

THE KNOWLEDGE

PYRAMID

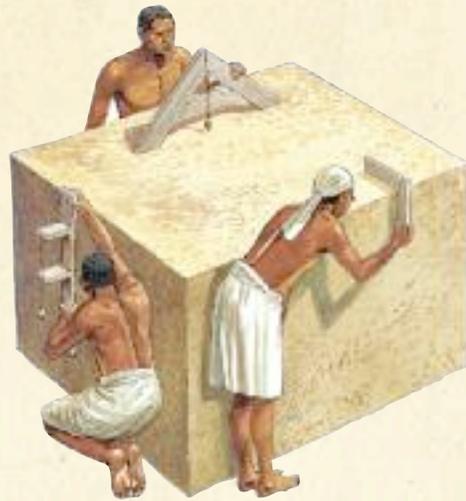
CONSTRUCTION PROJECT



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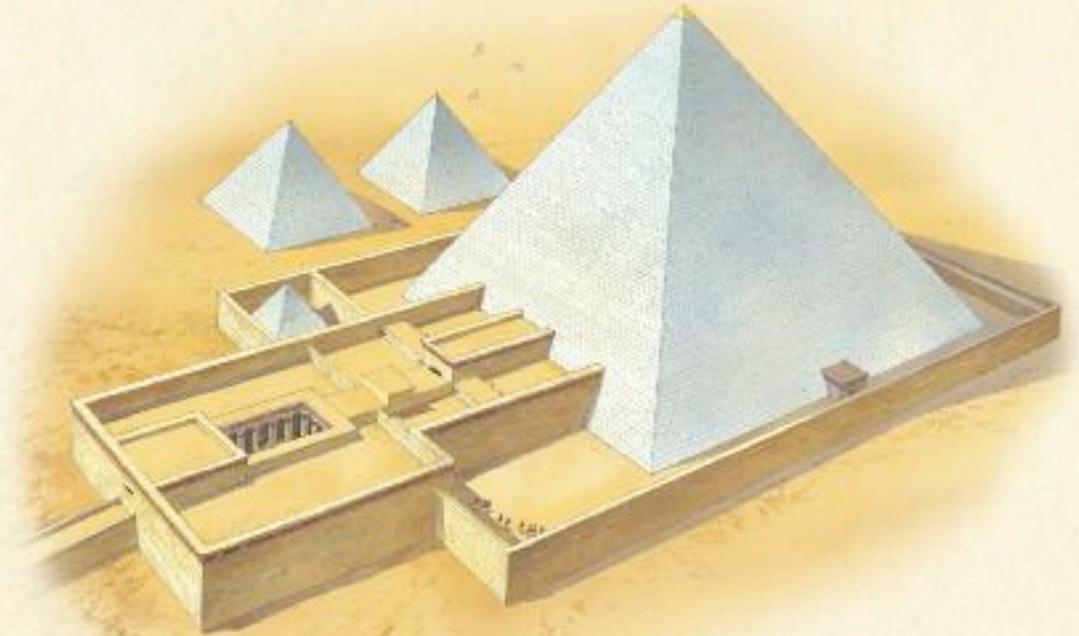
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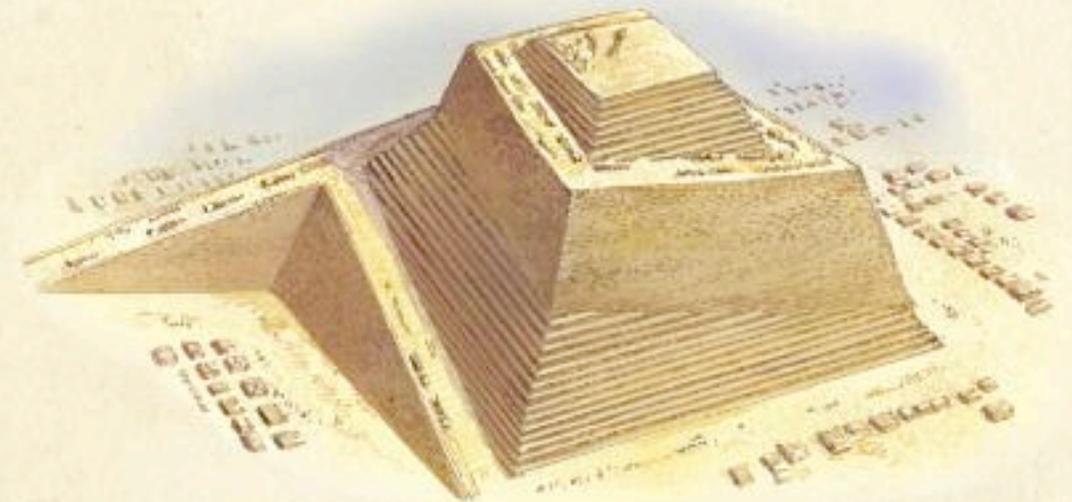
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INTRODUCTION

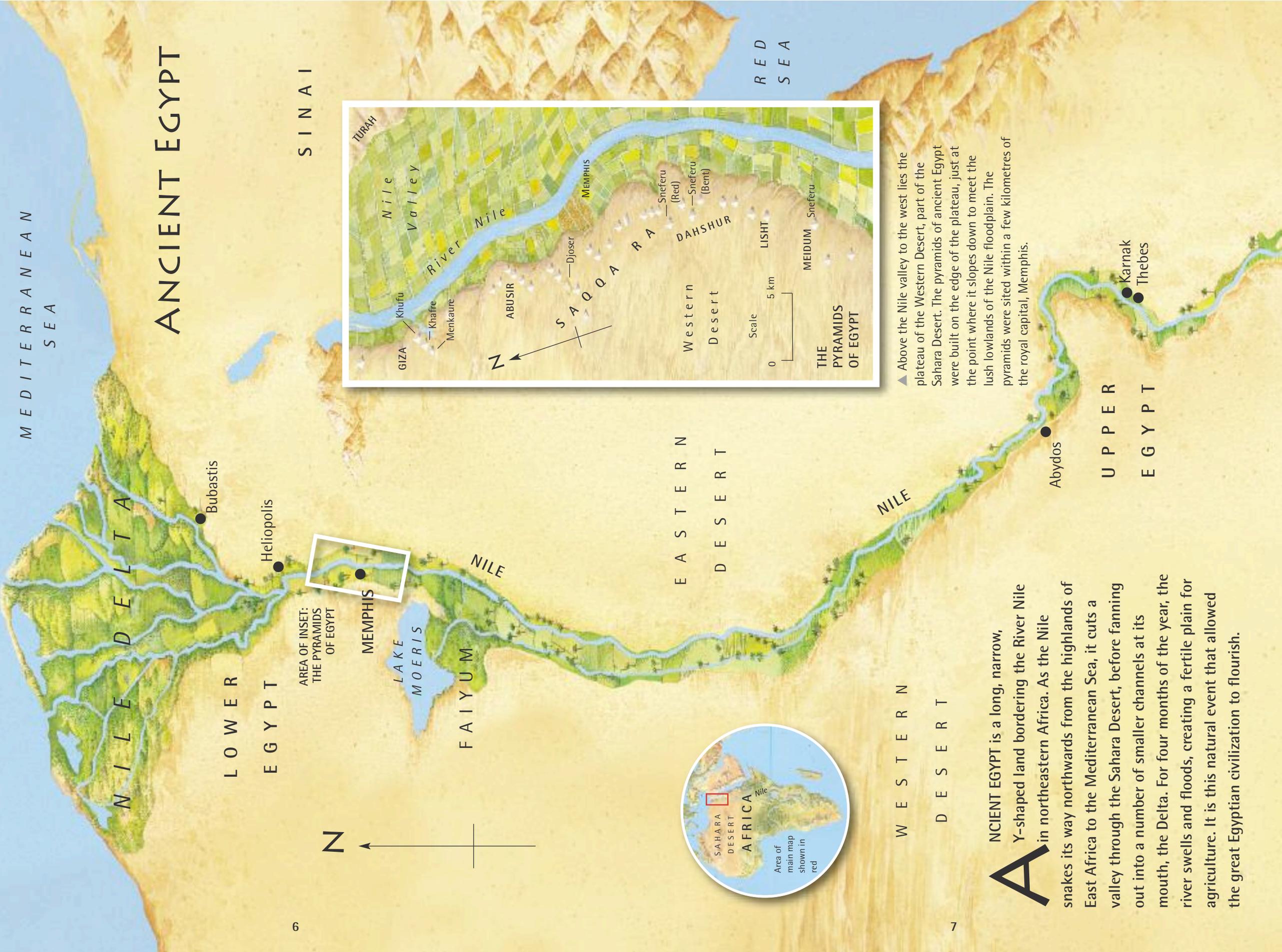
IT IS 24 CENTURIES before the birth of Christ. The pharaoh, the King of Egypt, has hired you to design and build a new pyramid which will serve as a burial place for him and his wives. You are to use the latest techniques to erect a structure that is strong enough to stand for the rest of time. It must also be perfect in shape—accurate to within a few centimetres—perfectly aligned to the points of the compass, and generally an extremely impressive monument to a proud man regarded by his subjects as a god. How do you set about this task?

First, you should steep yourself in the history and culture of your native land, Egypt. An understanding of the Afterlife and religious beliefs is an essential part of this research. Next, you must study the history of pyramids so you are familiar with up-to-date construction techniques. Thirdly, carry out a review of the tools, machines and the workforce you are going to need. You must also find out about where your basic building material, stone, is going to be quarried, and what the various different types are to be used for. Finally, you are ready to tackle the building works step by step, ensuring that all the features of the pyramid are completed to the necessary specification.



MEDITERRANEAN SEA

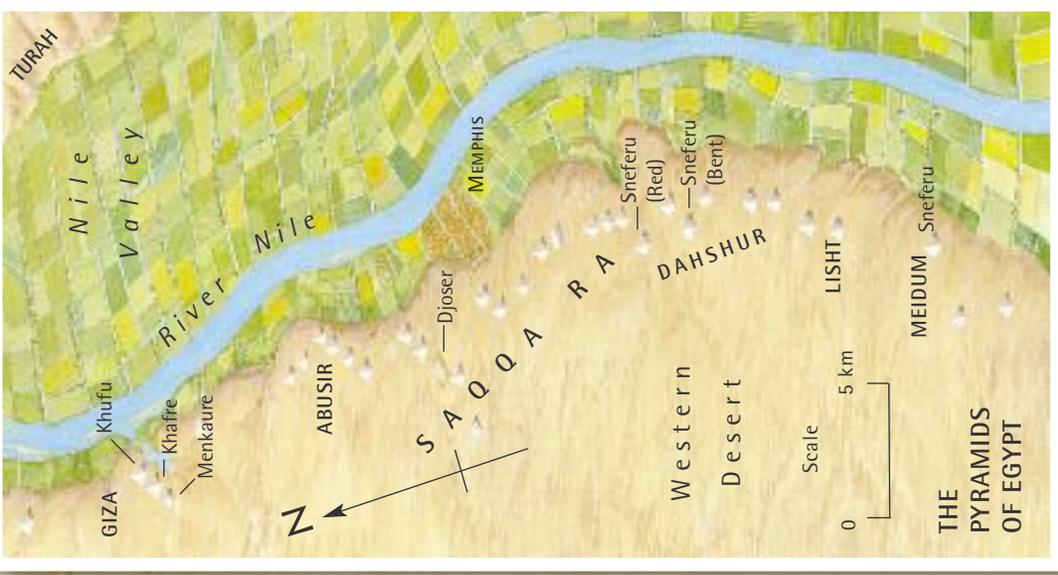
ANCIENT EGYPT



AREA OF INSET:
THE PYRAMIDS
OF EGYPT

N

SINAI



WESTERN
DESERT

ANCIENT EGYPT is a long, narrow, Y-shaped land bordering the River Nile in northeastern Africa. As the Nile snakes its way northwards from the highlands of East Africa to the Mediterranean Sea, it cuts a valley through the Sahara Desert, before fanning out into a number of smaller channels at its mouth, the Delta. For four months of the year, the river swells and floods, creating a fertile plain for agriculture. It is this natural event that allowed the great Egyptian civilization to flourish.

▲ Above the Nile valley to the west lies the plateau of the Western Desert, part of the Sahara Desert. The pyramids of ancient Egypt were built on the edge of the plateau, just at the point where it slopes down to meet the lush lowlands of the Nile floodplain. The pyramids were sited within a few kilometres of the royal capital, Memphis.

