

CHAPTER 9

Writing and Secular Knowledge Outside Modern European Institutions

Charles Bazerman

University of California–Santa Barbara

Paul Rogers

University of California–Santa Barbara

Knowledge is a large, vague term often considered coterminous with civilization. In this first section, we narrow the scope of the term to suggest that much of what we think of as knowledge is embedded in literate institutions and associated with particular forms of writing. This chapter and the next then review the forms of written knowledge and the institutions by which this knowledge has been produced and disseminated in various societies. A third chapter (11) then examines the institutions created to archive, maintain, organize, and index knowledge.

By knowledge, we mean concepts and information shared with other people rather than personal certainties. Some knowledge is shared through physical guidance and imitation, often supported by language, to orient people toward perceptions and tasks. Other forms of knowledge, however, are realized in the statements. Such declarative knowledge can be passed down by oral traditions, but holding knowledge stable in oral cultures is labor intensive and constrained by the kinds of devices that keep them stable, such as narrative, imagery, sound patterning (e.g., rhythm, rhyme, alliteration, or assonance), and ritual performance (Rubin, 1995). Oral memory may also be supported by drawings, monuments, and architectural arrangements (Renfrew & Scarre, 1999).

The invention of writing made knowledge more readily and reliably remembered, transported across time and space, and shared, by copying, among multiple people and sites. This shared knowledge forms common reference points for those who have access and who attend to it. It forms “what everyone knows” and what dissenters dissent from. At times the knowledges available in a time and place are harmonious and at times they may be contending or contradictory, representative of different interests and peoples. Also the advance of knowledge may be built on organized contestation among claimants in structured forums based on mutually recognized criteria, as in the contemporary academy.

Jack Goody (1977, 1987), Eric Havelock (1982), and Walter Ong (1982), among others, further suggested that writing facilitates organizing information into lists and charts, aggregating multiple instances into general categories, constructing abstractions apart from instances, and reasoning about them. Writing also holds stable procedures, rituals, formulae, recipes, and experiments, thereby allowing comparison of the consequences of repeated

behaviors. Writing facilitates inspecting exact wording to hold authors accountable for what was said, as well as to comparing accounts for inconsistencies, differences, and contradictions. Although these tasks can be carried out in oral contexts, and none are a necessary consequence of the acquisition of literacy, these facilitations nonetheless are consistent with historically observed changes occurring with literacy. One interesting aspect of the inspectibility of writing and its potential for reflectiveness about language is that in most societies discussed herein, some form of linguistics emerged early in the wake of literacy.

Sylvia Scribner and Michael Cole (1981), in investigating the three forms of literacy of the Vai people in Africa (in Koranic Arabic, in Western schooled languages, and in an indigenous script), noted that differences in thought came from the social practices and institutions associated with each form of literacy rather than as a general consequence of literacy. Thus, the impact of literacy on thought and knowledge should be understood within particular social, cultural, and historical circumstances and practices. Writing in turn reshapes the forms of social and cultural organization within which literacy is practiced (Goody, 1986). Schooling, for example, developed to meet needs for literacy training. In turn, the conditions of schooling removed from other daily practices changed the distribution and production of knowledge—with impact on other social institutions such as the state, which came to rely on schooling to prepare functionaries. Literacy also extended communicative networks among people interested in advancing knowledge; philosophic and scientific communities formed around the inscribed (and later printed) text. (For sociological analyses of how such communities take shape, thrive, move to abstraction, differentiate, and fragment, see Collins, 1998; Kaufer & Carley, 1993.) Literacy knowledge and associated social arrangements became intertwined with each other (Bazerman, 2006; Goody, 1986).

This chapter and the next give a synoptic overview of that intertwined story. This chapter reaches backward to the earliest production of written knowledge in the Fertile Crescent, the Middle East, the Mediterranean, China, India, and Mesoamerica and leaves off in each region just before the introduction of modern Western universities and accompanying structures of modern scholarship. For Europe, that means this chapter ends with the fall of the Roman Empire; for the rest of the world, this chapter continues until just prior to European colonization, Westernization, or integration into a global knowledge economy. In these chapters, we further narrow our scope to look at secular knowledge, in contrast to the sacred knowledge of scriptural religions. The sacred–secular distinction is admittedly a whiggish one, in that we look backward from contemporary knowledge systems and social organization to find traces in earlier periods and other geographic regions where those things we might call secular knowledge may have been bound up with sacred knowledge. Furthermore, although these two chapters touch on law and the economy, the focus is primarily on the kind of knowledge currently associated with academic research and the universities. It is only from the perspective of the modern university that we would identify the subject matter of this chapter as secular knowledge abstracted from both religious belief and daily affairs.

We have one further prefatory comment concerning the sources cited. Intellectual and cultural histories of the various global societies have documented and analyzed, extensively and in detail, the contents of knowledge-bearing documents. In these histories, knowledge-bearing texts serve as evidence of what individuals and cultures knew, believed, or discovered, but only rarely has the production and circulation of texts been given central focus. Such a concern for the role of writing itself has been most evident in the study of the rhetoric of modern science and modern disciplines. Where such literature is available we draw directly on it. For the most part, however, we glean from the more traditional intellectual and cultural historical literature for indications about the nature of the writing and texts. We also present uncited, widely known facts of intellectual history. We hope that our sketchy story of how writing has had an influence on the production of knowledge will spur further investigations.

EARLY FORMS OF INSCRIBED KNOWLEDGE

The origins of written language in the impressing of tokens into clay envelopes are closely linked to the inscription and storage of knowledge about plant and animal produce (see chap. 1, this volume). This invention in the Fertile Crescent soon led to aspects of Sumerian religious, governmental, and business affairs being transcribed to facilitate activities stretching over time and space, and over many parties. Sumerian cuneiform dominated the region from the middle of the third millennium to the middle of the first millennium BCE even when spoken Sumerian was long dead. It was used by the Akkadians, Hittites, Elamites, and even the 18th Egyptian dynasty in the latter half of the second millennium when it ruled the East (Vanstiphout, 1995).

