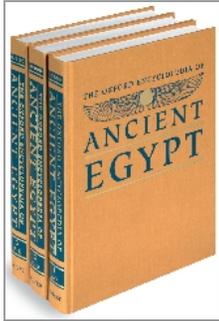


## Oxford Reference



### The Oxford Encyclopedia of Ancient Egypt

Edited by Donald B. Redford

Publisher: Oxford University Press

Print Publication Date: 2001

Print ISBN-13: 9780195102345

Published online: 2005

Current Online Version: 2005

eISBN: 9780195187656

## Technology and Engineering.

Since the decipherment of hieroglyphs, Egyptologists have delineated the religion and customs of the ancient Egyptians, as well as their economic development. The mathematical level of the ancient Egyptians, basically a simple trigonometry, is apparent from a few documents containing mensuration problems. The relationship of astronomy to Egyptian religion, and the derivation of time-keeping and calendars from it, is relatively well understood. Insight into their **technology** and engineering, however, has been provided primarily by their monuments, ruins, and artifacts. The available evidence indicates that they were a practical people, very much directed to meeting daily needs. There is little confirmation, however, that they could also pursue the more abstract theoretical knowledge of science. The development of **technology** and engineering in Egypt was consequently rooted in practicality. Only the broadest outlines of these changes can be sketched here, by following the origin and spread of agriculture throughout the Nile Valley and the Delta, noting the structural use of mud bricks and stone, determining their capabilities in metalworking, and observing their use of wood, pottery, and ceramics.

### Agricultural Origins in the Nile Valley and the Delta

The economic history of ancient Egypt has been said to be characterized as one continuous ecological adjustment to the available water supply, in an attempt to intensify productivity by increasing land area and use (Butzer 1976). Agriculture there is first known from about the fifth millennium BCE, at Merimde Beni Salama, to the north-west of present-day Cairo; in the Faiyum of northern Egypt; and in the Badarian communities to its south (Hassan 1997). Prior to 5000 BCE, there was possibly some domestication of local animals (e.g., cattle) and seed grasses; but the real beginnings of agriculture include the introduction of emmer wheat, barley, and herd animals (sheep, goats, pigs, cattle) from the Near East into Egypt.

In Predynastic Egypt, "natural irrigation" resulted from the annual flooding and draining of the Nile floodplain, providing sufficient crops to meet population demands. With an increase of population, however, an increase in food productivity

could only be achieved with additional, or “artificial” irrigation, which would have increased the available arable cropland and given some water control, permitting a second or third crop during some years.

Artificial irrigation **technology** throughout the pharaonic period was geared toward the regulation of the annual “normal” Nile floods. The ability to control the effects of low or deficit flood levels was limited by the lack of an effective water-transport system; most of this time, water was hauled manually, using shoulder yokes—hardly sufficient for more than local horticultural-type plots. Even the late introduction of the *shaduf* water-lifting lever during the New Kingdom provided a practical use only in the local horticultural context. Butzer noted (1976) that such controls during the yearly flood stage consisted of improving natural levees; clearing natural overflow channels; damming natural drainage channels with earthen dams and gates; subdividing flood basins into smaller units; and controlling water access to those units. Although not centralized for the whole of Egypt, such efforts appear to have been locally administered from Predynastic times. Perennial irrigation and relatively sustainable cropping was a very late development, possible only after the introduction of the *saqiya*, an animal-turned water wheel, first used in the Faiyum during Ptolemaic times. The first archaeological evidence for artificial irrigation is a scene on the mace head attributed to the Predynastic King “Scorpion,” dated to about 3100 BCE, which shows him ceremonially cutting an irrigation ditch. Major land-reclamation schemes, however, were probably first attempted only during Middle Kingdom times by the twelfth dynasty pharaoh, Amenemhet III, in the Faiyum. Such irrigation **technology** could not cope with excessive or deficit flood levels.

Because irrigation was only controlled locally, trends to higher or lower floods would have initiated significant modifications to the immediate topography, with concomitant economic pressures that might have affected the local political hierarchy. Some pressures might have spread enough to affect the central authority of the pharaoh. That the social fabric could be undone at such times is evident from the examples of both the mass deaths and the mass plundering and pillaging by gangs of looters, as attested in various documented famines. When such conditions lasted for several generations, life along the Nile was nothing less than brutal. Deficit floods were most probably the ultimate check on population expansion in dynastic Egypt. Population density appears never to have exceeded about three million through this period; it did not surpass five million until late Ptolemaic times (undoubtedly the result of significantly improved agriculture and trade arrangements).