UPPER
EGYPT

RED
SEA

EASTERN
DESERT



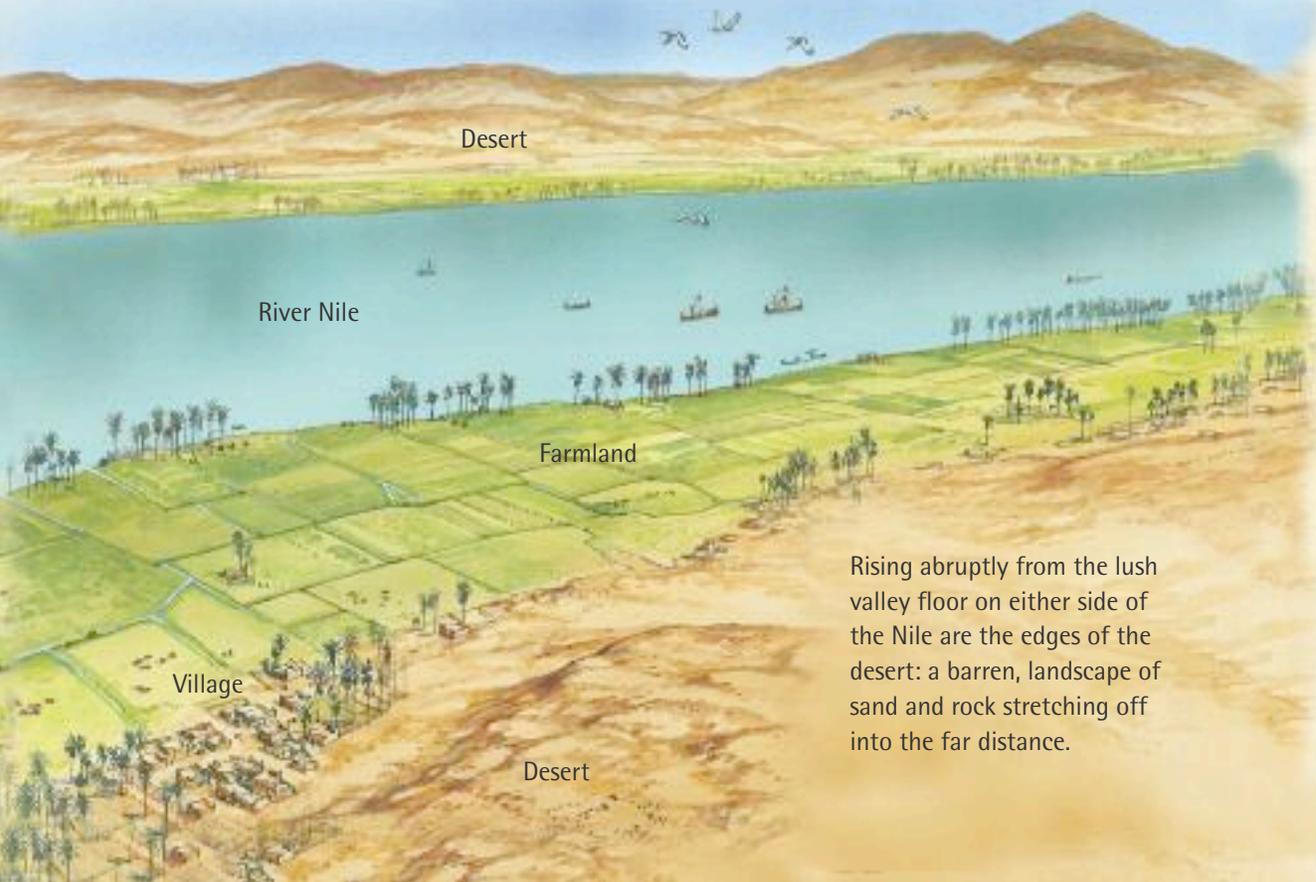
Area of
main map
shown in
red

1. ANCIENT EGYPT

WERE IT NOT for the River Nile, Egypt, a land where it very rarely rains, would be a parched, empty desert. Each summer, rains further upstream cause the Nile to burst its banks, laying down a fresh layer of rich, fertile earth across the floodplain on both sides. To the people who live near the banks of the river, this miraculous event allows them to grow their crops and raise their animals.

▼ Flanked by desert, the Nile valley is a lush, fertile, level land, excellent for cultivation and stock-rearing. Villages are sited just above the plain, to avoid the annual flooding. The river itself is vital for travelling from place to place and for transporting goods in bulk by boat. The waters also offer plentiful fishing and a habitat for game.

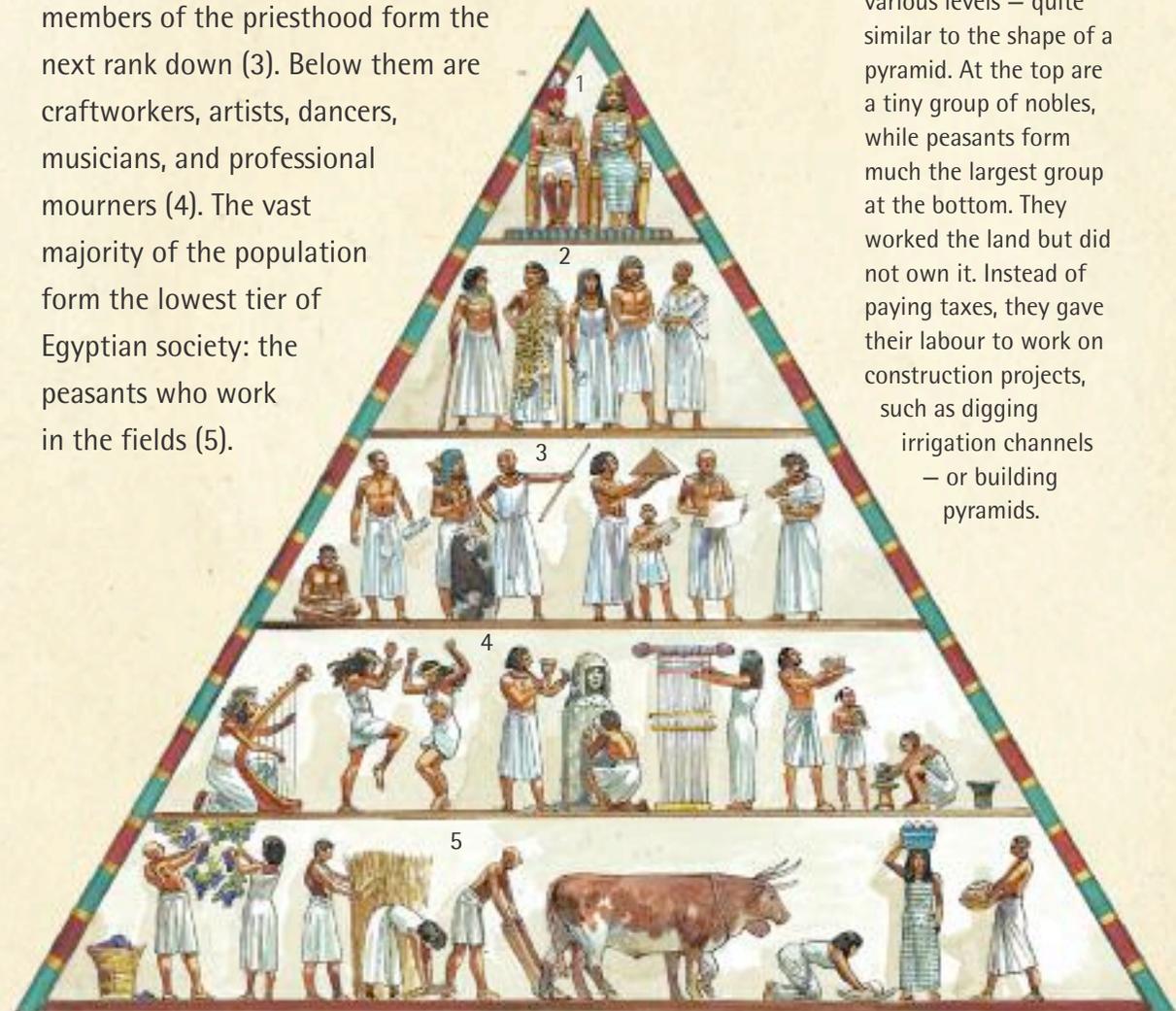
Since about 5000 BC, farming villages began to appear and, with such a bountiful food supply, the people prospered. Towns and cities were founded, some people became skilled craftworkers and the great civilization of Egypt began. About 3100 BC, the strip of land extending from the mouths of the Nile southwards for several hundred kilometres came under the rule of single king, whose title was pharaoh.



Rising abruptly from the lush valley floor on either side of the Nile are the edges of the desert: a barren, landscape of sand and rock stretching off into the far distance.

THE PEOPLE OF EGYPT

In ancient Egypt, social rank is extremely important. A person's position in society is closely linked to the work he does. The pharaoh is, of course, at the pinnacle of Egyptian society: he is supreme being, supreme priest and supreme military commander (1). Beneath him is his Vizier. His job, which he carries out with the help of other ministers, is to supervise building projects, including irrigation works, collect taxes and administer justice. The other highest-ranking Egyptians are high priests and priestesses and army generals (2). Government officials, scribes (people who could write – a tiny proportion of the population), architects, engineers, doctors, soldiers and other members of the priesthood form the next rank down (3). Below them are craftworkers, artists, dancers, musicians, and professional mourners (4). The vast majority of the population form the lowest tier of Egyptian society: the peasants who work in the fields (5).



EGYPTIAN LAW

All the ancient Egyptian people, whatever their social ranking, were viewed as equal under the law. Even the lowliest peasant could appeal to the Vizier if he felt he was the victim of an injustice. Everyone had the right to defend themselves from accusations before a court.

▼ Ancient Egyptian society is arranged in various levels – quite similar to the shape of a pyramid. At the top are a tiny group of nobles, while peasants form much the largest group at the bottom. They worked the land but did not own it. Instead of paying taxes, they gave their labour to work on construction projects, such as digging irrigation channels – or building pyramids.

▼ Between March and June, the cereal crop is ready to harvest. Farmworkers cut off the ears (which contain the grain) using sickles, leaving the lower stalks to be pulled up later. The ears are carried in baskets to circular threshing floors where cattle trample over the crop to separate the grain from the stalks. Now the workers winnow the grain, tossing it into the air so that the pieces of chaff, the husks, are blown away. The grain is then taken away for storage or grinding into flour.

FARMING

The Nile floods between July and October, spreading tons of mud and silt across its floodplain. A network of irrigation channels that farmers have dug in the ground spread the floodwaters of the Nile across the fields of the valley. As soon as the floods retreat in October, farmers use their ploughs to turn the mud into the soil before sowing their seeds. The Egyptians call the floodplain the *kemet*, the black land, after the dark colour of its fertile soil.

The main cereal crops are emmer, a kind of wheat, used for making bread, and barley, for making beer. Farmers also grow lentils, chickpeas, fruit and vegetables. Flax, used for clothing, sails, rope and oil, is also an important crop. Besides crops, the people also keep cattle, sheep, goats and geese.



FISHING AND HUNTING

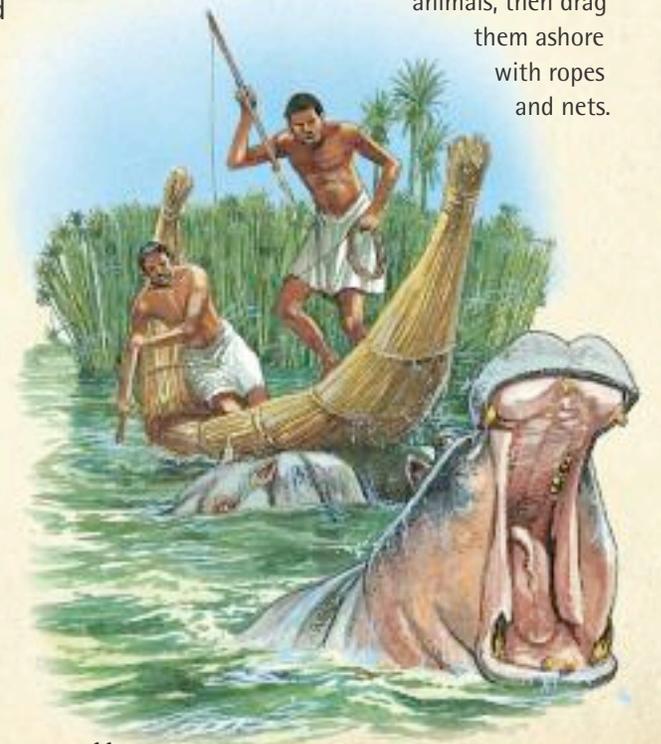
The waters of the Nile are rich with fish, so the river is constantly crowded with small fishing boats. These boats are mostly roughly constructed from bundles of reeds strapped tightly together. Fishermen trap large numbers of fish at a time by slinging a net between their boats (above). Fish can also be caught by casting hand-held nets, or simply by spearing them in the shallows.