Sumerian cuneiform was taught in the Eduba—or tablet houses—of the Mesopotamian basin. In these schools, the primary knowledge taught was the written language. Sumerian cuneiform not only inscribed knowledge of this dead language, but also became the vehicle for knowledge of the spoken languages such as Akkadian (Vanstiphout, 1995). The school was organized on a craftsman apprentice model (Vogelzang, 1995), where the central activity was the copying of vocabulary, grammar, and mathematics lists. Beyond the lists of common words and names, students copied word lists and documents largely pertaining to administrative, diplomatic, contractual, and legal matters, thereby simultaneously tutoring them in knowledge of administration, commerce, and the law. The archives of tablets at these schools may also be repositories of such knowledge, though it is unclear from archaeological evidence which documents were true archival information and which were student exercises.

Curriculum also included literary texts, which were largely narratives about the great deeds of gods and heroic leaders or poems of praise to them. Some reflective wisdom literature, lyric love poetry, elegies, and complaints as the civilization collapsed also became part of this knowledge of the scribal classes (Vanstiphout, 1995). These literary texts provided knowledge of both their contents and the styles they were realized in. These literary texts also became the basis of bibliographic information about them through catalogs. The knowledges recorded and gathered in the Eduba seemed to stay close to the Eduba, which became the center of an educated elite cultural life.

Two of the more widely circulated domains of knowledge concerned the law and the accomplishments attributed to the great leaders. Though we have tablets of legal code from prior to 2000 BCE, Hammurabi's code of the mid-18th century BCE was the first clear evidence we have of wide circulation. Hammurabi, who created the empire of Old Babylonia, ordered his legal code inscribed on stone stelae in temples. This public presence of his laws, even though intelligible only to the scribal classes, may have aided administration of and respect to a uniform law. As well, it may have served as a monument to leadership by establishing and maintaining a rule of law. Accounts of royal accomplishments of other leaders, such as prowess in battle and prosperity of their state, were inscribed on city and palace walls, as well as placed on decorative cones. This public recorded knowledge served to create fealty and obedience in subjects and respect and fear in others, as we can see in the opening lines of *Gilgamesh*, which we take as the first extended instance of literature (see also Kramer, 1981).

SCRIBAL EGYPT

In the bureaucratic state of ancient Egypt, complicated economic and social systems depended on writing. Scribes held distinguished positions within Egyptian administrative, political, and learned professions, and new scribes were trained principally to enter civil service. Although some children of the highest class were educated at the palace along with the royal princes, most were taught at home, by their own fathers or in schools asso-

ciated with the temple or office for which their fathers worked. Access to education was largely limited to those from the scribal and elite classes (Silverman, 1997). Advanced teaching was on an apprenticeship model, mentored by senior officials (Lichtheim, 1976).

The scribal craft embraced an ideal of the knowledgeable man, to measure, count, and record (Claggett, 1989). One instruction book from the New Kingdom (late second millennium BCE) presents the scribe as the most desirable of occupations: "The scribe he alone records the output of all of them" (Lichtheim, 1976, p. 170). Scribal employment was extremely diversified; one list of scribes indicates 58 distinct scribal positions (Claggett, 1989). The home of learning was in the temples where departments called "House of Life" contained libraries and scriptoria. Letter writing was a prominent feature of scribal activity, whereas Egyptian knowledge making most often took the form of the list (Silverman, 1997).

Surviving texts consist in large part of funerary forms, such as offering lists, the prayer for offerings, and other writing on the walls of tombs. The written word gave specific identity to pictorial representations, naming the tomb owner, his family, titles, and ranks plus the offerings he was to receive. From these funerary texts evolved many other genres of writing including the autobiography. Surviving administrative, business, and legal contracts (common forms include leases, loans, freight contracts, divorce contracts, deeds, deposits, and apprenticeship contracts; and receipts, judicial records, legal decrees, and letters of recommendation) cumulatively indicate an extensive government structure protecting contracts and collecting taxes. Surviving lists of prices, ships, soldiers, taxes, and food stuffs suggest the vitality of the economy. Lists and charts also record geographic, hydrologic, calendric, and astronomic charts revealing an extensive, practical knowledge of movements of stars and planets. Numerous texts also display measurement practices and decimal recording for applied purposes (Silverman, 1997).

Surviving medical texts, dating back to the late Middle Kingdom, consist largely of prescriptions or recipes for treatment, but there is no evidence of organized anatomical inquiry. Nonetheless, though referencing some religion and magic, the texts show concern for "regular and predictable phenomenon with relatively little supernatural involvement" (Bernal, 1992). One late text during Ptolemaic era, shows a continuity of old Egyptian traditions, knowledge, and experience, within Alexandrine Greek culture (Reymond, 1976). Although controversies continue over the extent of Egyptian and Phoenician influence on the origins of Greek culture in the Middle and Bronze ages, some definite exchange did occur between these ancient cultures (O'Conner, 1996).

RECORDED KNOWLEDGE IN MESOAMERICA

Though historically and geographically discontinuous with Sumer or Egypt, the uses and forms of written knowledge in Mesoamerica bear some similarities to those in the early Middle East. The oldest sample of Mesoamerican writing, Mayan calendar inscriptions on buildings in San José Mogote in the Oaxaca Valley, have been carbon-dated from circa 650 BCE (Flannery & Marcus, 1983). Early samples of this writing, which developed from prior symbols and iconography, are found on stone stelae, lintels, masks, jade plaques, and cliff carvings (Coulmas, 1996). Mayan glyphs were also painted on codices made of either deer hide or bleached fig-tree paper, which were then covered with a thin layer of plaster and folded accordion-style. Most nonarchitectural Mayan writing did not survive natural deterioration and the burning of Mayan texts during the 16th-century Spanish invasion. The loss of these texts demonstrates the importance of writing in preserving and transmitting knowledge, and the difficulty of re-creating that knowledge without such texts.

