may get some of the credit he deserves.

Hediger's book handles a wide range of zoo problems, from the completely practical to the philosophical. His arguments are strongly supported by a splendid selection of photographs. Like many European professors, however, he tends to be hard on colleagues who dare to differ. He hammers without mercy on the head of Hans Wackernagel, who is a proponent of artificial diets. But one suspects that Wackernagel's sin is not so much his advocacy of the Ratcliffe-Philadelphia diets as his location in Hediger's former parish. In spite of this special pleading, perhaps partly because of it, this work is a classic in the sparse zoo literature.

John Perry, a former management consultant who is now assistant director of the (U.S.) National Zoological Park, has written a book so full of common sense and tolerance that it is a pleasure to read. It is, however, rather formless, being a discursive collection of anecdotes and ideas, and the author has been poorly served by his publishers, who allowed it to appear without illustrations. Perry shows an exceptional grasp of the management difficulties and domestic politics of the American zoo business. He makes generalizations with a simplicity lacking in the more earnest professionals. He inflicts no wounds and takes a constructive attitude even in the least hopeful of situations. Like Hediger's book, his is so personal that one is apt to review the man rather than his work. Let us pray for the conversion of more management consultants.

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Essential Accumulations

Natural History Collections. Past, Present, Future. A symposium, Washington, D.C., Oct. 1968. DANIEL M. COHEN and ROGER F. CRESSEY, Eds. Biological Society of Washington, National Museum of Natural History, Washington, 1969. Illus. Paper, $4. Proceedings of the Biological Society of Washington, vol. 82, pp. 559–762.

Space-consuming accumulations of dead animals, fossils, and dried plants, the tools of the systematist and evolutionist, are not held in the same high esteem as scintillation counters or electron accelerators, but as man modifies and pollutes the environment they may provide the only records we have of the disappearing fauna and flora. This symposium deals with the problems of preserving such records.

The recent shift of research emphasis in systematics and evolutionary biology as it affects ornithological collections is well presented in these proceedings by R. L. Zusi. Bird species, unlike most groups of invertebrates, are well known. Whereas in the past only the skin with feathers was preserved, present needs are for collections of skeletal material, collections of tissues and organs preserved in alcohol (esthetically not so pleasing as stuffed skins), tapes of bird songs, and x-ray pictures to resolve the many problems of phylogeny which remain puzzling. On the applied side, the medical requirement for parasite collections is discussed by W. W. Becklund. The collections are needed for studying what parasites cause or transmit disease, their distribution, their diagnostic features, and the hosts parasitized and for determining whether a species is new to science. In his report on electronic data processing R. B. Manning discusses the use of computers for storage and retrieval of data concerning stored specimens.

The vast use that is made of natural history collections is indicated by the report that 372,886 lots or specimens were loaned by the U.S. National Museum in 1967 and that 1195 students used its collections during a single year. The importance of the national resource that collections constitute is pointed out. The growth of collections and the increasingly burdensome and costly housekeeping are discussed by several authors. It is suggested that most collections could be housed in less expensive quarters away from exhibitions.

The symposium published here is somewhat one-sided, all the participants being members of the Smithsonian Institution or other government agencies. It is pointed out in the book that 34 percent of the herbaria are owned by government institutions and 59 percent are university facilities. (No comparable figures are given for zoological collections.) Although not so large as the government institutions, the university museums are probably in the majority. Many of these museums were originally started in agriculture schools to aid in determining plant and animal pest species. Their growth, especially in recent years, attests to their value in training and assisting new generations of biologists for systematic, evolutionary, and environmental studies.

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Chartings of Progress

A History of Technology and Invention. Progress through the Ages. MAURICE DAUMAS, Ed. Translated from the French edition (Paris, 1962 and 1964) by Eileen B. Hennessy. Vol. 1, The Origins of Technological Civilization (xii + 596 pp., illus.). Vol. 2, The First Stages of Mechanization (x + 694 pp., illus.). Crown, New York, 1969. $10 each volume.