Although irrigation **technology** improved throughout the pharaonic period, evidence for innovations in other agricultural methods seems to be lacking. For example, surviving tomb scenes all intimate that seeds were always broadcast onto unprepared (unplowed) soil. The use of the plow (for breaking, turning, and aerating) and the hoe (for weeding and cultivating) appears to have been limited only to drier locales or horticultural plots. Scenes with plows and hoes from various historical periods show the same basic wooden designs throughout dynastic times; surviving examples tend to verify a lack of design initiative.

Naturally, the fertile silt deposited as topsoil by the Nile floods would have required some preparation and added fertilizer in land areas higher than or beyond the floodplain periphery, because of nitrogeneous losses. There is, however, no direct evidence that the Egyptians developed a systematic use of fertilizer; possibly, the keeping of dovecotes, a practice continued in some present-day Egyptian villages, provided a natural fertilizer in their collected bird droppings. Silt-laden topsoil would not have been depleted of nitrogen if the nitrogen-depleting grain and nitrogen-binding legume crops had been rotated; but nitrogen-binding fodder crops are not explicitly mentioned until Ptolemaic times and it is doubtful that the Egyptians recognized their practicality or potential as nitrogen-binding agents. The restoration of irrigated land by allowing it to lie fallow also does not seem to have been practiced in Egypt. The reliance was on fresh soil deposition by the annual flooding.

Agriculture in Egypt can therefore be summarized as a winter cultivation largely confined to the flood basins and dependent on the annual flood irrigation. Irrigation **technology** was rudimentary and was applied locally, rather than at the national level; this **technology** was designed to enhance acreage and winter-crop yield, to reduce the effects of short-term flood variability, and to protect settlements and fields from flood damage. It could neither cope with excessive

or deficit floods nor with long-term trends of decreasing flood volume. The storage and distribution of food was administered for the most part by the nomes (regional governorships), through local temples that controlled vast estates, or through the royal residences by the pharaoh.

An important adjunct to food production was the making of beer and wine. In addition to their use as beverages, both were also frequently used as mortuary offerings, libations in religious ceremonies, and as a constituent in medicines. Beer residues have been detected in Predynastic and later period jars; analyses of such residues, studies of tomb scenes and models, and comparisons with the manufacture of present-day peasant beer, indicate that the ancient Egyptians understood well the key steps in brewing beer: the conversion of the starch of a cereal grain into sugar and the alteration of that sugar into alcohol and carbon dioxide by natural (biotic) fermentation (Lucas 1962). The cereal grain most commonly used appears to have been the barley *Hordeum distichum*, a shorter two-rowed version distinct from the modern, longer two- or six-rowed barley (*Hordeum vulgare*). The cereal grain known as emmer wheat (*Triticum dicoccum*), having a two-grained spikelet, was also used as a starch source. Both cereals have been found in dried residues from beer jars and from dried and exhausted grain left after mashing. A present-day beer made by Nubians from barley bread, strongly leavened millet bread, or wheat bread, called *bouza*, seems to be a close approximation to the ancient drink, a thin gruel-like concoction averaging about 7 percent alcohol content.

Wines in ancient Egypt were produced from grapes, dates, the myxa fruit, pomegranates, and the sap of the dom palm tree. The most frequently depicted in tomb scenes and found in wine jars is that made from grapes. Since tomb scenes do show dark-colored—blue and violet—as well as red, pink, green, and white grapes, it may be inferred that both white and red varieties were produced; however, there are no specific written references to the colors of wine. The depth of wine color is a function of whether and how long colored grape skins have been included in the fermentation process. For example, even the darkest grapes will produce only white wines if the skins have been strained out during juice production. The docket labels on many surviving wine jars form an important source of study, because they are not unlike modern wine labels, giving the vintner, vineyard, quality of wine, date of production, and reigning pharaoh (Lesko 1977). The latter two items sometimes form the only means of determining the length of a pharaoh's reign if a statistically significant sample of jar docket labels have survived.