From the beginning, the Maya used writing to reinforce a ruler's military power and to legitimize his descent from noble ancestors and the gods. Inscribed on public buildings, tombs, and stelae are ruler reigns and genealogies, rituals, religious ceremonies, and state and military histories, including conquests, dates, place names, and captives conquered

and then sacrificed. Writing from later periods increasingly concerned wars and conquest of neighboring states (Schele & Matthews, 1998). The Maya considered writing to be a sacred gift from the gods and use of it was reserved to elite scribal classes who claimed to have sole authority to mediate between the gods and the common people (Boone, 1994). Nonetheless, the public nature of the monumental writing, wall carvings, and paintings suggests they may have been read and interpreted publicly. Moreover, the codices bearing on daily life would likely have been regularly consulted, although it is unclear whether this would have been mediated by scribal elites. Scribes also composed several types of manuscripts, which were housed in libraries, including maps, financial accounts, tribute payments, and legal records as well as astronomical/astrological records, genealogical accounts, and chronicles (Berdan, 2005; Boone, 2000). Although we know little of Mayan education, Aztec male children of the nobility received formal education in schools called *calmecac*. This education extended from basic literacy to study of military mechanical, astrological, religious, and legal texts (Berdan, 2005).

PEOPLE OF THE BOOK: HEBREWS

Although the date of origin and final redaction of the Torah, or the five books of Moses, are in dispute, from the time of Moses in the 15th century BCE until after the 6th century BCE Babylonian Exile, it is clear that the 10 commandments and other laws embedded within it provided the central principles and governing law from the earliest days. The textual organization of individual and communal life was further strengthened after the destruction of the second temple in 70 CE and the recording of the oral law, the Mishnah, in 200 CE and the writing of commentaries over the next three centuries, together forming the Talmud. Both in ancient times and currently in observant Jewish communities, all learning, law, government, commerce, hygiene, agriculture, food selection and preparation, and other aspects of daily life were regulated by these texts and in the educational, governmental, judicial, and religious institutions that grew up around them. Similarly, all philosophic influences from the peoples they lived among were considered within this scriptural community. Furthermore, the sacred books sacralized the knowledge of history. During the Diaspora, it became a religious obligation of all to participate in this learning through life-long study of the sacred texts. With no physical land and no access to the means of regional government, commitment to the sacred books held the Jews together as a people.

Because all practical and empirical knowledge of the world was made sacred by bringing it under the divine law, it is difficult to identify a distinctive secular knowledge even though many topics that might otherwise be considered secular are encompassed within in. Even modern commentary on the knowledge held by the ancient community is complicated by a strong motive to read that knowledge in sacred contexts. As Jews lived and participated among other peoples for more than 2,000 years, many pursued knowledges outside the sacralization of the holy books. Although secular learning usually was often encouraged or at least not proscribed and although the culturally developed practices of textual scholarship that arose from the universal obligation to study sacred texts provided skills and tools for those Jews who engaged in secular learning, the secular learning remained outside Jewish identity. For example, Moises ben Maimon, who lived in 13th-century Cordoba, was famous with the both Jewish and the secular world for his medical skill, but within the sacred tradition his identity is distinctly that of the great talmudic commentator and philosopher Maimonides. The issues of allegiance to knowledge systems were to become increasingly problematic for both individuals and communities with the development of European knowledge in the 18th century and after. That tension is now evident in the modern secular state of Israel and in other countries with sizable populations who have a similar relation to their scriptures.

WRITING AND KNOWLEDGE CREATION IN ANCIENT INDIA

Writing was widespread in ancient India from at least 500 BCE, the time of the great linguist Panini, but because few, if any, inscriptions or written records are left of the civilization in the Indus valley between 2500 and 1500 BCE, it is not definitely known when the art of writing evolved in India. Yet since the birth of the oldest Vedic poetry, religious texts were central to the culture and even nonreligious texts had religious ends. The term *Veda* comes from the root *Vid* and designates sacred lore as a branch of literature. Inscriptions on stone and copper, the palm leaf records of the temples, and in later days, the widespread manufacture of paper, all alike indicate the common use of the art of writing. Furthermore, Buddhist Vinaya texts, the *Mhavagga*, and the *Vighanga* refer to the occupation of the clerk or scribe as a source of livelihood (Mookerji, 1969). Scribes, nonetheless, had low status and the texts they wrote were judged to be less reliable than what was transmitted orally.

This textually transcribed knowledge was transmitted orally, directly from a teacher to his students in small domestic schools with students in residence with the teacher's family or *Brahmacharya*. Teaching was recitation, and learning was by memorization (viewed as necessary, but not sufficient). The written word was valued as a teaching aid for those too dull to remember. Systematic education, available only to the three higher castes (Brahman, Kshatria, and Vaisia) but not to the Sudra or the untouchables, was based on the direct and personal relationship between a teacher and his pupils. In the Vedas, *education* was defined as the transmission of life from life to life: "Every literary man of ancient Indian was himself a living library, so to speak each man a book" (Mookerji, 1969, p. 78). Even today, access to traditional knowledge of subjects like art, music, grammar, or philosophy is widely held to require a direct oral transmission from master to pupil.

Indeed, the first great accomplishment of Indian written secular knowledge, Panini's analysis of the prosody, syntax, and grammar of Sanskrit, appears to be a gathering and codification of a highly developed set of principles developed and transmitted orally for the purposes of proper recitation of classic texts. The ancient Hindu texts thus went through a period of initial invention, inscription, and compilation and then were highly codified and preserved through an elaborate and diffuse system of oral transmission. The phase following the creation of these original sacred texts was marked by a shift from the hymns themselves to a focus on commentary and the priestly work of ritual, reserved to the Brahman class. This gave rise to a system of "higher education" focused primarily on the work of the priests and the ritual systems. It has been argued that the shutting up of knowledge work to the Brahman caste slowed the development of writing activity in India in the centuries that were to follow their initial creation (Perrett, 1999). The system of oral tradition was as much the characteristic of Buddhist as Brahmanical education, though the causes of its adoption might be different in the two cases (Mookerji, 1969).