About 150 kilometres from the sea, the Nile divides into seven main channels and hundreds of smaller ones which fan out across the lowlands. This triangular area of land resembles the shape of the Greek letter "delta", so the region is known as the Nile Delta. The waters of the Delta are rich with wildlife and provide good hunting and fishing. A common plant found in the Delta marshlands is a tall reed called papyrus. Its stalks have many uses, including making mats, everyday utensils, boats and "paper" for writing on (see page 16).

▼ Catching wild birds is a real skill. Hunters use curved sticks to stun the birds in mid-flight with a careful aim and powerful throw.



▼ The waters of the Nile Delta are home to crocodiles and hippopotamuses. These dangerous animals are the favoured target of the most daring sportsmen. Risking their own lives, the hunters harpoon the animals, then drag them ashore with ropes and nets.



THE FIRST PHARAOH

Historical records tell us that a king named Menes unified Egypt. But it is likely that he also went by the name of Narmer. A decorated stone slab, called the Narmer Palette, records this king's victory over Lower Egypt in about 3100 BC.



THE PHARAOH

To the Egyptians, their king is more than just a ruler: he is like a god, descended from Re, the sun god. They believe that the spirit of the falcon god Horus entered the king at his coronation. When the king dies, his spirit unites with the god Osiris and Horus's spirit passes to the next king.



▲ The White Crown (*Hedjet*) was worn in Upper Egypt, in the south. The Red Crown (*Deshret*) was worn in Lower Egypt, around the Nile Delta.

The king is too awesome a figure to be referred to by name. Instead, Egyptians speak of him as "the Great House", in Egyptian *peraa*, which is the origin of the word "pharaoh". The king's full title is *nsw-bjt* (pronounced "Nesubit"), which means literally "he of the sedge and the bee", but more formally, King of Upper and Lower Egypt. The sedge is the symbol for Upper Egypt, the bee for the Lower. He wears the Double Crown, which shows his authority to rule the two lands. The uraeus cobra on the rim of the crown represents the eye of Re, placed to protect him from his enemies.

▲ It is two years since the new pharaoh took the throne. Now, with his queen sitting beside him, he instructs his architect to start work on designing a tomb for him.

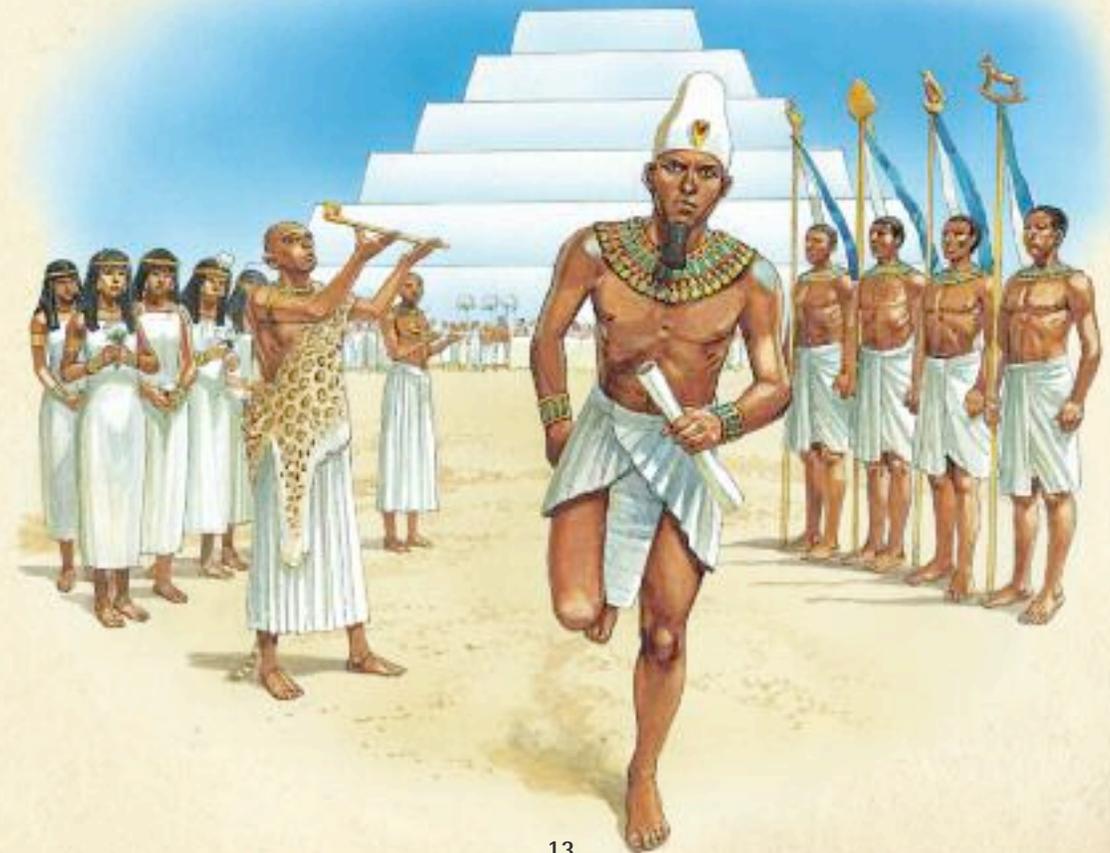
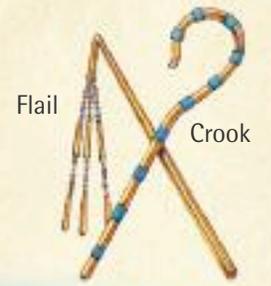


▲ The pharaoh wears the Double Crown (*Pschent*) combining the White Crown of Upper Egypt and the Red Crown of Lower Egypt. The *Pschent* is a symbol of the united Egypt.

The pharaoh has absolute power, but he must also rely on his ministers to help him govern Egypt. His most important official is his Vizier, his "prime minister". As god-king, the pharaoh is the chief priest of every god in Egypt. All offerings to the gods are made in his name. The pharaoh is entrusted by the gods with keeping order in the land. Called *ma'at*, the principle of justice and mercy is one even the pharaoh himself is obliged to respect. He is also responsible for ensuring that offerings are made to the gods so that they will continue to bless Egypt with floods, and thus provide the harvest on which all his people depend for their livelihoods.

The *Heb Sed* ("The Festival of the Tail") takes place after the pharaoh has reigned for 30 years. He must perform physical activities, such as this ceremonial run in the courtyard of the stepped pyramid at Saqqara, to prove he is still physically fit enough to rule Egypt.

▼ The royal regalia are symbols of the pharaoh's kingship. The most important are the crook and flail. The crook was used by shepherds and so symbolized the pharaoh's duty of protecting his people. The pharaoh's crook was gold-plated and reinforced with blue copper bands. The flail, a whip, symbolized the pharaoh's power to punish his enemies.



GODS AND GODDESSES



▲ Amun was originally god of air and wind. He later became the king of the gods and father of the pharaohs.



▲ Isis is goddess of women, mothers and children.



▲ Anubis is god of the dead, mummies and embalming. He guides the dead through the underworld. He is often shown with the head of a jackal.

The ancient Egyptians worship hundreds of gods and goddesses. As religious beliefs changed over the centuries, some old gods became less popular, became merged with others, or disappeared altogether.

In time, some new gods appeared. Many gods and goddesses are associated with different animals, and are shown in paintings or sculptures with animal heads. Most gods are gods of specific things (for example, Nut, is goddess of the sky) or an activity (Khnum, god of making pots). Some, however, represent ideas or qualities (Ma'at, the goddess of truth and justice).

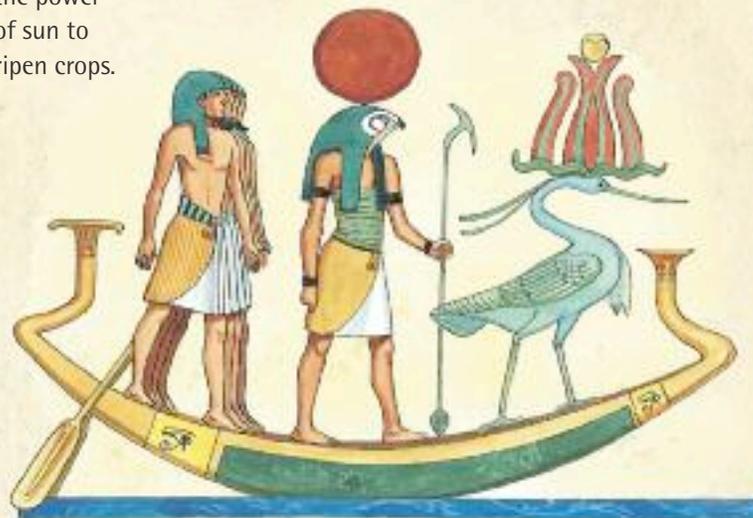


▲ Horus is the god of the sky. His spirit enters the living pharaoh.



▲ Bastet is goddess of the power of sun to ripen crops.

One of the most important gods is Re (sometimes called Ra), the god of the sun. In Egyptian myths, he is shown making a journey across the sky each day in his boat. He has a falcon's head, and carries the sun's disc, the wadjet, above his head (*below*).



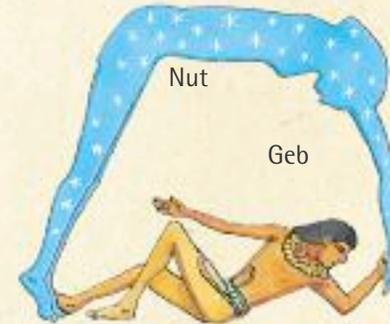
▼ Ma'at is the goddess of truth and justice.



▲ Ptah is the god of artists, architects and craftsmen. He was also the god of the Egyptian capital city, Memphis.

According to ancient Egyptian myths, the world began with dark waters of chaos, called Nun. One day, a mound rose out of these waters. The mound was called *ben-ben*. On it stood Atum, the first god. Atum coughed and spat out Shu, the god of the air, and Tefnut, the goddess of moisture. Shu and Tefnut had two children: Geb,

the god of the earth and Nut, the goddess of the sky. Nut stretched from one horizon to the other, touching the ground with only her fingertips and toes. Nut and Geb had four children: Osiris, Isis, Seth and Nephthys.



Osiris took his father's place as king of the earth and Isis was his queen. Osiris ruled fairly and justly over the earth for many years. However, Seth was jealous of Osiris because he wanted to be the ruler of the earth. One day he killed Osiris.

Osiris went down into the underworld and Seth became king of the earth. Osiris and Isis had one son called Horus. Isis protected her son by hiding him in the reeds of the Nile until he grew old enough to avenge his father's death. Horus battled against Seth and regained the throne to become king of the earth. Every pharaoh, the Egyptians believed, had the spirit of Horus inside him. When he died, he went to the underworld, the Afterlife, where he was joined with the spirit of Osiris.



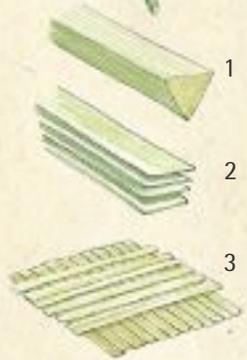
▲ Hathor is the goddess of love, music, beauty and joy.



▲ Osiris, god of the dead and symbol of eternal life. He rules the underworld where the souls of the dead are judged.



▲ Seth is god of deserts, storms, evil, darkness, war – and trouble in general.



PAPYRUS

Papyrus reeds, which grow along the Nile, can be used to make a kind of paper. The skin of its stalks is stripped away, leaving the pith (1). This is cut into strips and soaked (2). The strips are laid on top of each another (3) and pressed together using weights.



▲► Scribes write on papyrus, or, when less expensive material can be used, on wooden tablets or ostraca. They use black or red ink, stored as dry blocks on palettes and moistened for use. Pens are made of reeds.

SCRIBES AND WRITING

The ancient Egyptian language is written in two ways. Hieroglyphic script is used for writing on monuments and tomb walls. The Egyptians use a simplified version, called hieratic, for everyday writing.



Written records are vital to the way Egypt is governed, so for a person to take any important job it is necessary for them to train as a scribe. All high-ranking government officials, priests, army generals, and the pharaoh himself, know how to read and write. Pupils start learning at the age of five. Nearly all are boys and girls from wealthy families, the only ones that can afford education for their children. They learn the



hieratic script; only a few will go on to study the more complicated hieroglyphic script. They write using ink with a reed brush and practise on ostraca: flakes of stone or pieces of old pottery (above).

A (ah) vulture	A (ar) forearm	B foot	CH (as in German "ich") animal's belly	D hand	DJ (as in "church") tethering rope	F horned viper
G jar stand	H twisted flax	H reed shelter	I reed	J snake	K basket	KH (as in "loch") jar lid
M owl	N water	N red crown	P mat	Q hill slope	R mouth	S folded cloth
SH pool	T loaf of bread	W or OO quail chick	Y two reeds	S or Z door bolt	WA lasso	ANKH sandal strap
KHAST hill	HTP altar	NEB basket	RA sun	KHPR dung beetle	MN game board	SHA pool with flowers

Hieroglyphs are pictures of people, animals and objects, but most of them also represent a sound. There are more than 700 of them.