## Structural Engineering

The first monumental architecture of the Early Dynastic period occurred at Hierakonpolis, Abydos, and Memphis—an indication of the presence of a viable, multitiered economy. The monumental building programs of the Old Kingdom pharaohs required large-scale labor input. Consequently, these programs probably contributed to the establishment of a stable social order because they involved not only *in situ* construction but also the large-scale transportation of agricultural products and material. Dieter Arnold (1991) has noted that the economic effects of this organizational effort to work and move stone permeated nearly the whole of the three thousand years of ancient Egypt. The zenith was reached with the New Kingdom constructions of many temples, palaces, massive obelisks, and gigantic statues.

The use of stone as a building material appeared late in Egyptian history. Predynastic structures were first made of dried reeds and twigs that were later plastered with clay. The first use of sun-dried mud bricks also dates to the Late Predynastic period (still commonly used today). Houses in villages and towns were all made of mud bricks coated with plaster; only the doorposts and jambs of upper-class houses were lined with stone. Stone was also used for support bases of pillars made of wood. Even pharaohs' palaces were usually made of mud bricks. The prime surviving example of urban planning is the New Kingdom city of Akhetaten, near the present-day village of El-Amarna. There all the temples, palaces, and houses of the bureaucracy, as well as those of the peasants, were made of mud bricks. The outer-wall plaster coatings of gypsum were of two types: a white surface, covered with polychrome artwork (Smith 1970); and a light brown or tan surface, mimicking the appearance of limestone (Wells 1989). In its pristine completed condition, the city must therefore have been an imposing sight.

The earliest uses of stone on a small scale all date to the first dynasty. By the third dynasty, increased use of stone is evident, mostly in mortuary complexes. The archetype of that dynasty is Djoser's Step Pyramid, the adjacent buildings, and the enclosure wall. This architectural complex at Saqqara represents an unparalleled transition in the use of stone for building purposes. Yet careful examination shows the still tentative nature of the construction, as for example in the use of support columns undetached from their wall matrix. These columns are little more than bas-reliefs in the walls—portraits of reed bundles and lotus plants frozen in stone. The principal types of stones used in ancient Egypt were limestone, granite, sandstone, basalt, calcite, and quartzite. Many quarries that were used to supply these building materials still exist, and studies of them have provided much information on the ancient Egyptian ability to cut and move large blocks.

No detailed architectural plans of houses, temples, or tombs have yet been discovered; however, there are a number of surviving sketch plans, or drafts, of architectural elements of such buildings on paving slabs, ostraca, and wooden panels. Some contain measurements, as though they were on-the-spot orders issued by an over-seer, which were to be discarded after completion of the depicted task. The chief measuring unit was the cubit, which seems to have averaged about 52.5 centimeters (20 inches) in length (Arnold 1991). Measuring rods in cubit multiples—the square, the square level, the *bay*, and the *merkhet*—are the principal surviving surveyor's instruments. The square was used as it is today, for constructing walls at right angles. The square level, an A-frame with a plumbbob attached at the vertex of the A, was used to maintain level walls or foundations. The *bay* was a notched palm rib, probably used for sighting in the manner of a modern theodolite. The *merkhet* was essentially a plumbbob device of various shapes. The most common was an L-shape with the bob hanging from the short vertical arm. The Egyptian sun clock evolved from this device by the addition of a T-bar to the short arm, for the casting of a shadow along the longer arm held horizontal as the sun moved across the sky, a natural development since the sundial needed to be kept level.

Arnold (1991) reports that modern field tests suggest that a difference in height of about 1 centimeter could be recognized, albeit with some difficulty, at a distance of 40 to 45 meters (131 to 148 feet) using the simple square level. The accuracy in the leveling of the Great Pyramid indicates about 2 centimeters of difference in height between the casing stones at the foot of the pyramid on the northern and southern sides. This result is remarkable, considering the length of the sides at about 230 meters (541 feet), and there is a central bedrock mound about 7 meters (24 feet) high obstructing the diagonal sightlines. Thus field tests suggest that about three sequential forward/reverse measurements, at intervals of roughly 80 meters (262 feet), were made along the edge base length to level one side. Although it has been suggested that water-filled trenches were used to level the foundations of the Giza pyramids, that does not seem likely. Transporting the large quantities of water necessary to fill the trenches, uphill, over the long distances from the river, would have been difficult; and the water probably would have been absorbed into the surroundings before adequate measurements could have been made.