The development of a complex ritual structure by the Brahman caste also created a stable location of early speculative reflection, from which connections can be made to Upanishadic speculation and philosophy (Houben, 2000). Mathematics and astronomy were central in Vedic studies, for without acknowledgment of astronomy and mathematics one could not perform the sacrifices, and the construction of sacrificial altars of various sizes and shapes involved the knowledge of geometry and geometric figures. Pythagoras is even said to have been familiar with the Upanishads, which contains in Baudhayana's *Sutra*, an early statement of the Pythagorean Theorem.

By the sixth century CE, Indian astronomers had made significant discoveries concerning planetary motion: Aryabhata described the earth as a sphere that rotated on its own axis, provided a model of planets orbiting elliptically around the sun, correctly explained solar and lunar eclipses, and deduced that the moon and planets shined by reflected sunlight. He also propounded the heliocentric theory of gravitation, predating Copernicus by almost a thousand years. His work, which was translated into Latin in the 13th century, acquainted European mathematicians with methods for calculating the areas of triangles and volumes of spheres, as well as square and cube roots. The use of the decimal system and the concept

of zero—which originated in India—were essential in facilitating large astronomical calculation and allowed such seventh-century mathematicians as Brahmagupta to estimate the earth's circumference at about 23,000 miles.

Similarly, the beginnings of biological and medical knowledge in ancient India are buried in polemical texts that are not normally thought of as scientific. For example, the Vedic literature demarcated the body parts of plants into roots, shoot, leaves, branches, flower, and fruit. Furthermore, plants were grouped in flowering and nonflowering groups. Practical biological knowledge continued to grow, such as a treatise on bovine animals, which play a significant role in the Indian economy. Also horses and elephants, because of their military importance from ancient times, were the subject of a number of veterinary works. There is an extensive written legacy of Indian writers on the subject of medicine, particularly Ayurveda—a health-oriented regimen having its origins in the ancient Rig Veda. Buddhist literature from the Vinaya texts downward evidences progress in medicine and surgical operations. The progress of medical science is further testified by the first-century BCE Milinda Panha, which names the oldest teachers of medical science, each renowned for a treatise of his own (Mookerji, 1969).

WRITING IN THE GREEK AND ROMAN WORLD

Despite Plato's distaste for writing, expressed by Socrates in the *Phaedrus*, the written legacy from the Greek and Roman world has been formative for Western culture, to the point where the contributions of other traditions have until recently been obscured. Nonetheless, ancient Greece contributed knowledge texts of a distinctive character. The prior forms of secular knowledge we have noted in this chapter have been embedded in religious practice and/or immediate practical concerns, such as regulating agriculture, collecting taxes, or establishing the might and authority of rulers, but authors of Greece and Rome also offer texts at some philosophic remove from immediate ends—questioning, critiquing, or refining the knowledge arising from practice or taking up objects of inquiry with little immediate practical or religious relevance. Thus, from ancient Greece we gain redaction, collection, and comparison of regional religious stories; histories that stretch beyond the accomplishments of the current ruler and adopt a more critical perspective to events; and descriptions, measurements, and theories about plant and animal life, the physical world, and social life. Furthermore, there are analyses and evaluations of various forms of literary and linguistic practices, including the proper and allowable sequencing of statements that are to follow from one another (i.e., logic). We also have inquiries into various forms of life and government and how one might behave apart from asserted moral directives. Havelock (1963, 1978, 1982) has argued these developments are the direct consequence of literacy, and the collection, inspection, and comparison of texts. Perhaps these intellectual developments may have had other or contributing causes in the cosmopolitan character of seafaring people close enough to learn from Near Eastern empires but far enough away to follow their own path, geographic conditions encouraging communication and movement of individuals among city-states but discouraging centralization of power, the formation of prosperous city-state economies and leisured classes resting on slavery, the formation of guild classes of wandering specialists to take advantage of these conditions, the presence of competing views fostering debate, or transient political conditions that distributed power and decision making. Whatever the causes, in Greece between the sixth and fourth centuries BCE an intense philosophic life flourished producing texts representing several schools of thought that continued within the literate culture in Rome. Together these two cultures produced texts of philosophic inquiry into all areas of life that are still considered foundational for our current knowledge and modes of inquiry (Brunschwig & Lloyd, 2000).

The early work of the wandering presocratic philosophers, sophists, and rhetoricians is known only through short and fragmentary documents and by the report in the writings

of later philosophers. The founding of Plato's Academy in a suburb of Athens and his composition of the Socratic dialogues mark the robust organization and production of knowledge and knowledge texts. Although the teaching within the academy remained oral, the texts of the dialogues spread the fame of the school. The dialogues discuss issues such as the nature and guiding principles of law and government, the nature of virtue and love, the sources of truth and knowledge, and the development of the individual spirit.

Plato's student Aristotle established a school at the Lyceum, outside Athen's walls, already a gathering place for philosophic debate. There he collected books for study purposes. His student Theophrastus continued the school and the library, which was then to continue, though with disruptions, for almost 600 years into the third century CE (Lynch, 1972). The learning in the Lyceum was more closely linked to writing than in Plato's Academy, as many of the 30 surviving texts of Aristotle appear to be notes for his lectures, whereas others appear to be more polished treatises. His works and the curriculum apparently covered all aspects of life from metaphysics and ethics to the earth sciences and biology. Three of his treatises are particularly concerned with the art and science of using language: the *Poetics*, the *Rhetoric*, and the *Organon*. The *Organon* consists of six works on logic (Categories; On Interpretation; Prior Analytics; Posterior Analytics; Topics; On Sophistical Refutations) concerned with how knowledge can be formulated in language and what one can properly say following on one's premises. Much of the remainder of Aristotle's work is based on empirical observation, which is then reported, organized, and theorized within the treatises.

Epicurus and the Stoics also founded schools in Athens in the fourth century BCE and produced many books, but we have only fragments and secondhand reports. We have only complete works from the Roman period and not much knowledge about the workings of their schools.