The chart shows the hieroglyphs that represent the simpler sounds – like the letters of an alphabet. Included are a few of the many that stand for part of a word (e.g. *wa* or *khpr*). The hieroglyphic script does not include true vowels, although some do sound quite close to "a", "i" or "o".

The characters used in hieratic script (below) resemble hieroglyphs. Written in ink with a reed brush on papyrus, the script allows scribes to write more quickly.



▼ Words are made up from a combination of sounds. Sometimes a sign is added to confirm what the word means.



NEFER "good"



MUT "mother"



DJESEM "dog"



An early burial pit



▲ Early graves were marked on the surface by stone slabs.



Pharaoh Djoser



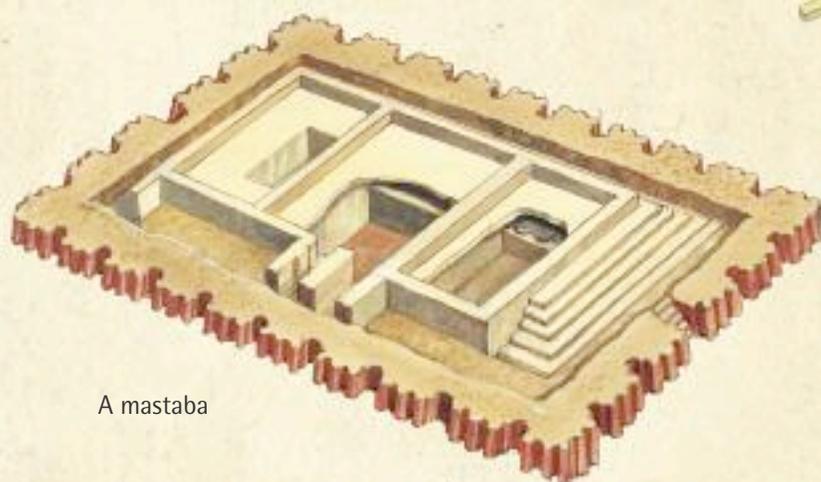
▲ Imhotep, the architect of the Step Pyramid, was Djoser's Chancellor and High Priest. He later became famous as an astronomer and doctor. He was even seen as a god: the son of Ptah, god of Memphis.

THE STORY OF THE PYRAMIDS

Centuries before the first pharaohs, rulers were buried in pits in the ground, covered by small mounds of sand and gravel. Their bodies were accompanied by figurines (miniature statues), pots and weapons. Over the years, rulers' graves became more elaborate. They resembled underground apartments, divided into separate pits or "rooms" with mudbrick walls (right).



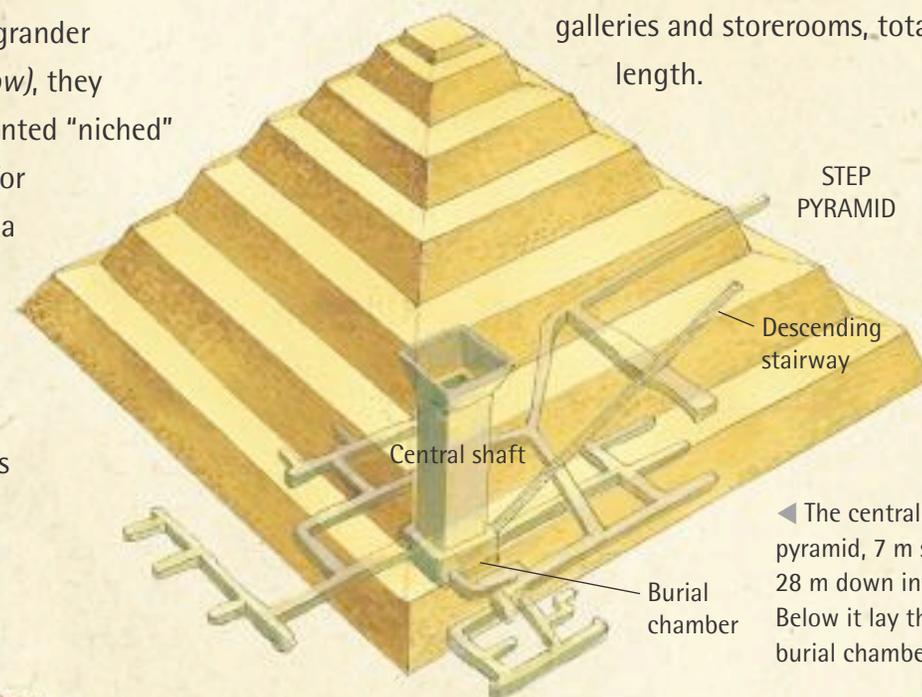
With the emergence of the first pharaohs, even grander burial places were needed. Called mastabas (below), they were flat-roofed, rectangular structures with painted "niched" walls. Inside the mastaba, there were chambers for storing burial goods and provisions, chapels and a burial chamber.



A mastaba

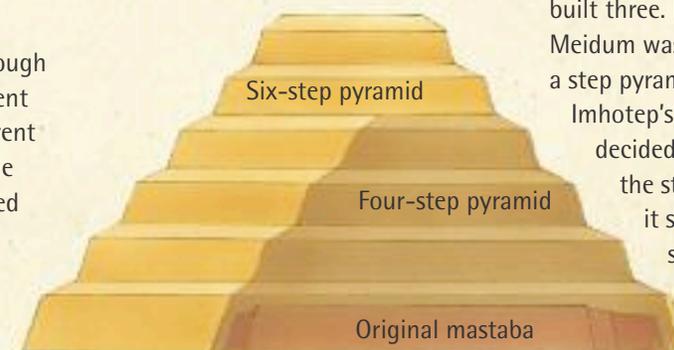
On a site in Saqqara, on the desert plateau overlooking the royal capital at Memphis, Imhotep built a huge enclosure surrounded by a stone wall, 10.4 m high and 1645 m long. Within the walls was a vast complex of pavilions, terraces and courtyards. Towering over them, rising to height of 60 m, was the Step Pyramid.

The Step Pyramid was built in stages, beginning with a simple square mastaba. Workers built a central core made of roughly-shaped stones with a fine limestone casing. Then they added sloping upright layers to the core, each layer leaning inwards. The stones they used were bigger and of better quality than in the core. Underneath, the builders carved out a network of shafts, tunnels, chambers, galleries and storerooms, totalling 5.7 km in length.



◀ The central shaft of the step pyramid, 7 m square, was dug 28 m down into the bedrock. Below it lay the granite-walled burial chamber.

► This is a cross-section through the Step Pyramid. The different shades indicate the six different stages of its construction. The original mastaba was enlarged twice before a four-step pyramid was built above it, and the final six-step pyramid added to that.

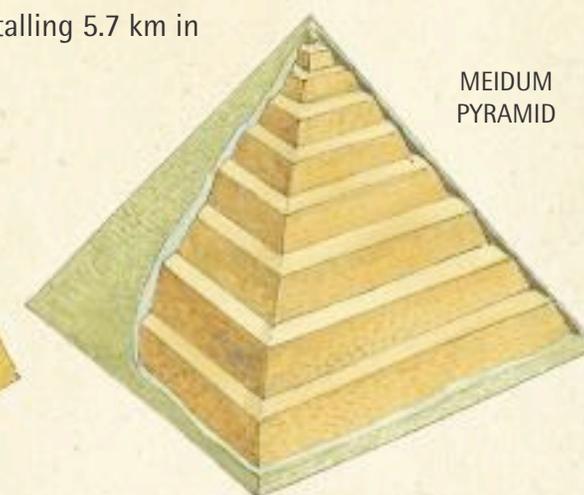


SNEFERU

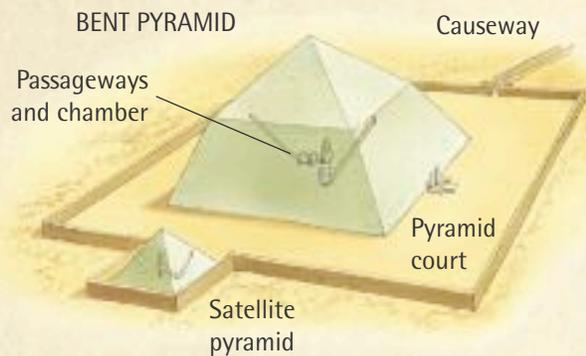
Pharaoh Sneferu was the greatest pyramid builder ever. He was the first to build smooth-sided pyramids. He also introduced the internal design in which a long descending passage ran from the north face entrance down to the burial chamber.



MEIDUM PYRAMID



▲ When Pharaoh Sneferu came to the throne in 2575 BC, he decided to build a pyramid. In fact, he built three. His first at Meidum was originally a step pyramid like Imhotep's. He later decided to fill in the steps to make it smooth-sided.



THE GREAT PYRAMIDS

Meanwhile, Sneferu commanded the building of another pyramid at Dahshur. The method of construction in the early stages was the same as before, but this time, the builders ran into structural problems. So, about halfway up, workers started laying the stones horizontally, and the rest of the pyramid was built with a gentler slope. The result is the "Bent Pyramid". Perhaps dissatisfied with its imperfection, Sneferu commanded yet another pyramid to be constructed. With a gentler slope planned from the outset, the "Red Pyramid" was successfully completed without mishap.

KHUFU
Sneferu's son, Khufu (*below*), chose the desert above Giza as the site for his pyramid. It was to be the most ambitious construction project yet. Containing about 2,300,000 blocks and standing 147 m tall, it would remain the tallest structure in the world for nearly 4500 years.



Work commenced on the Great Pyramid, as it came to be called, soon after Khufu ascended to the throne in 2551 BC. It consisted of casing and core stones laid horizontally. Inside the pyramid were three chambers, together with several passageways. The King's Chamber was reached via the Grand Gallery and three granite portcullis sliding slabs. Five more slabs bore the weight of the pyramid above the King's Chamber.

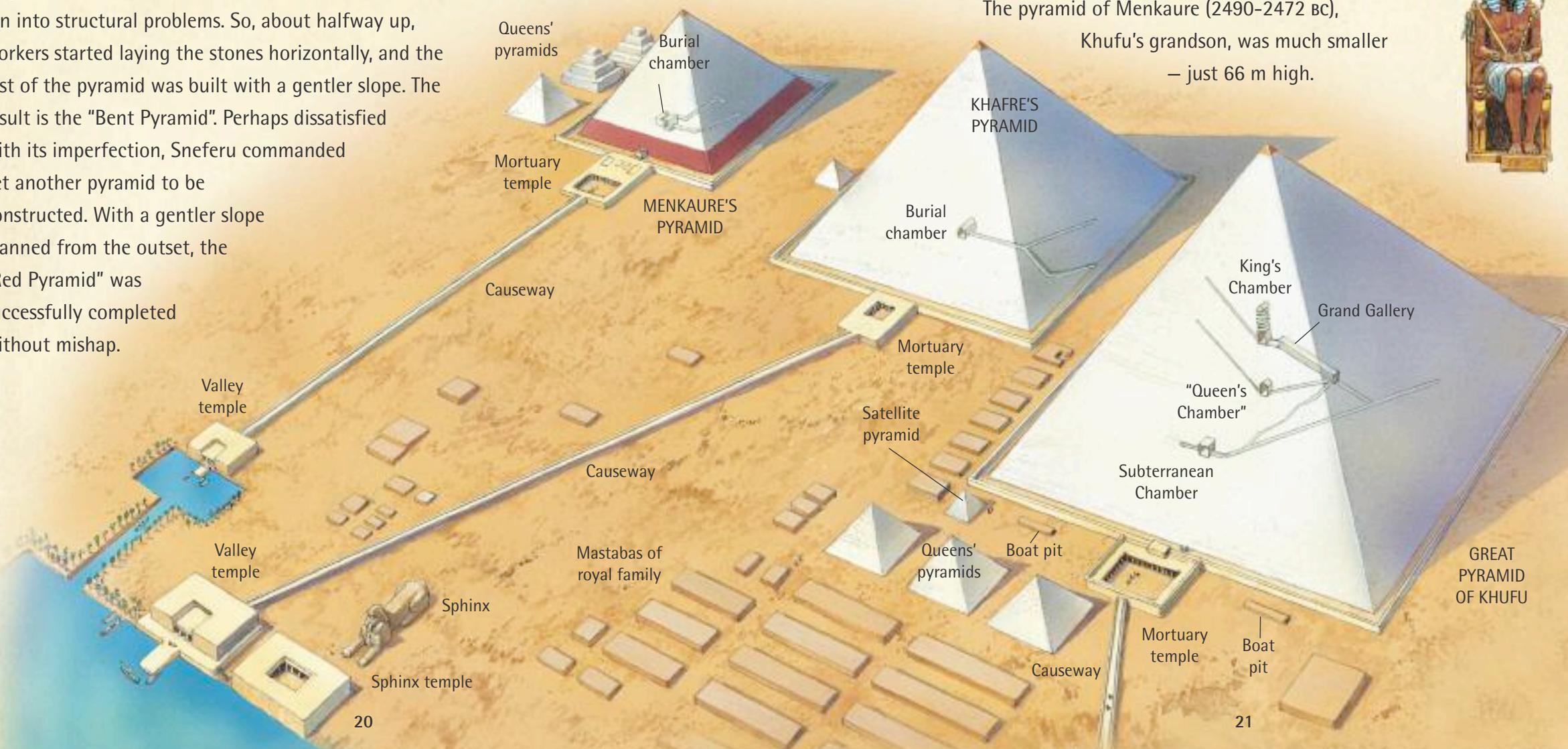


▲ Funeral boats were dismantled and buried in pits near the pyramids.

