A 17th-Century Scientific Community

Harvey and the Oxford Physiologists. Scientific Ideas and Social Interaction. ROBERT G. FRANK, JR. University of California Press, Berkeley, 1981. xviii, 368 pp. + plates. $27.50.

The topic Robert Frank takes as his focus—respiration theory in 17th-century England—is an old favorite with historians of science, but the insights Frank brings to it are new. His purpose is to show the interplay between the flow of ideas about respiration at that time and the conditions, or context, that permitted ideas to flow. Frank is of course not the first to interweave conceptual with contextual history, but he integrates them more meaningfully than other authors have done, and the resulting synthesis makes his book historically important and interesting to read.

Frank pays more attention to the impact of context on concept than to the reverse relation. Take his account of transfusion (a technical innovation with conceptual implications). Some readers will have known, without reading Frank, that transfusion was first successfully performed by Richard Lower at Oxford in 1666. Fewer are likely to have realized that Robert Boyle was temporarily involved in this venture. Frank tells us that together Boyle and Lower had unsuccessfully attempted transfusion from the veins of one animal to those of another, having been inspired to make the attempt, in part, by the current vogue for intravenously injecting animal (and occasionally human) subjects with poisons, drugs, nutrient fluids, pigments, and—after numerous failures—blood. We hear further that Lower (who had been away courting in Cornwall) returned to find that Boyle had left Oxford in order to escape the "intolerable distractions" of the royal court, which had moved there because of the plague that swept London at the time. Lower proceeded to perform successful transfusions (from artery to vein), first working alone and then in the presence of observers. Observers played the special role in that era of authenticating scientific claims should these be contested.

The foregoing and related developments are spelled out by Frank in copious and colorful detail. In the course of recounting them, he incidentally presents a portrait of Lower the man: his upper-class Cornish origins; his education, partly at Westminster, the school that was also attended by Hooke, Locke, and Wren; his scientific curriculum vitae; his temperament; and his intellectual style. Meanwhile, we become familiar with Oxford, the university and the town, and with the semiorganized and exuberant way in which science was prosecuted there. We make a tour of High Street and neighboring streets in order to discover who is pursuing what experiments on what human or, more commonly, animal subjects. We find different persons present before and after the Restoration and learn that individual political leanings (toward Cromwell or king) played a role in deciding who could and could not remain. In this and other ways politics affected what happened in science. So did epidemiological conditions, since the plague brought not only Charles's court to Oxford but certain scientists as well.

On transfusion and on other and more conceptually important aspects of Frank's story, we obtain information about accidental encounters and planned interaction between friend and friend, master and apprentice, and teacher and student as well as between coexperimenters, correspondents, fellow club members, and casual conversants—say in somebody's lodgings or at a particular coffeehouse on a particular afternoon (all fully documented by Frank). The web of interaction spreads as he traces its involvement of a dozen "major" and a score or more "minor" scientists and peripherally participant "virtuosi." At intervals, Frank pauses to insert synoptic summaries. These summaries are among the most instructive parts of the book. No other history save contemporary firsthand reports gives the reader as direct a sense of having been there, of having personally attended meetings of, say, Petty's club at Oxford or the Royal Society in London. No other author so vividly portrays the collective, barnstorming manner in which experiments often were planned and their outcomes appraised.

The story could not have been told by a skimming-off of large ideas from principal authors' principal works. Frank in fact has consulted both major and minor writings of major and minor investigators; their published and in some cases unpublished scientific and personal records; correspondence by and about them; diaries; biographies; and special and general histories of science, of the scientific societies, and of the culture of England and Europe.

But I have said too much about the kind of account that Frank renders and not enough about conceptual content. As a history of ideas about respiration, that is, about air and heat in relation to life, his book shows how ideas on this subject responded to two convictions strongly held at the time—that blood moved, to use Harvey's phrase, "as if in a circle" (*quasi in circulo*); and that vital functions were the visible expressions of subvisible corpuscular movements (these being mechanical, chemical, or both). First, we hear how Harvey evolved an Aristotelian—hence anticorpuscular—interpretation of respiration, then how early admirers, among them Bathurst and Highmore, extended, applied, and corpuscularized Harvey's views, and then how later theorists—principally Boyle, Hooke, Willis, Lower, and Mayow—revised, rearranged, and in some cases wholly replaced an array of inherited beliefs, among them the notions that the atmosphere contained a volatile aerial salt or "niter" and that fermentation or some analogous reaction was fundamental to life.

The critical question of the day concerning respiration had been posed by Galen when he divided respiration research into inquiries about the mechanics and aerodynamics of breathing and about the beneficial outcomes thereof. At Oxford, the interest lay chiefly in outcomes. Did breathing refrigerate or "depurate" or comminute and refine the blood? or permit, or at least enhance, its flow through the lungs? or allow the uptake from the air of something needed to support fermentation or some other thermogenic reaction? These classic questions—their origins were indirectly Greek—acquired a new urgency and meaning now that almost everyone acknowledged that blood followed circular paths through body and lungs. They likewise elicited at London and Oxford a wave of sophisticated experimentation Frank's portrayal of which by implication reminds us that Harvey had been the major exemplar of the extension to physiology of the experimental method.