With the writings of the fifth-century-BCE Herodotus, history emerged from traditions of genealogy, mythic narrative, and geographic description. His contemporary, Thucydides, developed a more critical approach based on examination of documents and interviews with participants in events. He attempted to a more neutral, objective stance, thereby separating history from the accounts written in the service of the state or religion. Following the footsteps of these two were many Greek and Roman historians including Xenophon, Polybius, Arrian, Plutarch, Flavius Josephus, Sallus, Livy, and Tacitus.

Greek medicine is usually associated with Hippocrates in the fifth century BCE, to whom more than 60 volumes have been attributed, but they were likely written by others following in his wake, including the Hippocratic Oath, which embodies the ideals of his practice. These 60 volumes along with other works provided learning that Galen built on through his own practice. A second-century-CE Greek physician from Pergamon who went to Rome to serve at the Imperial court, Galen, wrote the 17-volume *On the Usefulness of the Parts of the Human Body* that was to dominate the instruction of medicine through the Renaissance.

Greek learning also flourished in Hellenized Egypt, particularly in Alexandria, founded around 334 BCE and that became home of the great library (see chap. 11, this volume). The textual work of compilation and extension carried out by Euclid and Ptolemy there produced books that were to be viewed as founding modern mathematics and astronomy. Euclid, who arrived in Alexandria within a few years after its founding, compiled the *Elements*, based on the work of earlier mathematicians, placing them in a coherent framework and filling out missing proofs. This work established the foundations for geometry to follow and remained as an authoritative textbook to the current day, only in the past century to be set beside what is called non-Euclidean geometry based on alternative postulates. Euclid, in addition to other works on geometry, wrote a geometrically grounded volume on optics, containing the elements of perspective.

Ptolemy in the second century CE compiled the astronomical knowledge of the Greek and Middle Eastern world in *Hê Megalê Syntaxis*, translated into Arabic as *al-kitabu-l-mijisti*, or the great book, and then Latinized as the *Almagest*. He relied heavily on the work of Hipparchus of three centuries prior, whose star catalog he updated and incorporated. His synthesis of

astrology, the *Tetrabiblos*, was also taken as authoritative through the Renaissance. Ptolemy's work on geography was as well compiled from Roman, Middle Eastern, and other sources. In addition, his *Harmonika* synthesized competing approaches to music—the Pythagorean based on mathematics and physics and the Harmonist based on auditory experience, whose leading proponent was Aristoxenos.

The wide learning available as Rome took over political and cultural leadership of the Mediterranean set the ground for continuing interest in synthesis and compilation. The first-century-BCE Varro was considered the most learned of all Romans and compiled a widely used (though now lost) nine-volume encyclopedic work called *Disciplinae*. Pliny the Elder of the first century CE in addition to writing histories compiled his *Naturalis Historiae*, finished posthumously by his nephew. In preparing this 37-volume encyclopedia that covers geography, peoples, cultures, physiology, zoology, botany, medicine, and mineralogy, he consulted many hundreds of volumes. His contemporary Strabo wrote in Greek an encyclopedic 17-volume *Geographika*.

Whereas the Roman period is notable for its many technological advances in building and construction, mining and metallurgy, hydrology, and transportation, these seem to have been developed and transmitted primarily in material practice. Vitruvius's 10 volumes of *de Architectura* seems to be a unique exception and serves to document much of contemporary practical knowledge of machinery, hydrology, and materials as well as construction and architecture. Vitruvius, however, seems to have a more learned and literate vision than his colleagues, as he considers the architect to need theoretical knowledge of mathematics, rhetoric, history, philosophy, medicine, and law. The one practical area that seems to have developed numerous manuals and compilations is agriculture, as in Palladius' handbook *Opus Agriculturae*.

Roman education was largely private and reserved for upper-class males, aimed at making them effective public orators. Rhetoric, following Greek models, was at the center of education, incorporating written exercises in imitation of rhetorical models (known as *progymnasmata*). The anonymous *Rhetorica ad Herrenium* (ca. 84 BCE) is the earliest extant Latin rhetoric manual. Cicero at about the same time added his own rhetorical treatises, culminating in *De Oratore* (55 BCE), which is cast as a guide to rhetorical education. Quintillian, in *Institutio Oratoria* (95 CE), set out a course for the development of boys into orators; he views wide reading of admirable texts, along with written composition of orations and other imitative exercises to be cornerstones of the education of a respected public person—"the good man speaking well."

CHINA'S IMPERIAL BUREAUCRACY

As the largest, most stable empire throughout human history, China has over millennia developed an extensive learning, based on a cultural heritage of classic texts. Indeed, the entire national order was built on an administration trained in and valuing classical learning and its ideals, and institutionally regulated by the imperial civil service examinations that lasted over two millennia, until the final collapse of Imperial power in the early 20th century. First instituted in the Han dynasty (206 BCE–220 CE), the exams defined the aims of schooling, the prized texts, and the literate development of every individual seeking power and place (Connery, 1998). State-sponsored schools usually trained students for the exams, although at times private academies, often little more than the extended following of a renowned teacher, flourished. These private schools periodically were seen as training grounds for political opposition and sedition, and were banned. Whether schools were governmental or private, the examinations and the canon of texts needed for the examinations remained a constant. Furthermore, the need for objectivity of evaluation led to a narrowing of the canon of texts concerned, a formalization of the questions, and a ritual patterning of expected answers in the notorious eight-legged essay based on eight matched pairs of opposing concepts. Because the most valuable knowledge was that which

would provide advantage on the examinations, much scholarly production was summary, commentary, and interpretation of the classic texts. Some of these commentaries in turn became part of the examined canon. Confucius (551–479 BCE) had synthesized the ideal for this education from earlier sources as self-improvement, ethical growth, and moral perfection for the sake of a harmonious self and a harmonious society. The five classic Confucian arts that became the heart of the curricula were rites, archery, chariot, writing, and mathematics, each embodied in canonical texts, although the canon was modified to reflect political and ideological changes during different dynasties. The sixth classic Confucianist art, music, did not enter the educational canon. Taoism and Buddhism also influenced the exams and curriculum. Within this examination culture, knowledge of the key texts and of the expected form of the essay soon outweighed substantive understanding of the specifics of knowledge, values, and arts expressed within the texts (Lee, 2000).