Two other massive pyramids were built at Giza, almost perfectly aligned along a diagonal. The pyramid of Khafre (2520-2494 BC), Khufu's second reigning son, is a little smaller than his father's, but was built on higher ground.

▼ Khafre, Khufu's second reigning son

The pyramid of Menkaure (2490-2472 BC), Khufu's grandson, was much smaller — just 66 m high.



THE PYRAMID OF KHUFU

The Great Pyramid of Khufu is the most exactly aligned of all the Egyptian pyramids. It deviates from true north on average by a tiny fraction of one degree: 3 minutes and 6 seconds (less than one fifteenth of one degree).

2. BUILDING PLANS

HERE ARE the scale drawings you will need for building the pyramid. Be careful to follow the plans exactly: supreme accuracy is a requirement the pharaoh has laid down.

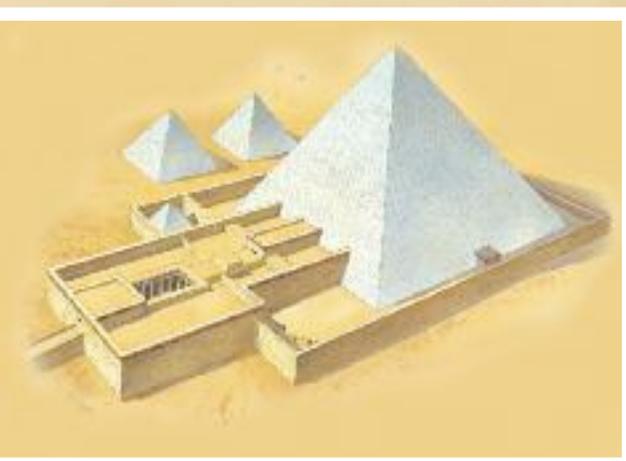
The pyramid must be exactly square and aligned with each face pointing directly towards north, south, east and west. The angle of slope must be exactly the same for each face, with the pyramid's peak lying precisely above the exact mid-point of the square that forms its base. The pyramid is to stand for all time, so its stones must be fitted with great care.

Its interior will be made up of horizontal stone layers with outer casing blocks of superior-quality Turah limestone.

All pyramids of this period, known as the 5th Dynasty (2465–2323 BC), have the same basic layout. Built against the eastern face of the pyramid is the mortuary temple. A miniature satellite pyramid, where the pharaoh's *ka* (see page 41) is entombed, is built next to the temple. Surrounding the

complex is an enclosure wall. A long causeway links the main complex on the high plateau down to the valley temple, which lies on the banks of the Nile, or a channel connecting the river. Outside the complex are the queens' pyramids and pits for the burial of funerary boats.

▲ This is what the pyramid will look like on completion in about 20 years from now. The pyramid itself measures 110 cubits (or 57.75 metres) square and 82 cubits (45 metres) high. It has a slope of 56°. The mortuary temple, causeway and valley temple are built from lesser-grade limestone.

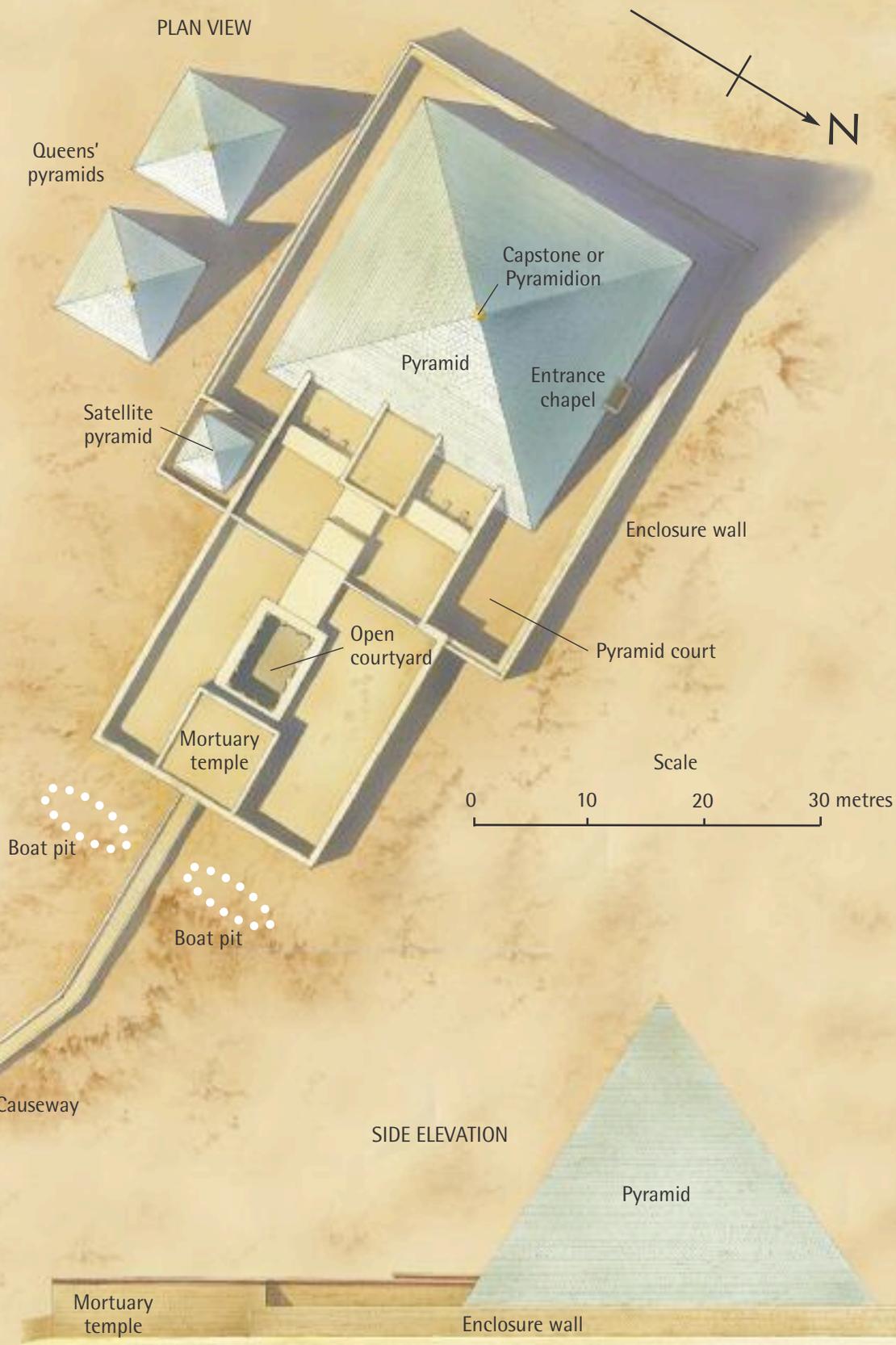


River Nile (in flood)

Quay

Valley temple

PLAN VIEW



Queens' pyramids

Satellite pyramid

Capstone or Pyramidion

Pyramid

Entrance chapel

Enclosure wall

Pyramid court

Open courtyard

Mortuary temple

Scale

0 10 20 30 metres

Boat pit

Boat pit

Causeway

SIDE ELEVATION

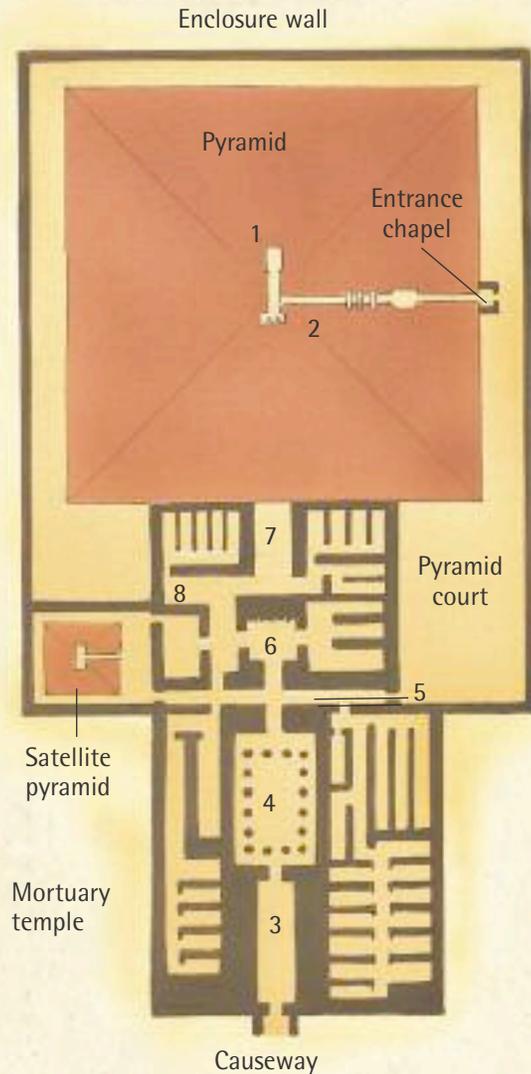
Pyramid

Mortuary temple

Enclosure wall

INTERIORS

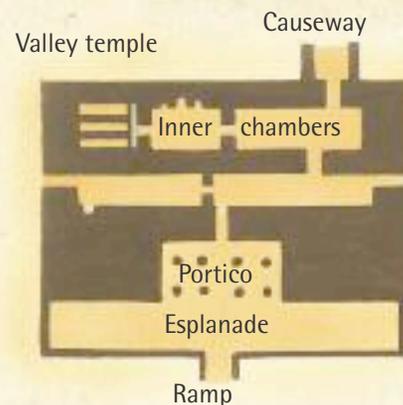
These plans show the internal layout of the pyramid complex's buildings. The burial chamber (1) is carved out of bedrock beneath the pyramid at the end of a long passageway (2). This points north, towards the stars that revolve around the Pole Star as seen from Earth. The mortuary temple, the dead pharaoh's "eternal palace", consists of a front hall (3) leading to an open courtyard with columns (4). Beyond a corridor running crossways through the temple (5), there is an inner sanctuary, which includes a statue chamber (6) and an offering hall (7). At the face of the pyramid, there is a false door. Leading off to the sides of these halls are magazines (8), stores of provisions for the Afterlife.



▼ This is a view of the valley temple as it will look when completed. The mortuary temple, causeway and valley temple are all to be built from lesser-grade limestone than the pyramid itself.



From the mortuary temple, a causeway, a long enclosed corridor, leads down to the valley temple. A ramp leads up from a narrow jetty on the Nile to a wide esplanade at the front of the temple. Behind that is an elaborate portico (entrance hall) with columns, inner chambers and magazines.

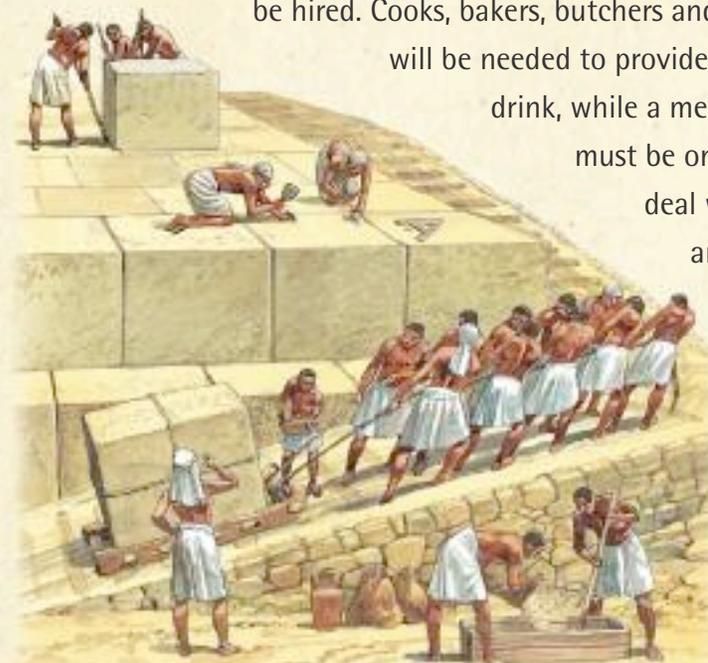


3. WORKFORCE AND MATERIALS

VAST QUANTITIES of stone, a huge workforce of thousands of men and effective tools will be needed to build the pyramid. While it is hoped that the pharaoh will live for many years, you should plan for completion well ahead of the fateful time when it becomes a tomb. A large proportion of the workforce are peasants, conscripted from villages the length of the land. Teams of 25,000 will be drafted in to serve three months' work on the site, before they are replaced by another team.

