his own research in Mesopotamia had shown previously that population increase, large-scale irrigation, and certain cultural achievements were consequences rather than antecedents of state development.

State institutions nevertheless did not develop among hunting and gathering societies or among simple farm villages. They had at least preconditions of land use, settlement pattern, and population. Perhaps it is my own predilection for simplifying things that leads me to find very convincing causes of state institutions in Adams's excellent analysis. Specifically, he shows that there was a highly specialized development of eco-niches that produced symbiotic interdependence between adjacent segments of society. Primary importance need not be ascribed to population density, community size, potential surplus production, or any other single factor. But it seems to me that the author has documented the incipiency of crop improvement, better utilization of microenvironments, and increased specialization and interdependency of local population segments as the new processes or trends that led to state institutions.

Adams says that there were "certain built-in incentives to population growth" in agricultural regimes based on better exploitation and expansion of ecological niches (p. 44), and "there were significant respects in which [the state's] component producing units were not self-sustaining" (p. 47), as in Mesopotamia, where different localities were devoted to wheat and barley, gardens, herding, and fishing (p. 48). Although these specializations culminated in the state, they can surely be assumed to have been essential processes in the development of state institutions and not merely their results. Specializations similar to those of Mesopotamia were, he says, "the most advanced and characteristic institutions of Mesoamerican society . . . [which] may even have had their origins in mediating the relationships and interchanges between the specialized components" (p. 52). Additional factors that created heterogeneity and cooperation as well as competition betwen social segments were pressures and movements of external groups, including nomads in Mesopotamia, who were "one of the strategic disequilibrating factors that may have set the core of processes of the Urban Revolution in motion" (p. 19).

There emerges a clear picture of early specialization and interdependency between the peoples of adjacent localities, which contrasts with the general assumption previously held that productive activities of early states were fairly uniform over wide areas. Local specialization and trade entailed other kinds of social interaction which in time required formal, institutionalized controls. Once any local society becomes sufficiently specialized, it also becomes inextricably and irreversibly linked with institutions that have emerged as a higher level of organization.

Institutions that had the potentials for filling new functions already existed in the temples and priesthoods of the early farm villages, where they served many purposes, including performance of fertility rites (pp. 120–129). By extending the theocratic institutions across communities, strengthening their authority, and adding such new functions as control of deployable surplus, the basic theocratic state institutions were evolved (chapter 5).

Subsequently, the emergence of militaristic controls represented another disjunctive step in evolution. While this involved further social differentiation in societies that were already complexly structured, it is not quite clear whether the new goals of acquiring additional wealth through tribute and conquest of land represent an irreversible trend toward aggrandizement of certain social segments that had begun in the theocratic period, or whether new factors are discernible. Since the primary states elsewhere were at first theocratic and later militaristic, further comparative study might disclose several dissimilar factors that led to conquests.

In addition to analyzing the basic evolutionary processes, Adams devotes considerable attention to the smaller processes—the particular links in the chain of causality by which the original corporate village kin groups were modified within the state structures, subordinated to higher classes, and even differentiated internally into status groups, while the temples, nobles, and militaristic kings acquired increased control of the land and of the labor of certain segments of the population. The final picture in both areas is complex in similar ways. Lands became concentrated in the hands of nobles, kings, and temples, although kin groups and even merchants retained land rights. Labor was mobilized through slavery and through *corvée* and other kinds of obligations for construction of public works, expansion of productive land, and service in households. Militarism enlisted various segments of the population, and frequently rewarded successful armies. The social structure included slaves, semi-slaves, corporate kin groups, nobles, and kings. Certain segments became craft specialists, some of them organized in guilds, which advanced technology and learning.

Adams does not contend that the processes he has analyzed for Mexico and Mesopotamia do not hold for other primary states. Very probably many of these processes will be recognized elsewhere. The crucially important features of Adams's analysis is its detailed empirical basis. Any generalizations that are extended to other cases must be based on equally detailed study. In the perspective of 100 years of cultural evolution, the contrast between the postulation of stages through which mankind progressed and Adams's delimited and meticulous comparisons is very vivid.

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A Chinese Classic

What little we know of Sung Ying-hsing's life as a scholar-bureaucrat seems ordinary enough. What was rare about him was a sense of wonder, developed through observation of the farmers and artisans of his native South China, at the creative power of nature and at the ingenuity of man in disciplining it and turning it to productive use. He wrote a classic survey of the techniques of his time, now translated by E-tu Zen Sun and Shiou-chuan Sun as **T'ien-Kung K'ai-Wu. Chinese Technology in the Seventeenth Century** (Pennsylvania State University Press, University Park, 1966. 386 pp. Illus. $15). Sung's aim was to demonstrate to his fellow gentry, "who knew the taste of their meals well enough, but not where they came from," that not everything worth knowing is learned from the classics or through meditation. He predicted the fate of his masterpiece: "An ambitious scholar will undoubtedly toss this book onto his desk and give it no further thought; it is a work that is in no way concerned with the art of advancement in officialdom." It dropped out of sight, in fact, soon after publication in 1637,

and remained obscure until the class of people to which he had directed it no longer existed. Nonetheless, since 1927 Sung's book has been reprinted in China eight times because of its clear, elegant, and usually reliable descriptions, accompanied by over a hundred attractive and well-conceived illustrations of agriculture, the preparation of foodstuffs, the manufacture of textiles, dyes, weapons, and vehicles, the exploitation of metals, minerals, and precious stones, and the making of ceramics, paper, and ink. Many of his methods had been in use for centuries, and many (those of intensive rice culture, small-field irrigation, oil extraction, and hand papermaking, among others) are still in use today.

