obtain a regular academic position. Like many of the best educated on either side, he worried that the conflict would end before he saw action. A little time in the trenches satisfied him. He got out by inventing a rudimentary earth telegraph. Soon he was behind the lines consulting scientists and also industrialists, for whom he had an inordinate respect, and even subservience. Although perhaps not an attractive quality, it proved valuable in setting up mathematical institutes.

Courant returned to Göttingen as assistant to his prospective father-in-law, Carl Runge. (An earlier marriage ended in divorce during the war.) He soon succeeded to the professorship once held by Felix Klein. From this base he edited the important series of monographs on mathematics known as the yellow books (or yellow peril), worked on his own subjects, prepared the first volume of the incomparable Courant-Hilbert *Methods of Mathematical Physics*, and obtained money from the International Education Board to build a mathematics institute at Göttingen. The institute flourished until 1933, when the racial laws rooted out the Jews, including Courant. He seems to have felt the blow more as a good German and former soldier than as a Jew.

Almost half the book concerns Courant's life in the United States, his appointment at New York University, his efforts to place emigré scholars, his attempts to build a new institute. These attempts failed until world war again gave scope to Courant's entrepreneurism. The applied mathematics cultivated under his protection at NYU came into demand; and the resultant expansion was consolidated in peacetime by government contracts and the capture of the Atomic Energy Commission's UNIVAC, which brought with it the promise of a building.

As portrayed by Reid, Courant was an ambiguous man, indecisive yet confident, nondescript but authoritative, irritating and reassuring, subservient, commanding, cautious, speculative. Although she does not resolve these

ambiguities, Reid deserves praise and thanks for bringing them out. Professional historians may object that she does not make clear the source and reliability of her information and that she has nothing useful to say about the history of mathematics. But Reid has been where historians have not, in the private papers of Courant, which include letters from his student days and his wartime diaries, and she has used them sensibly if not exhaustively. She has done the same with the many interviews she conducted with Courant's friends and colleagues. The result is excellent journalism, informative and engaging if not deep, an appropriate successor to Reid's well-regarded book on Hilbert (reviewed in *Science* **170**, 965 [1970]).

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Caves

The Science of Speleology. T. D. FORD and C. H. D. CULLINGFORD, Eds. Academic Press, New York, 1976. xiv, 594 pp., illus. $29.50.

Once a field for the gentleman naturalist, speleology has been metamorphosed into a legitimate science as a result of the recent emphasis on the environment, pollution, and endangered wildlife. Still, however, the cooperation of the amateur caver with the professional scientist is responsible for many new speleological data. Speleology is also a multidisciplinary field. A plethora of recent volumes have attempted to summarize this new science, but most are either restricted to one subject, such as karst, or technically limited by virtue of being written by a single author.

The Science of Speleology attempts to surmount these two limitations. The subject matter is reviewed by about a dozen authorities, most of them British, and it encompasses the entire scope of speleology: geology, biology, and other, less obviously related fields.

Of the geological topics covered, the discussion of the chemistry of cave waters is particularly innovative. The solution reactions involving limestone are summarized along with the pertinent variables controlling them, and the technical level of the discussion is such that any professional would benefit from it. An "advanced discussion" follows this in which the equilibrium reactions are quantified with their respective constants, the values for the constants are evaluated, and tables of applicable values are calculated. Reaction rates and rate-limiting factors are also treated, as are the effects of foreign materials in solution. The final section of the chapter discusses practical techniques of water analysis, describing the various methods and listing the necessary reagents and glassware. Various analytical techniques are compared and evaluated, and the reader is referred to the original publications for details. This latter section is aimed at the amateur scientist or caver: "For studies in limestone areas much useful work can be done using relatively inexpensive equipment and techniques which can be mastered quite readily" (p. 249).

Several of the topics covered in the book are not frequently treated elsewhere. An interesting chapter on the physics of caves discusses both cave meteorology and the geophysical detection of caves. One does not normally think of plants growing in the total darkness of a cave, but a brief chapter on cave flora discusses the bacteria and fungi found in caves, particularly the chemosynthetic autotrophs, bacteria that derive their energy from chemical reactions in the absence of sunlight. The application of the computer to speleology, both in data storage and retrieval and in complex chemical or physical calculations, receives coverage in the concluding chapter.

The need for careful conservation of the unusual biological and mineralogical features of caves is an integral part of the caving ethic around the world. A strong conservation plea is made in the discussion of bats. It is mentioned, for example, that Mexican free-tailed bats in Texas consume about 6600 tons of insects annually and that the handling of bats during their hibernation period may cause them to use up their fat supplies prematurely and die of starvation before spring. "Speleologists and other readers of this chapter may or may not be able to reverse the trend towards a declining bat population, but at least they can refrain from contributing to it" (p. 491). It is unfortunate that only in the chapter on bats and that on paleontology and archeology does a conservational attitude openly manifest itself in this book. Conservation is mentioned fleetingly in the chapter on cave faunas and ignored completely in the chapter on cave minerals, although in both cases flagrant amateur sample collecting is a major problem.

Although the editors have managed to overcome the prevalent drawbacks to a good speleological text, they are restricted in that *The Science of Speleology* is distinctly British. For instance, the biological coverage hinges on British Isles distribution, and orders that are dominant in other areas, such as the tropics, may scarcely be mentioned here. Chemistry escapes this fate by virtue of the basics included, but the coverage of geology, geomorphology, paleontology, and archeology is similarly restricted.

This should not be taken as a criticism of the editors, for this volume was obviously intended primarily for a British audience. Certainly the coverage is broad and the technical detail provided is of high quality, and, for the reader interested in the science of speleology, the excellent discussions of research in another geographical context may stimulate new ideas in his own area.

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Actinides in the Environment. Papers from a symposium, New York, Apr. 1976. Arnold M. Friedman, Ed. American Chemical Society, Washington, D.C., 1976. x, 108 pp., illus. $14.25. ACS Symposium Series, 35.

Advances in Agronomy. Vol. 28. N. C. Brady, Ed. Academic Press, New York, 1976. xii, 412 pp., illus. $34.

Advances in Carbohydrate Chemistry and Biochemistry. Vol. 33. Academic Press, New York, 1976. xii, 464 pp., illus. $44.

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Advances in Modern Toxicology. Vol. 1, Part 1, New Concepts in Safety Evaluation. Myron A. Mehlman, Raymond E. Shapiro, and Herbert Blumenthal, Eds. Hemisphere, Washington, D.C., and Halsted (Wiley), New York, 1976. xx, 456 pp., illus. $24.50. *To order this book circle No. 432 on Readers' Service Card.*

Applications of Energy. Nineteenth Century. R. Bruce Lindsay, Ed. Dowden, Hutchinson and Ross, Stroudsburg, Pa., 1976 (distributor, Halsted [Wiley], New York). xii, 420 pp. $32. Benchmark Papers on Energy, vol. 2. *To order this book circle No. 433 on Readers' Service Card.*

The Autonomic Nervous System. An Introduction to Basic and Clinical Concepts. Otto Appenzeller. North-Holland, Amsterdam, and Elsevier, New York, ed. 2, 1976. xviii, 404 pp., illus. $47.95.

The Bee Book. The History and Natural History of the Honeybee. Daphne More. Uni-

(Continued on page 803)