Around 4000 men work at quarrying, cutting, hauling and setting the stones themselves. Many more will be needed as "support" workers. A large crew will be employed just to build the ramps. Also required are: carpenters to make tools, sleds and the tracks set in the ramps; metalworkers to make and repair chisels; potters to make pots for carrying water; a team of water-carriers. Scribes, surveyors, masons, sculptors and overseers are among the higher-ranking employees that must be hired. Cooks, bakers, butchers and brewers

will be needed to provide food and drink, while a medical team must be on hand to deal with injuries and illnesses.



GANGS

From graffiti found at Menkaure's Pyramid at Giza, it is known that one gang of workers called themselves the "Friends of Menkaure" while another, rival gang, went by the name "Drunkards of Menkaure".



Cutting a channel using a dolerite stone



Carpenter sawing

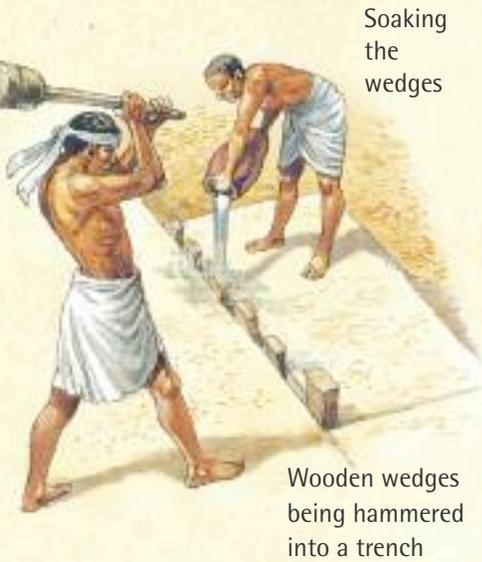
◀ The conscript workers taken on to cut, haul and set the stones are made up of crews numbering 2000 men, divided into two gangs of 1000 men. Each is then organized into teams of 20-25 men. With one of their number as foreman, they haul the stones and set them in place.

► While one worker drives wooden wedges into trenches in the rock with a mallet, another worker soaks them with water. In some instances – for example, when working with harder rock such as granite – it may be necessary to cut wider channels in the rock to give more room for levers to detach the stones from the bedrock.

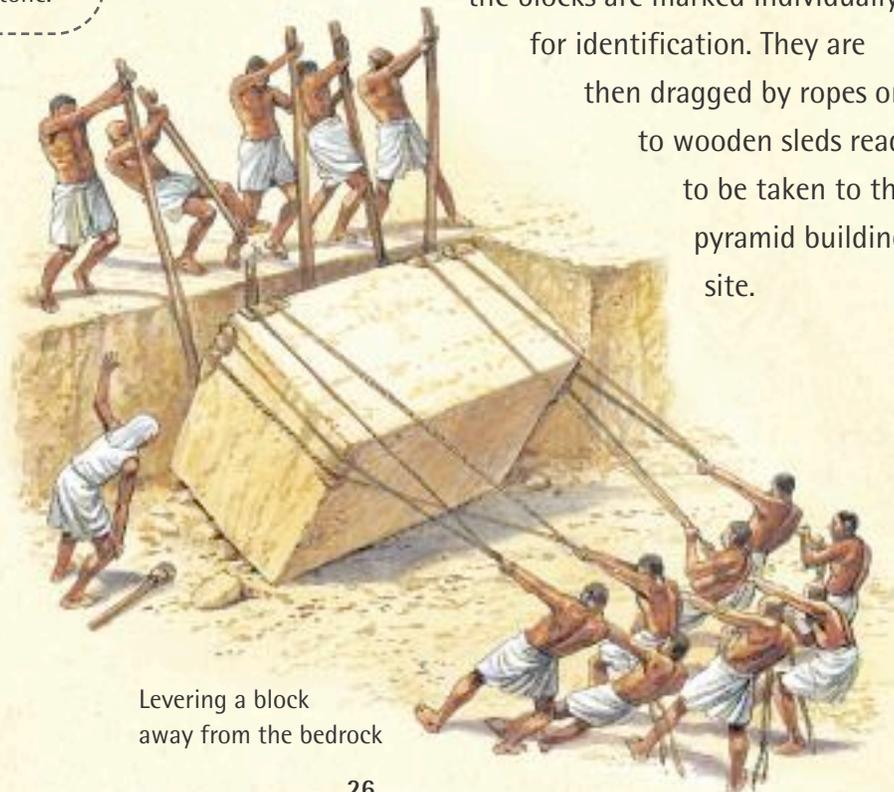
STONES

The pyramids are built from blocks of limestone. With no iron tools available, the blocks must be cut from the bedrock using wooden wedges and levers.

First, a workman cuts a narrow trench in the stone using an axe. Wedges are then driven in along the trench with a heavy mallet. The wedges are soaked with water. As the wood swells, the stone cracks. The quarry workers then use ropes and heavy timber levers to free the block. Each block weighs around three tonnes, so a number of men are needed to complete this task. Using a copper chisel,



the blocks are marked individually for identification. They are then dragged by ropes on to wooden sleds ready to be taken to the pyramid building site.



GRANITE

Granite is used for wall linings and roofing blocks, plugging passages, columns, false doors, sarcophagi and pyramidions. It can only be worked using hand-held pounders made of dolerite, a hard stone.

Most stones are quarried out of the rock near the site. But a fine white limestone, used for the polished casing, comes from Turah, a quarry on the opposite bank of the Nile. Granite slabs, also used in building the pyramids, are quarried at Aswan, some 900 kilometres farther upriver. The best limestone at Turah

is obtained from tunnels dug into the face of the cliffs.

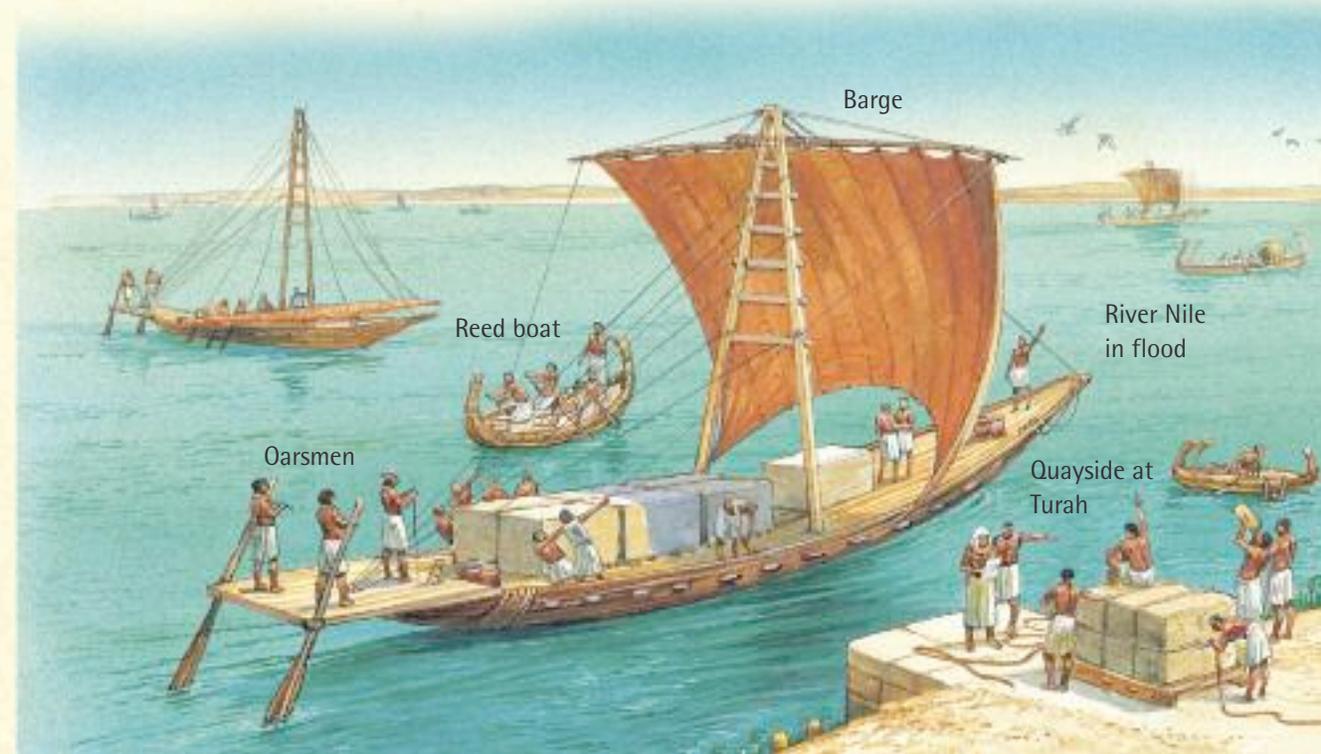


The blocks are dragged to the river's edge. To prevent them from sinking into the sand, tracks made from parallel wooden boards embedded in the ground are laid and the blocks dragged along them. Each stone is marked with the name of the work gang that hauled them; that name will be checked off at the site. Finally, the blocks are loaded aboard barges to take them across the Nile to the pyramid building site.

LIMESTONE

Just to cover the outer surface of the Great Pyramid of Khufu, 67,390 cubic metres of Turah limestone were needed.

▼ The casing blocks are stored at Turah until the time of the annual Nile flood. At this time, most of the distance between quarry and site can be travelled by river, making transportation of the heavy stones much easier. The Nile in flood is, however, fast-flowing and dangerous and great skill is needed to steer the heavily-laden barges across its waters.





▲ The shaping of stones is done by copper chisels hammered by heavy wooden mallets.

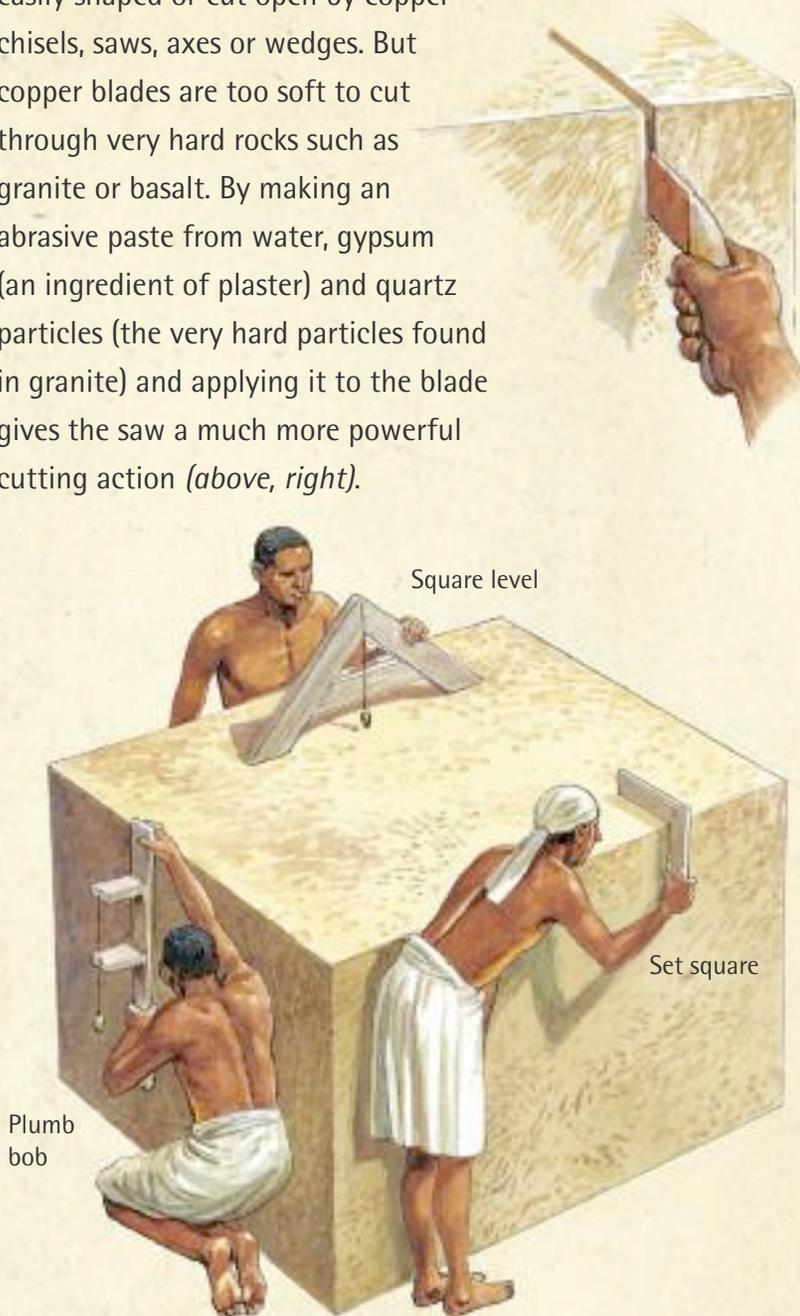
TOOLS

The tools available to the workforce are made from copper, wood, rope and a hard stone called dolerite. Handles for tools, mallets, measuring instruments, levers, sleds and wedges are all made of wood. Limestone, the type of rock most used in the construction of the pyramid, is quite a soft rock and can be easily shaped or cut open by copper chisels, saws, axes or wedges. But copper blades are too soft to cut through very hard rocks such as granite or basalt. By making an abrasive paste from water, gypsum (an ingredient of plaster) and quartz particles (the very hard particles found in granite) and applying it to the blade gives the saw a much more powerful cutting action (*above, right*).