The cutting and transport of large stone blocks weighing tens or hundreds of tons does not appear to have imposed an insurmountable problem for the Egyptians, for whom time was a cheap commodity. The analysis of quarry marks indicates that blocks were cut with either copper chisels or stone implements, depending on the hardness of the stone; surviving small sledges and some tomb wall scenes show that they were moved overland or by water. The great engineering feat of the eighteenth dynasty (New Kingdom) was the cutting and overland transport, for a distance of some 700 kilometers (435 miles), of the blocks for the Colossi of Memnon—the seated statues of Amenhotpe III positioned at the entrance to his mortuary temple in Western Thebes. Each block weighed about 700 tons. The peak in stone transport, however, was reached by Ramesses II in the next dynasty, with the positioning of many colossal statues and obelisks around the country, including the 1,000-ton monolith of himself at the Ramesseum.

One of the most interesting of surviving structures is the Old Kingdom valley temple of Khafre's pyramid, considered extraordinary because of the polished calcite floors, red granite walls, and the four-sided, monolithic columns and lintels. These aspects alone would rank it among the finest of the ancient Egyptian constructions. Yet a special design element lends it unique character. Apart from two entrances into the temple, at the northern and southern extents of its eastern

side, the building was originally completely enclosed and roofed with five terraces, the largest of which covered the main Hall of Columns. Consequently, without special provision, the interior of the temple would have been completely dark, making various ritual ceremonies impossible. The architect did, in fact, provide for natural sunlight illumination of the interior by a very clever design that utilized fourteen polished Egyptian alabaster (calcite) reflecting surfaces (as mirrors), with window slots cut into the walls at the roofline of the Hall of Columns in clerestory fashion. These surfaces would have scattered sunlight diffusely into the window slots and onto the ceiling (providing an illumination similar to modern fluorescent lighting behind milk-white Plexiglas panels). Predating Frank Lloyd Wright's indirect ceiling illumination by more than forty-five hundred years, this design feature must be ranked in the forefront of Egyptian technological achievements.

## Metallurgy

The primary ancient Egyptian metals were copper, lead, gold, silver, iron, and tin. Four main alloys were also used: (1) bronze, a mixture of copper and tin; (2) a copper-lead alloy; (3) electrum, a native alloy, a mix of gold and silver; and (4) brass, very late in Egyptian history, a mix of copper and zinc.

### Copper

The earliest known use of metal in Egypt was for copper beads, borers, and pins (found in tombs of the Badarian period). Some ornaments and small implements, such as needles and tweezers, also date to Predynastic times. Weapons of copper are known from Late Predynastic times and, in use during the first dynasties, were heavy axheads, adzes, knives, daggers, spears, chisels, ewers, and basins. Many copper vanity mirrors from all periods are known—some few mirrors were made of silver (Lilyquist 1979).

The well-known sixth dynasty statues of Pepy I (one small and one larger than life size) were made of beaten copper plates—they are the oldest known metal statues in Egypt. One of the most interesting examples of beaten copper, however, is the section of copper pipe found by Ludwig Borchardt (1910) in one of the causeway drains from the fifth dynasty mortuary temple of Sahure's pyramid. Along with Khafre's "alabaster [calcite] mirrors" of the previous dynasty, this unusual discovery must be ranked among the most innovative of ancient Egyptian architectural practices.

Although copper occurs as a native metal and was worked in the Paleolithic and Mesolithic like any other stone, the production of hardened copper was an Egyptian discovery undoubtedly related to their fabrication of copper weapons and edged tools. After such implements had been cast in molten copper, the cutting edges would have been cooled, then hammered for further shaping and thinning. Hammering produces a harder metal; if hammered too much, copper becomes brittle. Eventually, Egyptians discovered that reheating the copper for a short period restored the hardness, a process called annealing or tempering.

### Bronze

The introduction of bronze into Egypt is presumed to have been from Mesopotamia or one of the other Near Eastern countries. There are a few bronze objects from the Old Kingdom of uncertain provenance or date. The beginning of the Bronze Age in Egypt is therefore usually attributed to Middle Kingdom times, from which there are a number of well-authenticated bronze items and tools. The hardness of the bronze alloy can also be increased by a hammering-annealing process. From the eighteenth dynasty onward, Egyptian use of bronze is extensive and, in later times, bronze was largely used for making statuettes. The addition of lead to copper (and later to bronze) seems to have resulted from their discovery that the melt was easier to cast, a desirable property in the production of statuary.