The anti-intellectual and centralizing acts of the preceding Qin dynasty (221–207 BCE) ironically established some of the core concerns and practices of the Han educational and civil services reform. The Qin, to silence the Confucianist opposition, ordered all books in the empire to be burned and to replace all the varying scripts of principalities with a common script. With the collapse of the Qin, scholars set about recovering and editing remaining books as well as to translate the terms written in older scripts. This philology and lexicography became one of the chief forms of knowledge production and the core of knowledge disseminated. Collections of words that were glosses on ancient texts, analysis of ideographs, lexicography of dialects, and phonological study, aided by a rhyming form of spelling, formed the basis of an extensive linguistics and literary study.

Although throughout this 2,000-year period, there was great consistency in the kind of ethical, philological, literary, and aristocratic knowledge valued in the civil service, the exams and the schools that prepared candidates also at times supported learning in the law, medicine, astronomy and mathematics, and military arts in preparation for appropriate civil service roles. These forms of knowledge allowed for centralized control and maintenance of the economy and national welfare. Detailed astronomical records were kept and compared from observatories in the capital and provinces, but these were collected for the office of the astronomical directorate and existed only in small numbers, concentrated in palace and governmental collections, even after the invention of printing. This astronomical knowledge was considered a state secret facilitating the control of floods and agriculture—a key to dynastic legitimacy. Only a few fragments have survived. Meteorology and civil engineering with a focus on hydrology also helped manage and maintain the extensive agricultural basis of the society. More popular farmer's calendars dating from as early as the fifth century BCE, however, were widely spread, including astronomical information to establish dates. These calendars, often government produced, appeared frequently for more than 2,000 years (Ronan & Needham, 1981). Mathematics, as a classic Confucianist art as well as an underpinning of the other sciences and accounting of the bureaucracy, also flourished, with imperial sponsorship and production of treatises.

Medical specialists (to serve the nobility and officials) had from the second century BCE been monitored for proficiency. By the sixth century CE, medicine had become a high-level bureaucratic specialty with officers of the seventh rank, professorships at the imperial college, and written examinations. A medical literature became the basis for these examinations and training, bringing together the collected knowledge of medicinals, anatomy, acupuncture, and related arts. Moreover, the clinical practice of the civil service physicians was recorded and monitored for success (Needham & Lu, 1970a, 1970b). Thus, there was established the social infrastructure of an empirically grounded medical literature.

However, whereas these knowledge domains of use to the state had some coherent development and expanding literature, other areas of knowledge were sporadic with little organized distribution of texts or institutional support. So although a stable history and a prosperous gentry created the leisured conditions for many observations and inventions related to physics, biology, and engineering, these did not aggregate in coherent sciences.

Even medicine was restricted to interests of training, certification, and administrative practice, such as forensics.

The many technological advances made in agriculture, textile manufactures, mining, fishing, construction, weaponry, explosives, mechanical and civil engineering, shipbuilding, and other arts and crafts were developed largely by artisans, workers, craftspeople, or people in the lowest rungs of the state bureaucracy, even though the work may have been supervised by higher level administrators trained in the classics. Thus, its promulgators were neither educated and highly literate nor had access to the means of publication and text distribution. The work tended to be atheoretic and did not attempt much articulation with the dominant educated thought systems of Confucianism, Taoism, and Buddhism. Sometimes inventions and discoveries remained local and sporadic because of the lack of textual transmission. When this practical knowledge did spread it was through objects and practices; in these concrete forms, much of this knowledge diffused to India, the Islamic world, and Europe (Needham, 1970).

Whereas in Europe the invention of the printing press was to foster in the hands of its entrepreneurial printers novel texts, new communities of knowledge seekers and producers, and new disciplines of learning, in China the much earlier invention of printing (block printing at the eighth century CE or before and movable type ca. 1041–1048; Carter, 1955) led to much less diversity of new knowledge, as the control of the press remained largely in the hands of the state and monasteries (Luo, 1998). As a result, most mass-produced and widely circulated print documents reflected bureaucratic functions of the state, the literary classics and commentaries associated with examination, religious scriptures, and government-issued paper money. Sometimes leisured elites used the government press for publication of special-interest limited editions of their poetry and avocations. When private printing flourished (often based in private academies), it too was dominated largely by the culture of the classically based examination system. Only during the Ming (1368–1644) and Qing (1644–1911) dynasties did private printing of vernacular texts (such as popular novels and tales, books on crafts and technology, and gazetteers) appear on a large scale. However, most private printing remained devoted to such ritual artifacts as New Year pictures and funerary money. Thus, the printing press largely supported and participated in the same world of knowledge fostered by the government civil service and examinations.

Before leaving the topic of knowledge in China, we should address the question of why the greatness of Chinese civilization did not produce a scientific revolution of the sort that appeared in the West. This question motivated Needham's massive historical project of 21 volumes of *Science and Civilization*, beginning in 1954 and still not finished. This question also pervades most contemporary historical work on Chinese science and technology. Many reasons have been proposed along with redefinitions of scientific revolution. Without repeating or evaluating here the arguments that range from religious to economic, it is noteworthy that a number of the factors raised have to do with the character of writing and handling of texts: the nature of ideographic writing; the ambiguity of signs; the lack of syntax in the Western sense; the writing style fostered by the examination system of uncritical citation and extended commentaries within a limited domain of interests; the philosophic styles and reigning ideologies within classical prose, particularly fostering a taste for dualities and balances rather than critical debate; the control of astronomical texts as state secrets; the state control of large-volume printing; and the intellectual and professional enlistment of all highly literate people into the state system (Bodde, 1991; Huff, 2003).