As each new multivolume history of technology is published—this is the third in recent years—it becomes more amusing to read the editors' protestations regarding the uncertain state of knowledge in this new field of study. To those of us who have bet our careers upon the viability of the field as an intellectual discipline, however, the amusement is tempered by the uneasy feeling that, in a fundamental sense, the editors are right. The work under review compares very favorably with other histories of technology, but it does not bring us much closer to understanding the relations between technology and the social milieu in which it exists. Before arguing the point, however, let us look at the books themselves.

These are translations of the first two volumes of the projected four-volume *Histoire Générale des Techniques*, published by the Presses Universitaires de France. Most of the authors of individual chapters are scholars in French universities or museums; three or four are engineers not in universities. The editor is chief curator of the technical museum of the Conservatoire National des Arts et Métiers, in Paris.

The first volume departs radically and refreshingly from the usual preoccupation with Mediterranean origins

of Western technology. The first section is an intelligent survey of prehistoric technology by a Sorbonne professor who avoids the "scientific folklore" that plagues the field because theories about how ancient workmen behaved, which have become respectable through uncritical repetition, were spun by scholars who never carefully observed modern workmen. An Egyptologist who called in an old Italian quarryman as a check on his speculations wrote, "His range of knowledge was limited, but what he knew was painfully accurate." Following the section on prehistory the plan outruns the reality as more than a dozen authors survey world technology from the beginning of history (say 3000 B.C.) to the end of the Middle Ages (A.D. 1500). The Mesopotamian chapter is cryptic; scientific folklore returns in the Egyptian chapter; Greek and Roman chapters are pedestrian. The quality of the Chinese chapter has been diminished somewhat by the brilliance of Joseph Needham's latest volumes of his *Science and Civilisation in China*, unavailable to these authors. The chapters on India and the Byzantine Empire are fresh but lack the substance of dependable data, which do not exist. Chapters are included also for Islamic and pre-Columbian American technology. Finally, Bertrand Gille's section on the Western medieval period is a monograph in its own right. It is a solid contribution but lacks the arresting qualities of Lynn White, Jr.'s *Medieval Technology and Social Change* (1962).

The emphasis throughout the book is upon techniques, but more attention is paid in this than in the second volume to the social effects of technology and influences within a society that affect technological growth. Thus one author is impatient with Rome for failing to have an agricultural and industrial revolution; another analyzes the "failure" of China to maintain its earlier technical virtuosity, which gave the world paper, porcelain, gunpowder, the compass, and many other innovations. India's preeminence in textile development has filled the vocabulary of textiles with Indian place names, yet the arts of contemplation, such as yoga, were more influential in India's development than the technical arts. The unique agricultural contributions of pre-Columbian Americans, the presence of bark paper, closer to tapa than to papyrus, and the nearly total absence of wheels—for vehicles, potter's wheel, lathe, or waterwheel—suggest that the notion of simultaneous but independent invention is not a self-evident proposition. Western medieval history still gives hints that have been ignored century after century; for example, exploitation of forests without thought of replenishment results in crises. Forays of the authors into the meaning of their narratives are few and tentative, but they are not wholly absent.

The second volume, on the other hand, covering the two or three centuries after the end of the Middle Ages and before the Industrial Revolution, is organized along the lines of Charles Singer's five-volume *History of Technology* (1954–58). Each technical field is treated in a separate chapter, and in the work under review, as in Singer, no systematic attempt is made to pursue linkages between the techniques and the people they affect. Thus we find chapters on agriculture, mining, chemicals, textiles, clocks, roads, vehicles, power, fortification, guns, canals, water supply, building construction, printing, and so forth. Multiple authorship causes some annoying but not intolerable repetition. The unifying threads are the authors' enthusiasm for techniques, which musters equal fervor for building a cathedral and building a cannon, and their agreement that technical progress is a good thing. Technical progress in this early period is, as one might guess, anything that brings an art closer to the present level of practice. While the total effect of this volume must be one of great technical achievement during the preindustrial period, there is no concession made to the general historians who may wonder why it is necessary to read a dozen pages about, for example, the abortive steam engines of Denis Papin. I think there are reasons why Papin's work should be understood, but I have not found them in this book.