### Gold

Metalworking in gold is almost as old as the Egyptians' use of copper. Small items of gold have been found in

Predynastic graves. Native gold and gold ores were most often from alluvial sands and gravels or from veins in quartz rock of the Eastern Desert, between the Nile and the Red Sea. The only surviving ancient Egyptian map (a papyrus in the Museo Egizio in Turin, Italy) dates to the twentieth dynasty reign of Ramesses IV (c.1150 BCE), showing the location of a gold-bearing region in the Wadi Hammamat of the Eastern Desert. Although Egyptian goldsmiths were fine craftsmen with a high degree of skill, it is of interest that they do not seem to have purified or refined gold until long after the close of the pharaonic period. According to data quoted by Lucas (1962), proportional variability of gold in Egyptian dynastic jewelry (70.8–99.8 percent) is similar to that shown by assays of gold samples from modern Egyptian mines (76.0–90.3 percent); such data indicate that ancient Egyptians worked with varying grades of native gold rather than refining it. Nevertheless, the gold was so skillfully worked that few modern practices in goldworking were unknown to them.

## Electrum

The native alloy of gold and silver, electrum, was used in Egypt from Early Dynastic times through the end of the pharaonic period. Its silver content varies from about 20 to 30 percent, some as high as 40 percent. The more silver present, the lighter yellow the alloy appears. Electrum is harder than either gold or silver, so its primary use was for jewelry that had to withstand wear. In some instances, it was used for overlaying obelisks. The capstones of some pyramids may also have been made of electrum, with a low silver content, so that gold's bright, deep-yellow color could predominate.

## Iron

The most controversial question about the Iron Age in Egypt is, how early were Egyptians able to smelt and produce iron implements for practical purposes? Iron occurs on Earth both as a native metal (from terrestrial sources and from meteorites) and in mineral ores. Meteoritic iron has a high nickel content, which makes it possible for analysts to distinguish it from any other iron. Iron minerals—hematite, magnetite, and limonite—are plentiful in Egypt and, as early as Predynastic times, all have been made into beads, small amulets, and statuettes. Although iron was worked in this way, the intentional smelting of iron from mineral ore was probably a very late development in Egypt. In fact, native iron cannot be easily shaped and manipulated by beating in the cold state, as can native copper or even bronze. The earliest iron implement known is the iron dagger found on the body of Tutankhamun (eighteenth dynasty), presumed to be a gift from a king of the Middle East (where the Iron Age had already begun). Because no large similar tool or weapon has yet been discovered for an earlier or immediately later Egyptian dynasty, the Iron Age in Egypt is usually ascribed to later times, around the twenty-fifth dynasty, when such tools began to proliferate. [See IRON.]

A controversy also surrounds a piece of an iron plate ( $26 \times 8.6 \times 0.3\text{--}0.5$  cm/ $10.25 \times 3.25 \times 0.13\text{--}0.25$  in.) found in a joint, in the interior of the southern airshaft exit of Khufu's pyramid at Giza, by J. R. Hill in 1837, after he had blasted off two tiers of overlying stone. The fragment is not of meteoritic iron, since it does not contain nickel (an elemental component of meteoritic iron). From a modern chemical analysis of a bit of this fragment, El Gayer and Jones (1989) concluded, however, that the metal object was indigenous to the fourth dynasty; the authors stated that the piece had been manufactured by a comparatively low temperature, solid-state-reduction of iron oxide with charcoal, which produced a porous, spongy mass of iron metal that had never passed through the molten state. It was then hammered into a number of thin layers. This description is not inconsistent with the metal-production **technology** of the Old Kingdom. For example, from Old Kingdom tomb scenes, Scheel (1985–1989) has described the use of charcoal fires and ovens; the specially designed clay blowpipes for elevating temperatures; the smelting of metal from ores; the refining process; the reheating of metal bars and ingots to glow with specific colors that indicate the relative ease of hammering into a variety of shapes; the hammering of the metal pieces into thin layers and plates; and the polishing of the finished products with various sizes of grit, leather, and polishing cloths. In the tomb scenes, the metals were copper, gold, silver, and electrum; in later periods, also lead, tin, and bronze. Although iron was not specifically recognized in any tomb inscriptions, if that metal had been available from some source, then these scenes show that working it could have resulted in a piece not unlike El Gayer and Jones's description. The lack of other such

hammered pieces is difficult to explain. Craddock and Lang (1993), two British Museum metallurgists, dismissed this analysis primarily because El Gayer and Jones had reported the presence of gold on the outer layer; their own electron microscope scanning and X-ray fluorescence spectroscopic examination of both the bit examined by El Gayer and Jones and the larger fragment from which it came did not detect any traces of gold. They concluded that although the fragment exhibited a form of primitive metalworking, it was unnecessary to suppose that it was even of pharaonic origin, and they ascribed its production to post-medieval times. Although the sworn statement by J. R. Hill of the circumstances where he found the piece seems straightforward, precluding accidental or intentional insertion at some later date, the situation may never be definitively settled.