THE ISLAMIC CROSSROADS OF LEARNING

After the decline of the great Mediterranean empires, the Middle Eastern world became a repository and crossroads for the knowledge books of both the classical and the Asian world—preserving, translating, keeping alive, and contributing to the knowledge

recorded in these books. The transmission of Greek texts began as early as Alexander's conquests in the fourth century BCE and continued throughout the Middle Ages through the Roman outpost of the Byzantine empire. Nestorians (Christians in Persia who dominated the medical profession in Syria) were particularly active in transmitting and translating Greek texts into Syriac. With Mohammed's death in 632, the Umayyad dynasty ruled the Islamic world from Damascus, with the aid of educated Syrians and Persians such as the Nestorians. When the Abassid dynasty gained power in 749 they built and inhabited the new capital of Baghdad. The Caliph al-Mansur (754–775) created schools for bureaucracy and medicine drawing on the same educated groups, with the knowledge and texts they brought with them. Caliph Harun al Rashid (786–809) later sent agents to Byzantium to collect texts, and his son Caliph Al-Ma'mun (813–833) founded a research institute (House of Wisdom) in Baghdad. Nestorian Christian and Arab Hunayb ibn Ishaq (808–873) headed the House of Wisdom and translated the medical texts of Galen and Hippocrates into Syriac and Arabic. However, to understand this medical knowledge scholars were drawn to translate the Greek philosophy, mathematics, and astronomy underlying it. By the end of the first millennium, Arabic translations existed for almost all Greek texts on medicine, natural philosophy, and mathematical sciences. Several Indian works on medicine and therapeutics were translated into Arabic from 786 to 809 CE.

Beyond the universal appeal of medical knowledge, the Islamic way of life also deeply supported astronomy, mathematics, and related mathematical sciences, such as optics. Learned scholars became deeply versed in the classic philosophic texts and advanced knowledge in their model. The 9th-century Al Kindi and the 11th-century Ibn al Haytham and Ibn Sina (Avicenna) starting from Greek knowledge contributed to philosophy, optics, astronomy, and other areas of knowledge—including extending and correcting details of the Ptolemaic system. Other notable astronomers such as Al-Farghani (ca. 861), Thabit ibn Qurra (d. 901), and Al Battani (d. 929) improved star charts and found new values of solar and lunar motions. The ninth-century Muslim mathematician al-Khwarazmi adopted the Indian innovation of zero and was the vehicle for the concept's transmission to the West. He also was the author of the first work on algebra built on Greek and Indian predecessors. The philosophers al-Karaji and Khayyam further advanced knowledge of algebra in their works.

The need to recite, teach, and interpret the Koran correctly led to an extensive study of language, with a focus on Arabic phonology and lexicography (of which al-Khalil, d. 791, is viewed as the founder) and grammar (of which Sibawayho, d. 793, is viewed as the founder). The philosopher al-Farabi attempted to reform Arabic linguistics based on Aristotelian logical principles, but the field remained formalist and largely separate from philosophic concerns, consistent with the Koran becoming the center of education (Versteegh, 1995).

This secular knowledge constituted an initial rationalist movement among Islamic scholars and educational institutions; however, by the end of the ninth century religious traditionalists came to dominate the Islamic world, and Koranic knowledge became the core of learning. By the 10th century, *madrasas* (Islamic institutions of higher learning) were formed by the addition of residential colleges to mosques. The curriculum was organized around dialectic to determine proper legal opinion based on scripture and authoritative theological interpretation. Only with the license granted by this education could one take on a judicial-clerical position. Makdisi (1981) has argued, however, that this guild model of licensure through apprenticeship in dialectic within an approved institution of higher education influenced the formation of the medieval European university.

After being unseated by the Abassids, the Umayyads moved their center of power to Spain, where Caliph al-Hakam (d. 976) built and stocked libraries in Cordoba and Toledo. During the Christian reconquest of Spain, these libraries and the philosophers associated with them, such as Averroes (ibn Rushd) made possible Europe's rediscovery of Greek knowledge as well as Indian. Similarly, Arabic and Persian translations of Greek and Egyptian scientific texts found their way to India.

Muslim learning, texts, and schools spread with the Islamic empire both throughout North Africa and to the edge of the South Asia subcontinent by the eighth century. With trade, Islamic learning was to expand across the South Asian subcontinent into Southeast Asia and across the southern Sahara and down the east coast of Africa. In Africa, one of the most prominent centers of learning formed at Timbuktu, the seat of the Songhay Empire. By the 14th century a center of learning developed around the Sankore Mosque. This university was said to include faculties of law, medicine and pharmacology, letters, grammar, geography, and industrial arts. Indigenous learning also emerged as African medical practices entered into the medical texts. Local histories and biographies were also written. The lively book trade that surrounded the school at Sankore resulted in a number of substantial private book collections over the next several centuries. The late-16th-century conquest by Morocco marked the end of the university, the book trade, and the production of new written knowledge. Nonetheless, a number of the private family libraries have survived and are now being restored (Hunwick, 1991, undated).

The Greeks and Romans had created a new stage in knowledge formation in developing substantial domains of knowledge, texts, and communication outside the needs and networks of the church or state. Although the control and motives for knowledge in the Abassid Islamic world were brought back under a religious state, in the Umayyad caliphate, the condition of full access to secular knowledge combined with an interest in philosophy and the philosophic advance of the individual. As in the Greco-Roman world, this interest in philosophic knowledge was accompanied by a desire to collect and make available in libraries all knowledge. Because the Islamic world drew on great knowledge and text-producing societies of Asia and Europe, their collections were international in scope, gathering the texts of the entire literate world. This rich resource was to provide the motive and material for the founding of new knowledge institutions, practices, communities, and texts in post-Roman Europe.