The American publishers have preserved and in fact slightly expanded the lavish array of illustrations. The two volumes contain nearly 700 text figures and over 100 plates. A great majority of the text figures have been redrawn for clarity. Full-page engraved plates from Diderot's *Encyclopédie*, for example, have been nicely redrawn so that they could be reduced to a sixth of a page. A bibliography, chiefly of books and articles in English, follows each chapter or section. The bibliography is different from and better than that in the French edition, but a thorough student will want to refer to both editions.

In view of the publisher's apparently serious intention of producing a distinguished set of books, it is difficult to see how he could have failed to recognize that a translation that includes technical descriptions must be checked by a reader who knows the correct technical terms. These two volumes are peppered with errors that could have been readily caught but that make the books at least irritating and occasionally incomprehensible to a technical reader and utterly baffling to a reader who cannot guess the proper word or phrase to substitute for the one he sees before him. "Hydraulic wheel" instead of "waterwheel" is merely irritating, but such errors as "pushed up" for "pushed down," "genial" for "having genius," "burner" for "still," "soldered" for "welded," and "wick fed by soot" for "wick fed by tallow" make mincemeat of an author's intentions. Added to several score of such errors are many technical explanations that are not quite right, and a few that are entirely confused. Furthermore, errors of conversion—1 kg = 2.2 lb, usually, but sometimes 1 lb = 2.2 kg—and decimal errors make it desirable if not absolutely necessary to have the French volumes at hand when reading the English.

Finally (and this is a criticism of the French edition), a work as extensive as this must certainly be used primarily for reference. Footnotes are necessary when further study is desirable, and their absence is a serious error of omission.

To return to the point raised at the beginning of this review, I find in these volumes a number of valuable comments and insights that could lead to a viable history of technology, but I find also a point of view that makes unlikely any systematic expansion of the field to encompass (in Lynn White's phrase) the jungle of meaning.

The worldwide scope of the first volume is all to the good. A profound observation by Daumas, the editor, on the nature of technology appears in the first paragraph of the preface, but the implied question is not followed up. He notes that once prehistoric man's "essential needs had been satisfied, he could have remained indifferent" to most of the materials that surrounded him, as did all the other animals. Other animals did not make continual efforts, over the millennia, to improve their hunting techniques or their shelters, but man did. Perhaps, Daumas continues, the most significant characteristic of

man is his "constant need for progress."

Destinations that progress leads to must also, I think, be explored if the history of technology is to be more than an exercise in antiquarian description or an uncritical celebration of the single-valued progress implied just above. Daumas says specifically that his volumes are intended only to describe; political, social, and economic context is mentioned only when "indispensable." Surely he must be aware that the assumptions he and his collaborators make regarding the nature and importance of political, social, and economic context cannot help coloring their criteria for success, progress, importance, and other attributes of the technical developments they describe. A shift in point of view may even switch cause and effect. Context is not only indispensable but in fact unavoidable. History is not science. Better, then, that the reader be reminded frequently and explicitly of the assumptions surrounding the history of technology that he reads.

It ought to be possible to combine accurate technical description and an analysis of the relationships between technical alternatives and the dynamic situations of men in history. The general historian or any other reader of these books hardly needs 12 pages on Papin, but he is entitled to an explanation that will enable him to appreciate the technical alternatives that were open to Papin and the further possibilities that they opened for those who followed him. If the reader knows nothing of the technical milieu, he can only perpetuate the myth of a logical and rational pattern of technological development.

Perhaps the most important lesson to be learned from technical understanding would be the absence of an expected cause-effect relationship. The logical decision-making process of the technologist exists largely in his imagination, and his resemblance to the economic model of man is hard to maintain in the face of his enthusiasms and his loyalties. Historians of science have scuttled the stereotype of a scientific method leading inexorably in only one possible direction. Historians of technology may, one hopes, contribute to undermining our world view that sees technology as a benign social determinant that can be neither criticized nor controlled.