Probably no single reviewer could vouch for the accuracy of all aspects of a production as multifaceted as Frank's. But he gives the impression of having a strong—almost a fierce—compulsion to

get his facts straight. In my areas of competence I scoured the text and found no faults of commission and scarcely any of omission. Perhaps some readers may fail to distinguish Galen's and Descartes's ideas from those of Galenists and Cartesians as presented by Frank. Or they may take ideas to be Oxonian which, if they were that, were also Cartesian, Scholastic, Galenic, or Aristotelian. But these are quibbles. What we have in Frank's book if taken as a whole is as enterprising, engaging, and enlightening an example of historical interpretation as this reviewer has recently read.

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Physiological Adaptations

Environmental Physiology of Fishes. Papers from an institute, Lennoxville, Quebec, Aug. 1979. M. A. ALI, Ed. Plenum, New York, 1980. xii, 724 pp., illus. $69.50. NATO Advanced Study Institutes Series A, vol. 35.

The relationships between structure, physiology, and environmental variables in the largest vertebrate class, the fishes, are explored at length in this collection of 25 papers. Most of the papers (one of which is in French) provide summary reviews of major topics of investigation, such as the effects of gas concentrations; the problems of water, ion, and acid-base regulation; photoperiodic effects on reproduction; physiology of the pineal organ; and circadian rhythmicity. In addition, some responses to factors peculiar to the aquatic environment are treated in various degrees of detail.

One of these factors is the enormous range of hydrostatic pressure found in the oceans. Fishes are known to live to depths of at least 7000 meters, at which there is a pressure of over 700 atmospheres. Fishes furthermore migrate vertically in the water column, and thus may experience pressure fluctuations of 100 atmospheres or more. In a paper by Pequeux, some recent information on the effects of pressure on membrane permeability is reviewed. Pequeux points out that these pressure studies provide new evidence for the independent transport of sodium and chloride ions across membranes and may be a useful way to study the effects of local charge on membranes and the effects of charge on permeability. He also discusses pressure effects on equilibria that involve volume changes and the consequences for biochemical processes other than permeability. In a second paper on pressure, Blaxter reviews some better-known pressure problems, such as swimbladder gas secretion against high gradients and also reviews some very recent literature on how fish prevent oxygen leakage at high swimbladder pressures by the deposition of oriented guanine platelets in the swimbladder wall and by changes in the lipid composition to favor longer-chain components with low permeability. The technical challenge of obtaining animals from the ocean deeps in suitable condition for experimentation is formidable and has delayed progress in this fascinating area, so it is satisfying to see these new results collected.

Several papers deal with the sensory systems of the fishes. Below the thin surface layer, fishes exist in a dim blue-green to yellow-green environment in which the detection of contrast, or even of light emitted by photoluminescent fishes, is the prime consideration for visual organization. In reviewing the visual pigment composition and neural integration scheme, Lythgoe emphasizes the often conflicting demands of sensitivity, contrast detection, and detection of movement as well as the differences between land- and sea-dwelling animals. Dale provides some new information as well as a short review of the acousticolateralis sensory system, a unique sensory mode in the fishes that serves to detect vibrations in the environment. Popper and Coombs provide a short review and some new ultrastructural information on the ear and its role in sound detection underwater. Conspicuously lacking from the volume is any treatment of the production and detection of electrical information, another unique sensory mode that occurs in at least six taxonomically distant groups of bony and cartilaginous fishes.

Another conspicuous phenomenon among the fishes, and one of some practical importance, is migration behavior. The physiological basis of navigational performance, especially in the open ocean migrants, has been a great puzzle in fish physiology. How is a migration of thousands of miles accomplished with no visual ("landmark") clues? Recent evidence that fish may be able to sense electrical currents induced geomagnetically, either by natural water currents or by the movement of the fishes' bodies through the water, is reviewed by Tesch, along with information on the seasonal movements of some well-known migrant species such as eels, salmon, and tunas.

Overall the book provides timely and provocative summaries of most of the major areas of investigation in the environmental physiology of fishes. No single volume can hope to be comprehensive—another much-used review now comprises eight full volumes—but within the framework of the possible this volume gets high marks.

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Subsistence in the Tropics

Parmana. Prehistoric Maize and Manioc Subsistence along the Amazon and Orinoco. ANNA CURTENIUS ROOSEVELT. Academic Press, New York, 1980. xvi, 320 pp., illus. $29.50. Studies in Archaeology.

Few topics in archeology have generated as much heated debate as the mode of life of lowland South American peoples in pre-Conquest times. Clearly, theoretical issues broader than the archeology of Greater Amazonia are at stake. What is being debated is nothing less than the "nature" of tropical forest environments and the impact they have had on human cultural developments. Are the tropics capable of sustaining concentrated and complex societies? What are the agricultural productivity, settlement patterns, and carrying capacity of specific tropical habitats? In the context of Amazonia these questions take the form of comparing pre-Conquest demographic densities in the floodplain of the Amazon and Orinoco rivers with population densities in adjacent interfluvial habitats.

The hypothesis proposed by the author of *Parmana* can be stated briefly. Roosevelt suggests that the higher carrying capacity of floodplain habitats vis-à-vis the hinterland is due to the adoption of maize by peoples who grew primarily manioc before. (Other scholars have argued that it was due to better soils or more abundant fish and game.) She contrasts manioc, which grows well in upland soils and is rich in calories but poor in proteins, with maize, which is nutritionally more complete and is better suited to the floodplains. Once maize-growing peoples are released from the need to hunt and fish in order to secure their proteins they can (ergo) grow in numbers, become more sedentary, develop chiefdoms, engage in war, in short evolve a more complex society.

But how does Roosevelt actually reach her conclusions? She begins by criticizing the ideas developed by previ-