words, but it is an impression that can be given by them. For Sahlins there is no relationship between the two, again a flatter extreme than Sahlins may accept but an impression almost inevitable for anyone reading this book.

After casually but properly brushing off "vulgar sociobiology," exemplified by such extravaganzas as *The Naked Ape*, Sahlins goes after "scientific sociobiology." He believes that the success of scientific sociobiology depends largely on its theory of kin selection, and in a long chapter occupying half the text pages of his book he seeks to demolish sociobiology by demonstrating that it is contradicted by ethnological studies of tribal kinship. His account is interesting, indeed fascinating, and in its own frame of reference it is convincing. As a rebuttal of sociobiology it is less so. The argument is too complex for summary here, but its basis is that according to sociobiology social organization should be ordered by kinship and that in fact it is not. What seems to be actually demonstrated is that among tribal peoples, at least, social organization produces relatively small coefficients of relationship within a given social unit. On this Wilson's views may be somewhat equivocal but are not in flat contradiction, and I believe that most evolutionary biologists would expect an approximation of the observations reported by Sahlins. The "either-or" question of individual or group selection becomes involved, and this is a false alternative. Other problems arise from the fact that the "relationship" of biologists and the "kinship" of ethnologists do not have the same meaning and both sides have confused them. It is also questionable whether the whole structure of sociobiology can be brought down on the question of kinship, a small part of that broad structure.

Sahlins next devotes some 20 pages to his view that "the Darwinian concept of natural selection has suffered a serious ideological derailment" by expression in economic, rather than directly biological, terms. Such usage is a source of confusion and unnecessary conflict, and the matter deserves serious attention on the part of biologists. In some instances economic terminology represents an inappropriate approach. (The same may be said of some basically political attacks on sociobiology.) In others it introduces problems about the use and validity of analogies. The problems are real, but my impression is that relatively few evolutionary biologists have suffered this "derailment."

Much of the critical discussion of sociobiology, including this book, has been another form of the nature-nurture debate, a discussion that has proved futile and indeed meaningless because that is not a legitimate either-or question. Man is not born a tabula rasa, nor is he born a programmed automaton. When the argument approaches that extreme polarization, it is sensible to say, "A plague o' both your houses." That does not stand as an overall judgment of Sahlins's book. It is interesting and well written. It will be valuable reading for biologists, perhaps less so for ethnologists to the extent that it may more largely reenforce than modify or enrich their existing views.

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The Anatomy of Speech

On the Origins of Language. An Introduction to the Evolution of Human Speech. PHILIP LIEBERMAN. Macmillan, New York, and Collier Macmillan, London, 1975. viii, 196 pp., illus. Paper, $4.95. Macmillan Series in Physical Anthropology.

Based on the premise that "human speech shapes human language," this little volume outlines the evidence relevant to tracing the evolution of this primary human communication medium. Whether the book actually traces the origins of language is open to question, but the introduction it affords to the author's research method makes it worthwhile reading.

It is in the first two-thirds of the book that Lieberman is at his strongest. A discussion of the cognitive and communicative factors underlying language lays a foundation for the working principle that speech and language are interdependent and that the evolution of the one affected that of the other. By using the comparative method, citing functional examples from Darwin, Negus, and others, Lieberman discusses the relations between specific anatomical arrangements and the communication systems of various species. To one trained in vertebrate paleontology such an approach is so basic as to seem obvious. Its application in the study of the evolution of language has not been straightforward, however. Until the late 1950's, it was generally believed that the capacity for articulate speech depended primarily on the proper anatomical arrangement in the central nervous system.

Lieberman is to be given particular credit here for providing a clear introduction to basic acoustics to aid his demonstration of what Fant pointed out in 1960: that the capacity for articulate speech is dependent not only on the central nervous system, but also on a particular shape and functioning in the region of the head and neck referred to as the supralaryngeal vocal tract. This approach (the source-filter theory of speech sound production) is basic to Lieberman's method. With Lieberman's exposition of it as background, the reader is able to make the conceptual leaps that the remainder of the book requires.

On the basis of the phonetic features of language and what is known of the physiology of speech production, Lieberman compares the speech production capacities of human and nonhuman primates. This comparison centers around the production of formant frequencies. Roughly speaking, an animal is articulate to the degree that it can manufacture a range of formant frequencies corresponding to the vowel triangle [a], [i], [u]. The greater this range of frequencies, the greater the capacity for articulation.

A well-developed pharynx with the posterior one-third or so of the tongue forming its anterior wall is the arrangement required for the generation of the wide range of formant frequencies that facilitates speech. On this anatomical criterion adult humans are found to be able to produce the greatest range of such frequencies. Chimpanzees are found to have a limited capacity to generate them, and the human newborn is found to have a capacity only slightly greater than that of the chimpanzee. Lieberman notes that, in the adult human, the hyoid bone and the associated larynx are low in the throat, causing the posterior one-third to two-thirds of the tongue to lie below the oral cavity (rather than in it) and to form the anterior muscular wall of the pharynx. In the newborn, the hyoid is high in the throat, so that the tongue lies completely within the oral cavity and there is little or no pharynx. This latter arrangement is found in the nonhuman primates as well. Early in human ontogeny the larynx descends, forming the pharynx and making the production of speech sound possible.

Thus far, then, Lieberman has used comparative and developmental evidence in exploring the nature of human speech. Experimental evidence is added with the introduction of a computer-implemented analog of speech sound generation capacity. This program is capable of calculating what range of formant frequencies a vocal tract of a particular size and shape would be able to generate. The analog substantiates what is already known from direct measurement with

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