Because the book contains so much fresh observation (Sung used books and hearsay too, but not by preference), readers who are as interested in ideas as in techniques can learn a great deal from it about how Chinese perceived the natural world. For example, Sung refers three times to what we know as natural gases—one which was piped out of salt wells in West China and burnt to evaporate the brine, one which poisoned coal miners unless a hollow bamboo was inserted in the shaft to draw it out, and a "foggy" one which suffocated gem miners who were exposed to it too long. His technical term for "gas" was the common word *ch'i*, which originally meant "breath of life," like the Greek *pneuma*. Long before Sung's time it had become one of the most overworked words in the language. The translators correctly render it in other contexts as "quality," "properties," "vapor," "power," "essence," and "odor." Clearly, *ch'i* does not necessarily imply a material substance at all. Its breadth of meaning was a great obstacle in the way of a clear conception of "gas," which had to wait for the introduction of modern science.

Despite the difficulty of Sung's style, this is perhaps the most accurate English rendering to date of any lengthy classic from the Chinese scientific tradition. The translation is free enough to read naturally in English, but not so free as to violate the sense of the original. The annotations answer most, though not quite all, of the questions which will occur to the alert reader (*1*). The bibliographies are random, and the index perfunctory. The woodcut illustrations (all of those in the first edition, and others done for an 18th-century encyclopedia which quoted Sung) are beautifully reproduced. The design of the book as a whole is so exceptional that the high price is not unjustified.

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Note

1. For a longer and more technical assessment, see N. Sivin, *Isis*, in press.

Science and Technology Supplements

Three volumes have been published that supplement *The McGraw-Hill Encyclopedia of Science and Technology* [rev. ed., 1966; reviewed in *Science* **152**, 903 (13 May 1966)].

The McGraw-Hill Yearbook of Science and Technology (David I. Eggenberger, Exec. Ed. McGraw-Hill, New York, 1966. 461 pp. Illus. $24) is the fifth yearbook that serves to update both the 1960 and 1966 editions of the *Encyclopedia of Science and Technology*. The first 90 pages, called Preview of 1966, are devoted to nine brief and timely articles or essays: "Air pollution," by Aaron J. Teller; "Biosonar," by Thomas C. Poulter; "Computers and the mind," by Leonard Uhr; "Molecular biology," by Alexander Rich; "Mycotoxicoses," by Clyde M. Christensen; "Origin and evolution of the atmosphere," by Heinrich D. Holland; "World protein needs," by Max Milner; "Terrestrial navigation," by Peter C. Dandretto; and "Programmed learning," by Lawrence M. Stolurow. Next comes a 16-page section of "photographic highlights" followed by the 320-page encyclopedic portion that updates the 15-volume encyclopedia by incorporating new materials based on new developments or additional bibliographic research. The volume is indexed and is a valuable acquisition for owners of the parent work, as well as for those who buy only yearbooks as a means of keeping abreast of the progress of knowledge.

McGraw-Hill Modern Men of Science (Jay E. Greene, Ed. McGraw-Hill, New York, 1966. 630 pp. Illus. $19.50) contains brief biographical sketches of 426 contemporary scientists. The biographees were selected from among the recipients of the major awards and prizes for scientific achievement conferred since 1940, including 45 Nobel Prize winners. Approximately 300 of the sketches were written by the biographees. Each sketch contains a succinct account of the person's scientific and technological achievements, stated in as lucid language as the nature of the material makes possible. The reader is referred to articles in the encyclopedia "for further background" on the individual's fields of interest and activity. Many popular biographical accounts of scientists are strong on personal trivia and offer only fragmentary details of scientific contributions and professional achievement. This volume is unusually valuable because of its emphasis on the biographees' scientific work and achievements. The executive editor has told me informally that if the volume is successful a second will be forthcoming, for the one just published includes biographical sketches of only about one-half of those whose achievements merit inclusion.

The third supplement, **McGraw-Hill Basic Bibliography of Science and Technology** (David I. Eggenberger, Exec. Ed. McGraw-Hill, New York, 1966. 748 pp. $19.50) contains selected and annotated listings of 8000 books in all scientific and technological fields. Theodore C. Hines, associate professor of library service at Columbia University and a recognized authority in science and technology reference literature, served as coordinating editor. Subject headings correspond to the titles of articles in the encyclopedia and are additions to the references given at the ends of the articles. Citations include concise notes on contents and level of difficulty. The emphasis is on primary sources: textbooks, handbooks, research monographs, and original works. In a topical guide, the encyclopedic subject headings are grouped into 100 major categories of scientific or technical specialties and disciplines. The organization of this bibliography will make it more useful to teachers, students, and research workers than standard bibliographic works which are arranged according to standard library classification systems. On the other hand, it will not be as useful to librarians and others desiring a comprehensive acquisition guide as the standard works now in general use.

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