## Wood, Pottery, Ceramics, and Glass

Large-scale use of wood for Egyptian construction depended mostly on imported timber, of better quality and larger size than available locally. The most famous surviving examples are the solar boats of Khufu made from the cedars of Lebanon. One such boat, found in 1954, in an east–west-oriented boat pit, consisted of more than twelve hundred pieces, measures 45 meters (145 feet) in length, and took nearly two decades to reconstruct. The second still lies disassembled, in a neighboring boat pit beside the Great Pyramid at Giza.

Woodworking and joinery were special skills that could not have developed until after suitable metal tools were available. From local woods—acacia, fruit wood, willow—a number of statues, carved panels, doors, and tomb furniture date to the Old Kingdom. Cedar coffins and canopic chests, as well as ebony boxes, date to the Middle Kingdom. Numerous wooden objects, furniture, boxes, gaming boards, bows, and chariots came from the tomb of Tutankhamun and other New Kingdom tombs. The shrines covering the sarcophagus of Tutankhamun were of wood covered by gesso, a type of plaster, overlain with gold. An unusual aspect of Egyptian woodworking was the development of patchwork joinery, because of the local lack of large straight planks—the trees of the Nile Valley were small and sparse. Irregular pieces were joined by means of dowels, flat tongues, and cramps. Metal nails were rarely used until the New Kingdom. The skillful use of veneer and inlay to cover inferior and patchwork woods was also practiced in all periods. In building construction, wood was limited to beams that provided lateral wall support or, sometimes, the vertical support of roofs in elite housing. Wood was also used for sledges and similar transport devices that aided the movement of large stone blocks.

### Clay

In Egypt, the manipulation of clay into pottery vessels of various shapes dates to Neolithic times. Clay was also used to model small figures of animals and people in Predynastic times. The kneading, shaping, drying, and baking of clay into pots was portrayed in tomb scenes and in some wooden models of workshops. The introduction of the potters' wheel from the Near East is usually ascribed to the Old Kingdom; its use is illustrated in a fifth dynasty tomb scene, so it may have been in use even earlier. Categorized in considerable detail are the methods of manufacture, the materials, shapes, thicknesses, degree of firing, and surface decorations of many Egyptian wares. This work has enabled archaeologists to establish the provenance and dates of such pieces.

An interesting example of the many fragments of pottery found scattered at numerous sites in Egypt is a part of the neck of a water pot from Tell el-Amarna. Four fingerprints from the left hand of a potter can be seen on the inside. Although the ancient site is covered by potsherds from many periods, this piece is indigenous to the time of Nefertiti, because it is similar in material, thickness, and slip to broken pieces that can be seen in the matrix of many of the mud bricks used in constructing the houses there in her time.

### Glaze

The development of vitreous glaze is also an early craft in Egypt, dating to Badarian times, when small soapstone

(steatite) objects were covered by it. Later, in Predynastic times, the glazing of powdered quartz objects was used, which developed into the extensive Egyptian industry of faience—important in all periods, especially in the production of amulets, votive objects, *ushabtis*, and the like. Although faience has been particularly associated with Egyptian craftsmen it probably originated in Mesopotamia around the fifth millennium BCE, to appear in Egypt as the result of trade or invasions. The use of glaze on other materials was also common, such as the blue vitreous glaze on plastered ceilings in the Amarna housing.

## Glass

The production of pure glass, as opposed to glaze from which it is derived, was a development of the early New Kingdom in Egypt. It may not have been a pure Egyptian invention, because trade relations with the Near East suggest more glass there than in Egypt. Objects have also been unearthed in Egyptian tombs that have glass jewels of both the Egyptian and Near Eastern styles—indicating the presence of Near Eastern craftsmen in Egypt. Lilyquist and Brill (1993) have presented some detailed compositional analyses of both glasses.

## Conclusion

This brief survey of the development of **technology** and engineering in Egypt has focused on the practical necessities that led to some remarkable inventions, techniques, or skills. Most were used to promote the larger-than-life importance of the god-king to society; others to enhance the enjoyment of life, whether that be for the smaller proportion of the wealthier or the larger proportion of poorer inhabitants of the Nile Valley.