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Intercultural History

Clerks and Craftsmen in China and the West. Lectures and Addresses on the History of Science and Technology. JOSEPH NEEDHAM. Based largely on collaborative work with Wang Ling, Lu Gwei-Djen, and Ho Ping-Yü. Cambridge University Press, New York, 1970. xx + 472 pp. + plates. $22.50.

In the 1940's Joseph Needham abandoned a distinguished career in the biological sciences. As the 1970's open, he is without doubt the world's greatest intercultural historian. One may—indeed, one must—disagree with him on some details, but no controversy can dim the majesty of the task which he has set for himself. His massive *Science and Civilisation in China* (nearly half of its planned 12 volumes have been published) deals not only with China's very considerable achievements in technology and science but also with the radiation of these achievements to the rest of Asia and to the West. But these great systematic tomes are formidable even for specialists.

Fortunately Needham has now begun to gather, revise, and republish the many less formal addresses and papers which are partial sketches or by-products of his great work. Here his thinking is much more accessible: indeed, the fluidity of the lecture form, and Needham's artful way with words, make the casual reading of this book a delight. To pick it up is to join one of our century's remarkable minds as it ranges the whole of Eurasia and the millennia of history. It is also to learn to share Needham's moral commitment to studies which "may turn out to be a contribution not only to objective history, but also to the cause of international understanding and friendship."

The items assembled here are an intellectual smorgasbord. The essay on "The translation of old Chinese scientific and technical texts" is a revelation of the linguistic difficulties surrounding Needham's enterprise. "The earliest snow crystal observations" demonstrates that long before Albertus Magnus first pointed in the West to the geometry of these crystals the Chinese were familiar with it. Nowhere does the amazing empirical skill of the Chinese tradition emerge more luminously than in Needham's discussion of "Proto-endocrinology in medieval China": it is startling to learn of the extraction of male and female sex hormones from urine for pharmaceutical purposes, the early use of iodine-rich seaweed as a cure for goiter, and the intelligent efforts to aid diabetics. The metallurgy of iron and steel, Chinese clockwork, Chinese contributions to shipbuilding and the nautical arts which in the 15th century enabled great fleets to sail as far as Africa, the origins of chain suspension bridges, "The pre-natal history of the steam-engine," and much else are here to expand our horizons of both time and space. And always there is Needham's insistence on "The unity of science: Asia's indispensable contribution." As the astronauts look back at our small terrestrial globe and perceive it as a unit, so will Needham's readers.

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East and West

Western Medical Pioneers in Feudal Japan. JOHN Z. BOWERS. Published for the Josiah Macy, Jr., Foundation by the Johns Hopkins Press, Baltimore, 1970. xvi + 248 pp., illus. $8.95.

Dawn of Western Science in Japan: Rangaku Kotohajime. GENPAKU SUGITA. Translated from the Japanese by Ryōzō Matsumoto, supervised by Tomio Ogata. Hokuseido Press, Tokyo, 1969. xii + 74 pp., illus. 400 yen.

John Z. Bowers spent a year and a half as a visiting professor on the faculty of medicine of the Kyoto National University. After his return from Japan he published an important historical study entitled *Medical Education in Japan* (Harper and Row, 1965), which actually deals with the sequence of foreign medical systems imported into, and absorbed by, Japan and with a great many extraordinary personalities who were involved in this educational transfer. Now, in *Western Medical Pioneers in Feudal Japan*, Bowers devotes a complete volume to the first importation of Western medicine into Japan.

Western medicine was not the first foreign medical system to be adopted by the Japanese, who had begun their art of healing with the adaptation of Chinese ideologies and practices. Hence, in order to set the stage, Bowers presents in his new book a chapter on "Medicine before the Dutch." This brief chapter deals in an all too cursory manner with the more than 1000 years