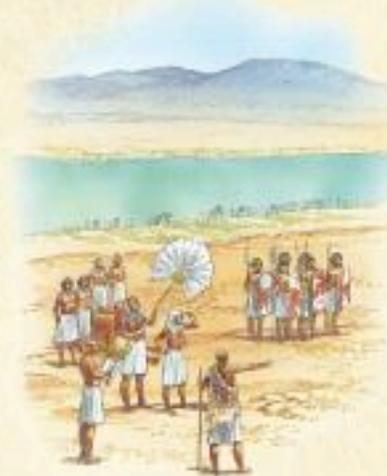
▲ In a bow drill, a cord is wrapped around the central spindle which has a copper drill bit attached to it. Rotating the bow winds up the cord tightly. Releasing it causes the spindle to spin rapidly, powering the drill.

► Measuring tools are vital if the incredible accuracy needed to build the pyramids is to be achieved. A set square measures right angles. The plumb bob is used to achieve exact verticals. The square level, an A-shaped wooden frame with legs of equal length, is used for measuring horizontal surfaces. When the plumb bob of a square level aligns with a mark at the centre of its cross-piece, the surface on which it is standing is exactly horizontal.



4. CONSTRUCTION

SITING THE PYRAMID



THE PYRAMID must be built to the west of the Nile, in the place where the sun sets: the Land of the Dead. But there are other factors to consider when choosing a site. It must, for example, lie above the Nile's valley floor (to avoid flooding), but not too far from the river, since some heavy stone blocks will be

arriving by boat. Secondly, it should be visible from the pharaoh's palace in Memphis, the Egyptian capital. Finally, the site must also be reasonably level and have a solid bedrock that has no underlying geological weakness. A position on the high desert plateau between Giza in the north and Meidum in the south, overlooking the Nile, is the perfect spot.

Next, the pyramid has to be aligned so that its sides face exactly north, south, east and west. Observing the stars can help with this. Because all the stars appear to revolve around the Pole Star, lying directly in the north, by plotting the passage of any particular star across the sky, and using some simple geometry, true north can be pinpointed.



▲ The enclosure where the priest stands to locate true north is a circular wall located at the centre of the chosen site. The wall is built high enough to block out the view of any surrounding hills. By making the top of the wall absolutely level, a perfect horizon is created.

◀ The priest stands in the enclosure and notes the position of a star just as it rises above the wall. Later that same night he notes the position where the same star drops below the wall. The mid-point between the two positions points directly due north.

► The pharaoh himself may perform the foundation ceremony. Together with a priestess dressed as the goddess Seshet, they drive posts into the ground at the four corners of where the pyramid will stand.

▼ How do you make the ground perfectly flat? One way might be to use water. Cut a series of trenches and flood them with water. Mark the height of the water level on the trench sides and drain the water away. Fill in the trenches with stone and carve out the ground in between, both to the height of the marks.



► If it is too tricky to get water up to the plateau, the workers can instead use a square level (see *Tools*). Resting a bar set at an exact horizontal on two stakes of equal length, they look along to a third stake and calculate by how much the land needs to be carved out or raised up to make it exactly level.



LEVELLING THE BASE

It would not be possible for each face of the pyramid to meet exactly at a point at the top if its measurements were not precisely accurate. So if the pyramid is *not* constructed on a level base, its corners are *not* at exact right angles, its sides are *not* precisely the same width at the base and the angle of slope is *not* the same for all four faces, you will run into trouble later on! Such precision requires ingenuity and careful use of tools.

Firstly, workers clear the site of sand and rubble. It may be possible to leave an area of unlevelled bedrock to form the core of the pyramid itself, provided the ground around it is made perfectly flat.



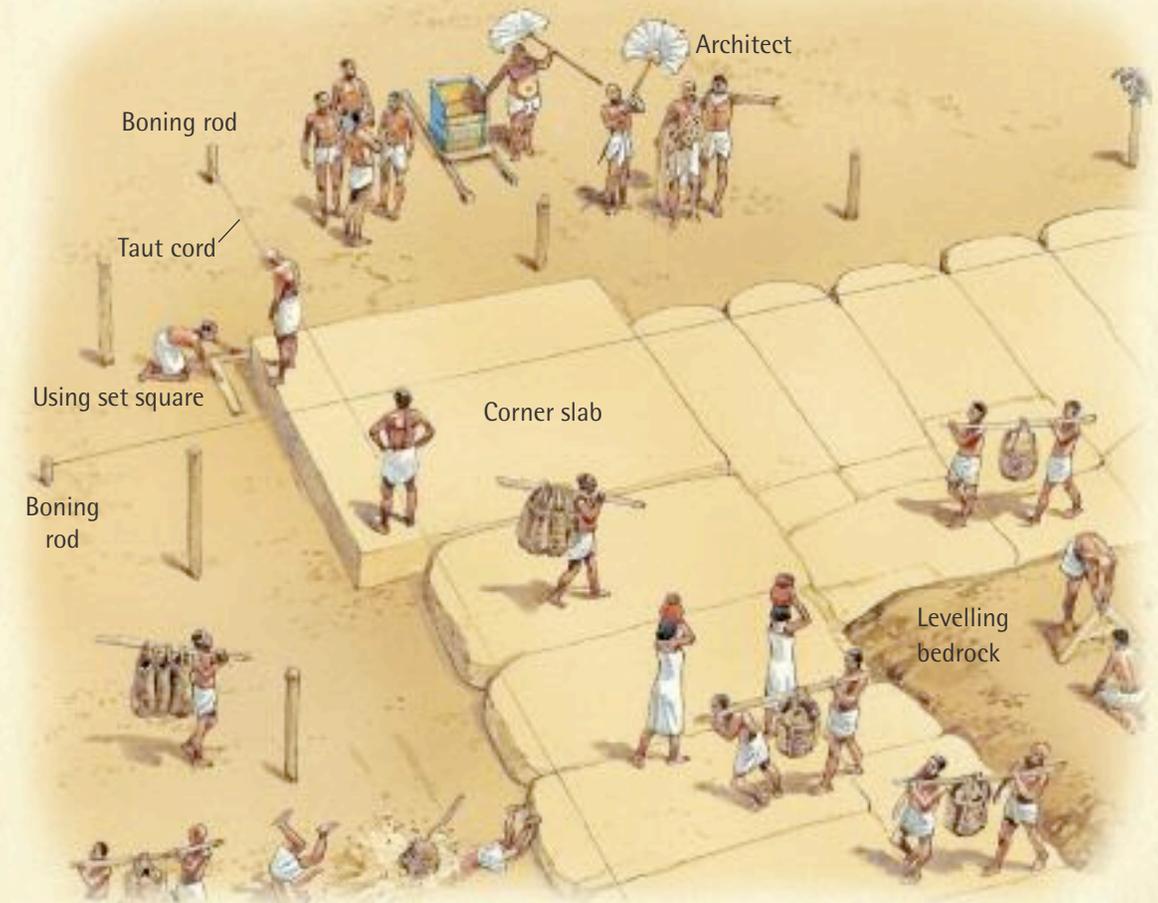
It is important to ensure that the first layer of slabs has an exactly horizontal upper surface. The accuracy of this can be checked by using boning rods. Rods of the same length are driven into the ground around the edges – already levelled – and linked by taut cords. The vertical distance between the cords and the surface of the slabs beneath should be the same. The outer rows should use the fine-quality Turah limestone (see page 26).

Using a combination of set squares and careful geometry, each of the all-important corner slabs should be positioned to form precise right angles. The other slabs are then levered carefully into place alongside one another. Regular checks must be made to ensure that the foundation platform forms an exact square.

PRECISION

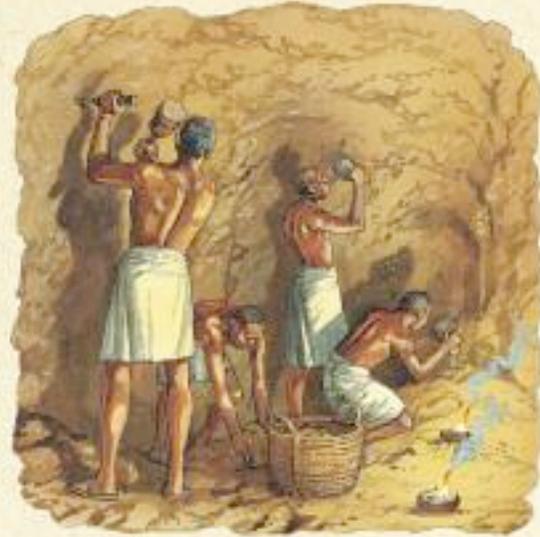
Besides its almost exact alignment with the compass points, the Great Pyramid of Khufu is amazingly accurate in other ways. Its base is level to within 2.1 cm and the greatest difference in the length of its sides is just 4.4 cm (each side measures 230.33 metres).

▼ The first level of stone slabs is being laid. Workers chip at the bedrock so that the next level of slabs can be laid exactly horizontally on top of the first.



BUILDING THE TOMB

While the ground is being levelled, workers can make a start on the burial chamber and the underground passage that will lead to it. Using their dolerite pounders, they smash their way through the bedrock to open up a gradually descending shaft. Men with chisels follow behind them, evening out the walls before finally smoothing their surfaces.



Meanwhile, a large hole is dug in the bedrock from above. This will form the burial chamber. A few metres below ground level, the passageway levels out and runs horizontally until it meets the chamber. The sarcophagus is too big to be hauled along the passageway, so it must be carefully

lowered into the chamber before the roof is put into position. Two rows of granite slabs are now fitted together to form a peaked shape (below). As the next levels of stone slabs are added to the pyramid base, the roof of the burial chamber will be gradually covered over.



▲ This is a cross-section through the pyramid as it will look when complete. The entrance is at ground level. The positioning of the blocks that make up the roof of the burial chamber form a peaked shape. This is designed to support the enormous weight of pyramid blocks above it.

► The roof of the burial chamber



▲ The sarcophagus is the outer stone coffin into which the wooden coffin is to be laid. This one is carved from pink granite.