See also AGRICULTURE; ARCHITECTURE; BRICKS AND BRICK ARCHITECTURE; BRONZE; CERAMICS; COPPER; GLASS; GOLD; IRON; LEATHER; SILVER; STONWORKING; TOOLS; and WOODWORKING.

## Bibliography

Arnold, Dieter. *Building in Egypt: Pharaonic Stone Masonry*. New York, 1991. The best available modern treatment of the subject.

**Find This Resource**

Borchardt, Ludwig. *Das Grabdenkmal des Königs Sahu-re*. Leipzig, 1910. The excavation report.

**Find This Resource**

Butzer, Karl W. *Early Hydraulic Civilization in Egypt: A Study in Cultural Ecology*. Chicago, 1976. A dry, but thorough exposition on the subject.

**Find This Resource**

Craddock, P. T., and J. Lang. *Gizeh Iron Revisited*. *Journal of Historical Metallurgy* 27.2 (1993), 57–59.

**Find This Resource**

Edwards, I. E. S. *The Pyramids of Egypt*. Rev. ed. Harmondsworth, 1993. The final edition of this classic work; the best treatment of the subject in English.

**Find This Resource**

El Gayer, El Sayed, and M. P. Jones. *Metallurgical Investigation of an Iron Plate Found in 1837 in the Great Pyramid at Gizeh, Egypt*. *Journal of Historical Metallurgy* 23.2 (1989), 75–83.

**Find This Resource**

Hassan, Fekri. *The Wealth of the Land*. In *Ancient Egypt*, edited by David P. Silverman. New York, 1997.

**Find This Resource**

Hölscher, Uvo. *Das Grabdenkmal des Königs Chephren*. Leipzig, 1912. The excavation report.

**Find This Resource**

Lesko, Leonard H. *King Tut's Wine Cellar*. Berkeley, 1977.

**Find This Resource**

Lilyquist, Christine. *Ancient Egyptian Mirrors from the Earliest Times through the Middle Kingdom*. Münchner Ägyptologische Studien, 27. Munich, 1979. The surviving mirrors in various Egyptian museum collections; some study of shape and sizes.

**Find This Resource**

Lilyquist, C., R. H. Brill, et al. *Studies in Early Egyptian Glass*. New York, 1993. The surviving glass objects in museum collections; some study of composition.

**Find This Resource**

Lucas, A. *Ancient Egyptian Materials and Industries*. 4th ed., rev. and enl. by J. R. Harris. London, 1962. This postmortem revision of Lucas's work by J. R. Harris is one of the most detailed expositions available on materials in engineering **technology** of the ancient Egyptians.

**Find This Resource**

Scheel, Bernd. *Egyptian Metalworking and Tools*. Aylesbury, England, 1989. More detailed treatment is available in three German articles entitled, *Studien zum Metallhandwerk im Alten Ägypten*, in the journal *Studien zur altägyptischen Kultur*, 12 (1985), 117–177; 13 (1986), 181–205; 14 (1987), 247–264. The first covers material from Old Kingdom tombs; the second, from Middle Kingdom tombs; the third, from the New Kingdom and Late period.

**Find This Resource**

Smith, R. W. *Computer Helps Scholars Re-create an Egyptian Temple*. *National Geographic* 138 (1970), 634–655. A photographic and descriptive article on reconstructing a wall of the Aten temple of Akhenaten at Karnak; the illustration on pp. 646–647, of polychrome artwork on a white background, may be like many of the buildings at Akhetaten. Areas of white gypsum coating the mud bricks of Akhenaten's mortuary temple can still be seen.

**Find This Resource**

Wells, R. A. *The Amarna M,X,K Boundary Stelae Date: Hwt-itrn Ceremonial Altar Initial Results of a New Survey*. *Studien zur Altägyptischen Kultur* 16 (1989), 289–327. Presents an engineering survey study of part of Akhenaten's mortuary temple at Akhetaten and comments on nearby mud-brick structures.

**Find This Resource**

RONALD A. WELLS

WAS THIS USEFUL?  Yes  No

PRINTED FROM OXFORD REFERENCE (www.oxfordreference.com). (c) Copyright Oxford University Press, 2013. All Rights Reserved. Under the terms of a single entry from a reference work in OR for personal use. Subscriber: University of Chicago; date: 28 May 2014



Log out