REFERENCES

- Bazerman, C. (2006). The writing of social organization and the literate situating of cognition. In D. Olson & M. Cole (Eds.), *Technology, literacy, and the evolution of society* (pp. 000–000). Mahwah, NJ: Lawrence Erlbaum Associates.
- Berdan, F. (2005). *The Aztecs of central Mexico: An imperial society*. Belmont, CA: Thomson Wadsworth.
- Bernal M. (1992). Animadversions on the origins of Western science. *Isis*, 83(4), 596–607.
- Bodde, D. (1991). *Chinese thought, society, and science: The intellectual and social background of science and technology in pre-modern China*. Honolulu: University of Hawaii Press.
- Boone, E. (1994). In E. Boone (Ed.), *Aztec pictorial writing: Writing without words* (pp. 50–77). Durham, NC: Duke University Press.
- Boone, E. (2000). *Stories in red and black*. Austin: University of Texas Press.
- Brunschwig, J., & Lloyd, G. D. (Eds.). (2000). *Greek thought: Guide to classical knowledge*. Cambridge, MA: Harvard University Press.
- Carter, T. F. (1955). *The invention of printing in China and its spread westward* (2nd ed.; rev. by L. C. Goodrich). New York: Ronald.
- Claggett, M. (1989). *Ancient Egyptian science: A source book* (Vol. 1). Philadelphia: American Philosophical Society.
- Collins, R. (1998). *The sociology of philosophies: A global theory of intellectual change*. Cambridge, MA: Harvard University Press.
- Connery, C. L. (1998). *The empire of the text*. Lanham, MD: Rowman & Littlefield.
- Coulmas, F. (1996). *The Blackwell encyclopedia of writing systems*. Oxford, England: Blackwell.
- Flannery, K., & Marcus, J. (1983). *The cloud people: Divergent evolution of the Zapotec and Mixtec civilizations*. New York: Academic Press.
- Goody, J. (1977). *The domestication of the savage mind*. Cambridge, England: Cambridge University Press.
- Goody, J. (1986). *The logic of writing and the organization of society*. Cambridge, England: Cambridge University Press.

- Goody, J. (1987). *The interface between the written and the oral*. Cambridge, England: Cambridge University Press.
- Havelock, E. (1963). *Preface to Plato*. Cambridge, MA: Harvard University Press.
- Havelock, E. (1978). *The Greek concept of justice: From its shadow in Homer to its substance in Plato*. Cambridge, MA: Harvard University Press.
- Havelock, E. (1982). *The literate revolution in Greece and its cultural consequences*. Princeton, NJ: Princeton University Press.
- Houben, J. (2000). The ritual pragmatics of a Vedic hymn. *The Journal of the American Oriental Society*, 120, 499–536.
- Huff, T. E. (2003). *The rise of early modern science: Islam, China, and the West*. Cambridge, England: Cambridge University Press.
- Hunwick, J. (1991). *West Africa and the Arab world: Historical and contemporary perspectives*. Accra: Ghana Academy of Arts and Sciences.
- Kaufert, D., & Carley, K. (1993). *Communication at a distance: The influence of print on sociocultural organization and change*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Kramer, S. N. (1981). *History begins at Sumer*. Philadelphia: University of Pennsylvania Press.
- Lee, T. H. C. (2000). *Education in traditional China: A history* (Handbook of Oriental Studies, Vol. 13). Leiden, Netherlands: Brill.
- Lichtheim, M. (1976). *Ancient Egyptian literature* (Vol. 2). Berkeley: University of California Press.
- Luo, S. (1998). *An illustrated history of printing in ancient China*. Hong Kong: City University Press.
- Lynch, J. P. (1972). *Aristotle's school: A study of a Greek educational institution*. Berkeley: University of California Press.
- Makdisi, G. (1981). *The rise of colleges: Institutions of learning in Islam and the West*. Edinburgh, Scotland: Edinburgh University Press.
- Mookerji, K. R. (1969). *Ancient Indian education: Brahmanical and Buddhist*. London: Macmillan.
- Needham, J. (1970). The unity of science: Asia's indispensable contribution. In J. Needham et al. (Eds.), *Clerks and craftsmen in China and the West* (pp. 14–29). Cambridge, England: Cambridge University Press.
- Needham, J., & Lu, G. (1970a). Medicine and Chinese culture. In J. Needham et al. (Eds.), *Clerks and craftsmen in China and the West* (pp. 263–293). Cambridge, England: Cambridge University Press.
- Needham, J., & Lu, G. (1970b). China and the origin of qualifying examinations in medicine. In J. Needham et al. (Eds.), *Clerks and craftsmen in China and the West* (pp. 379–395). Cambridge, England: Cambridge University Press.
- O'Connor, D. (1996). Egypt and Greece: The Bronze Age evidence. In M. Lefkowitz & G. Rogers (Eds.), *Black Athena revisited* (pp. 49–61). Chapel Hill: University of North Carolina Press.
- Ong, W. J. (1982). *Orality and literacy: The technologizing of the word*. New York: Methuen.
- Perrett, R. W. (1999). History, time, and knowledge in Ancient India. *History and Theory*, 38(3), 307–321.
- Renfrew, C., & Scarre, C. (Eds.). (1999). *Cognition and material culture: The archaeology of symbolic storage*. Cambridge, England: McDonald Institute.
- Reymond, E. (Ed.). (1976). *A medical book from Crocodilopolis*. Vienna, Austria: Verlag Brüder Hollinek.
- Ronan, C. A., & Needham, J. (1981). *The shorter science & civilization in China* (Vol. 2). Cambridge, England: Cambridge University Press.
- Rubin, D. C. (1995). *Memory in oral traditions*. Oxford, England: Oxford University Press.
- Schele, L., & Mathews, P. (1998). *The code of kings: The language of seven sacred Maya temples and tombs*. New York: Simon & Schuster.
- Scribner, S., & Cole, M. (1981). *The psychology of literacy*. Cambridge, MA: Harvard University Press.
- Silverman, D. (Ed.). (1997). *Ancient Egypt*. New York: Oxford University Press.
- Vanstiphout, H. L. J. (1995). On the old Babylonian Eduba curriculum. In J. W. Drijvers & A. A. MacDonald (Eds.), *Centres of learning: Learning and location in pre-modern Europe and the Near East* (pp. 3–16). Leiden, Netherlands: Brill.
- Versteegh, K. (1995). *Landmarks in linguistic thought: III. The Arabic linguistic tradition*. London: Routledge.
- Vogelzang, M. E. (1995). Learning and power during the Sargonid period. In J. W. Drijvers & A. A. MacDonald (Eds.), *Centres of learning: Learning and location in pre-modern Europe and the Near East* (pp. 17–28). Leiden, Netherlands: Brill.