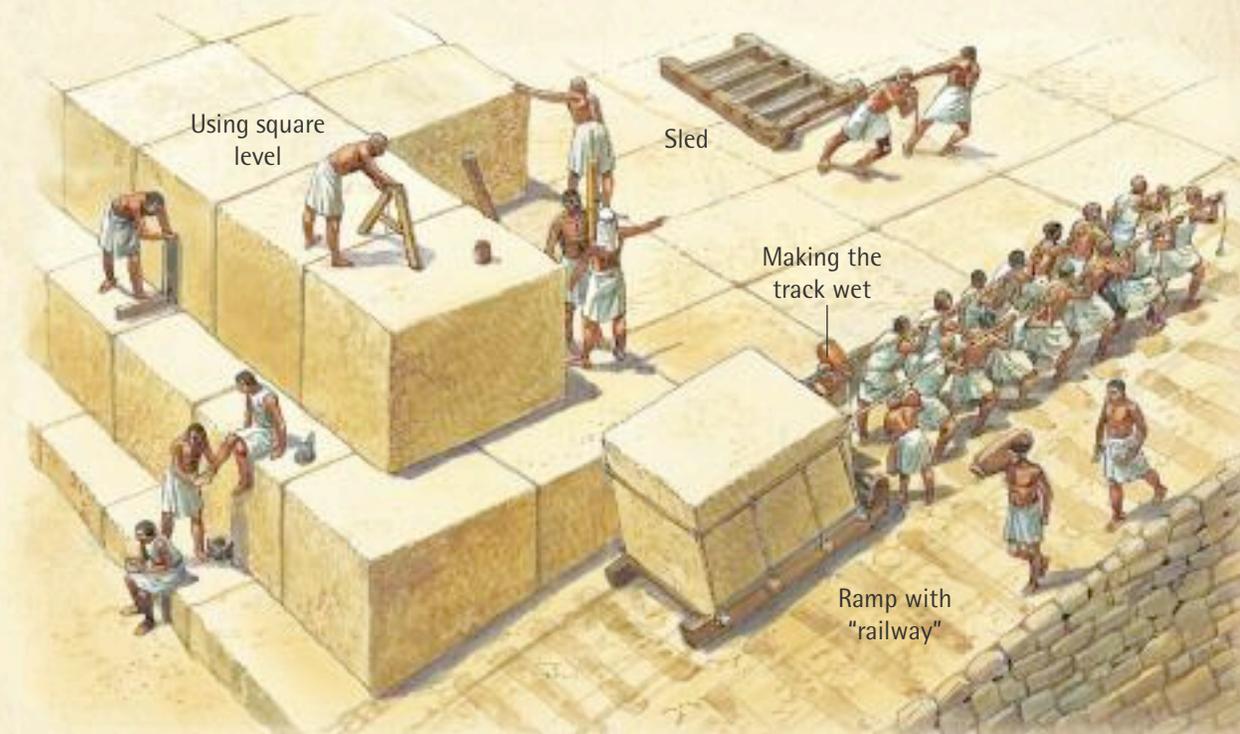
► Stonemasons toil in the shade, chipping away at the individual stones. Each block is carefully chiselled into shape and marked with a number to indicate its position in the pyramid structure.



FITTING THE BLOCKS

The area lying within the outer rim of casing stones is filled with blocks of lesser-quality stone quarried locally. But these, too, must be carefully chiselled so that their upper and lower surfaces are exactly horizontal. Now the blocks that will form the next layer are hauled to the site. The teams of workers drag the sleds, each with a block firmly attached, along a "railway" made of wooden boards embedded in the ground and coated with mud. Keeping the track constantly wet helps the sled to be dragged along much more easily. A ramp, built from close-packed rubble, allows the teams to haul blocks up to the higher level.

▼ Once the casing stone has been brought up to its allotted place, the side that will eventually form part of the sloping outer face of the pyramid is carefully marked with lines. These show the exact slope of the face. The stone is then levered snugly into position next to its neighbour.

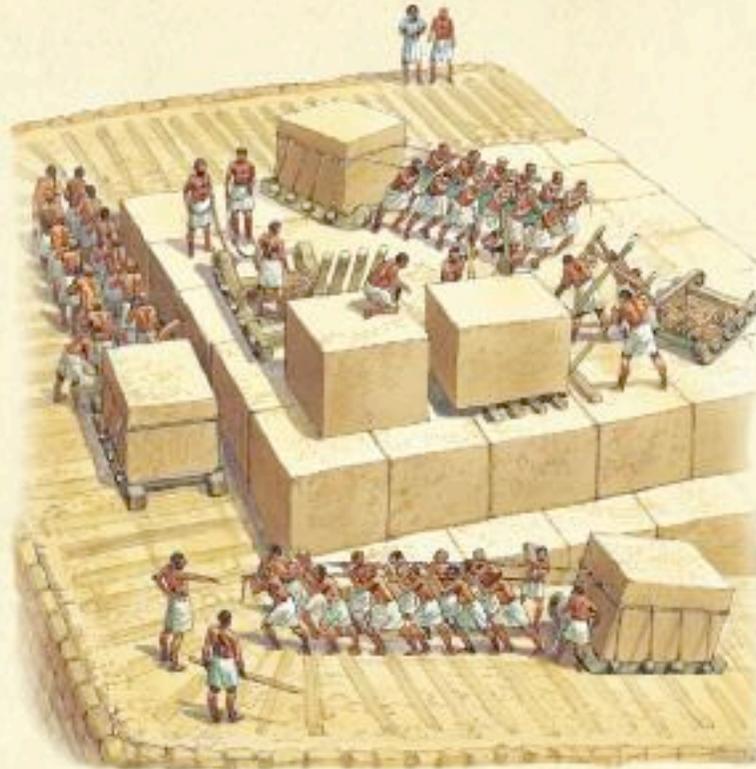


► The haulage team drag the sleds carrying the stone blocks on to the next level of the pyramid. The workers ease each block off its sled and on to wooden logs. They then roll the block into position, using heavy wooden posts as levers.

BOTTOM HEAVY

As the pyramid rises, each level can be added more quickly. This is because in a solid pyramid, about 70% of its total mass forms the lower third of the structure, and 25% its middle third. So just 5% of the stones used in its construction need be raised above the two-thirds mark.

▼ This is an aerial view of the pyramid approaching its full height. The spiral ramp, with two rising branches meeting at one corner, is built from rubble piled against the pyramid and held in place by an outer wall.



BUILDING UP

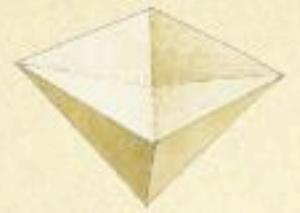
As the pyramid is built up higher and higher, the ramp used by the hauling teams must be built up with it. The ramp spirals up on all four sides, obscuring much of the outer faces of the pyramid.

Care must be taken to ensure that each level of stones is still exactly level, and that the angle of slope is precisely maintained. As with the stones on the lower courses, the slope is marked into the individual casing stones before they are put into position. As an extra precaution, the surveyors should use plumbines to ensure the faces are rising at the correct angle.

THE CAPSTONE

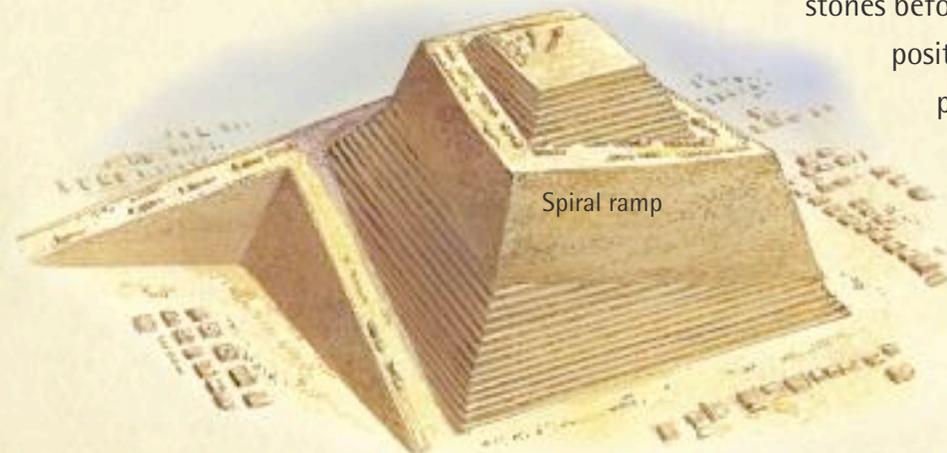
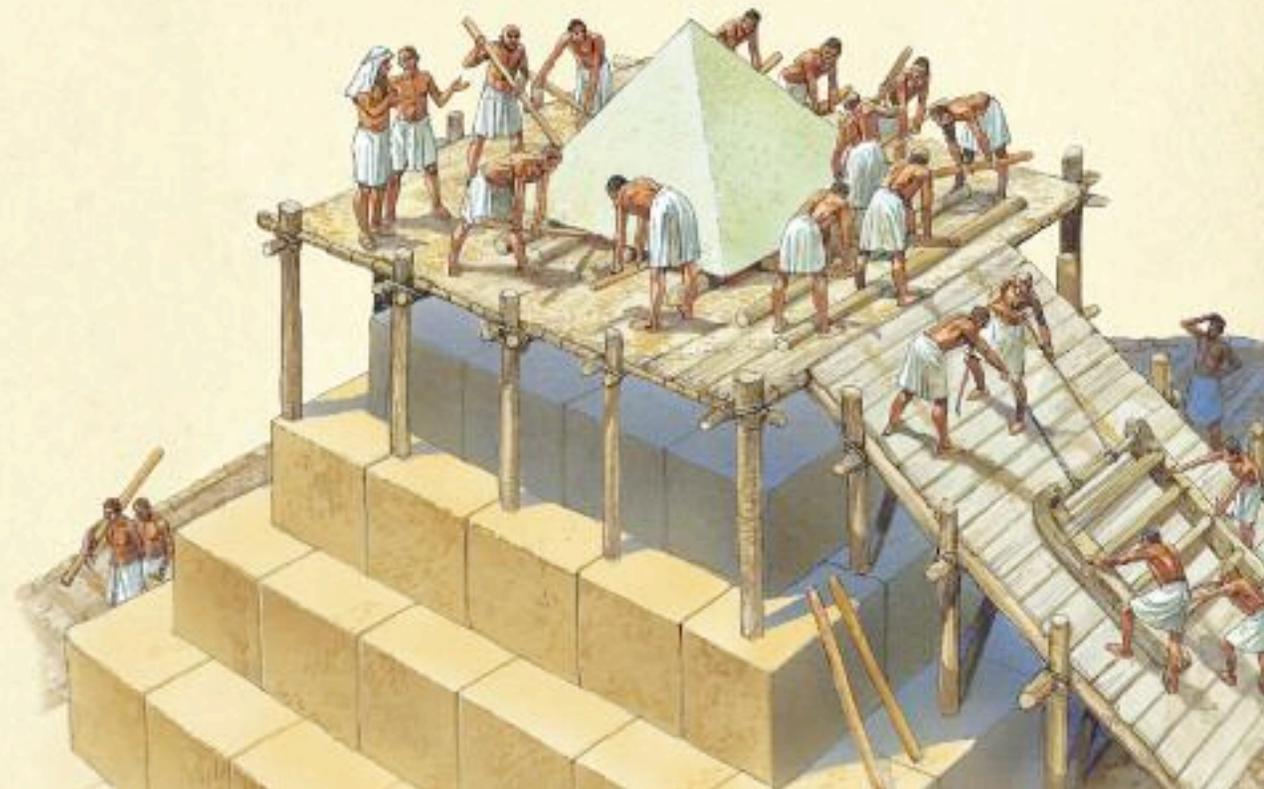
The layers of stone blocks have nearly reached the top. The challenge of keeping the angle of slope consistently the same and the dimensions of the faces exactly even becomes harder and harder – as does the physical task of raising and manoeuvring the blocks into position. If, despite all your checks for accuracy, the faces have obviously risen slightly out of line, it may necessary at this stage to adjust the positions of the stones. Using higher-quality stone for *all* the blocks at this higher level will give your masons more control in shaping the stones to improve their fit.

Soon the flat area at the top will measure just a few metres on each side. It is time to place the very highest block, the capstone – also known as the *pyramidion*, since it is itself shaped like a miniature pyramid. After a ceremony, the capstone is hauled up and levered into place by workers standing on scaffolding.



▲ The capstone may be carved from limestone, like the other blocks, or granite, a harder rock. Its base is given a concave shape: bulging outwards. The upper surface of the stone platform on which it is to be placed is carved to a matching concave shape. This ensures a snug, secure fit.

▼ After the capstone has been secured in place, workers cover it with a coating of gold.



A TIGHT FIT

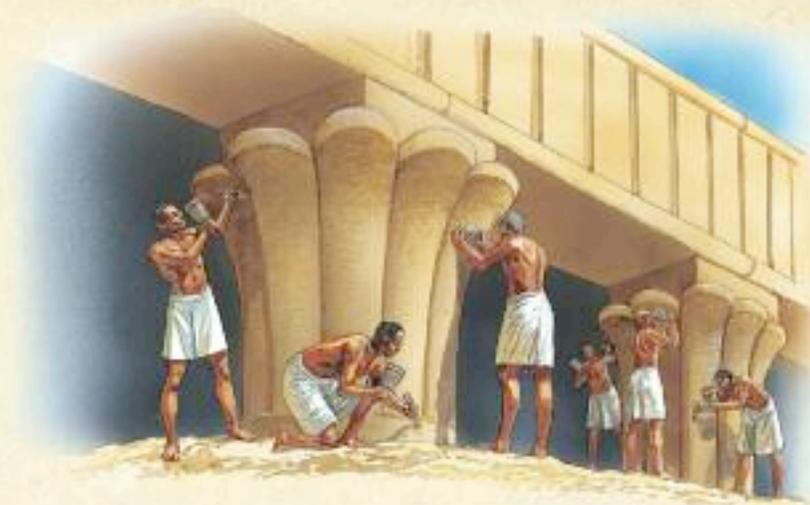
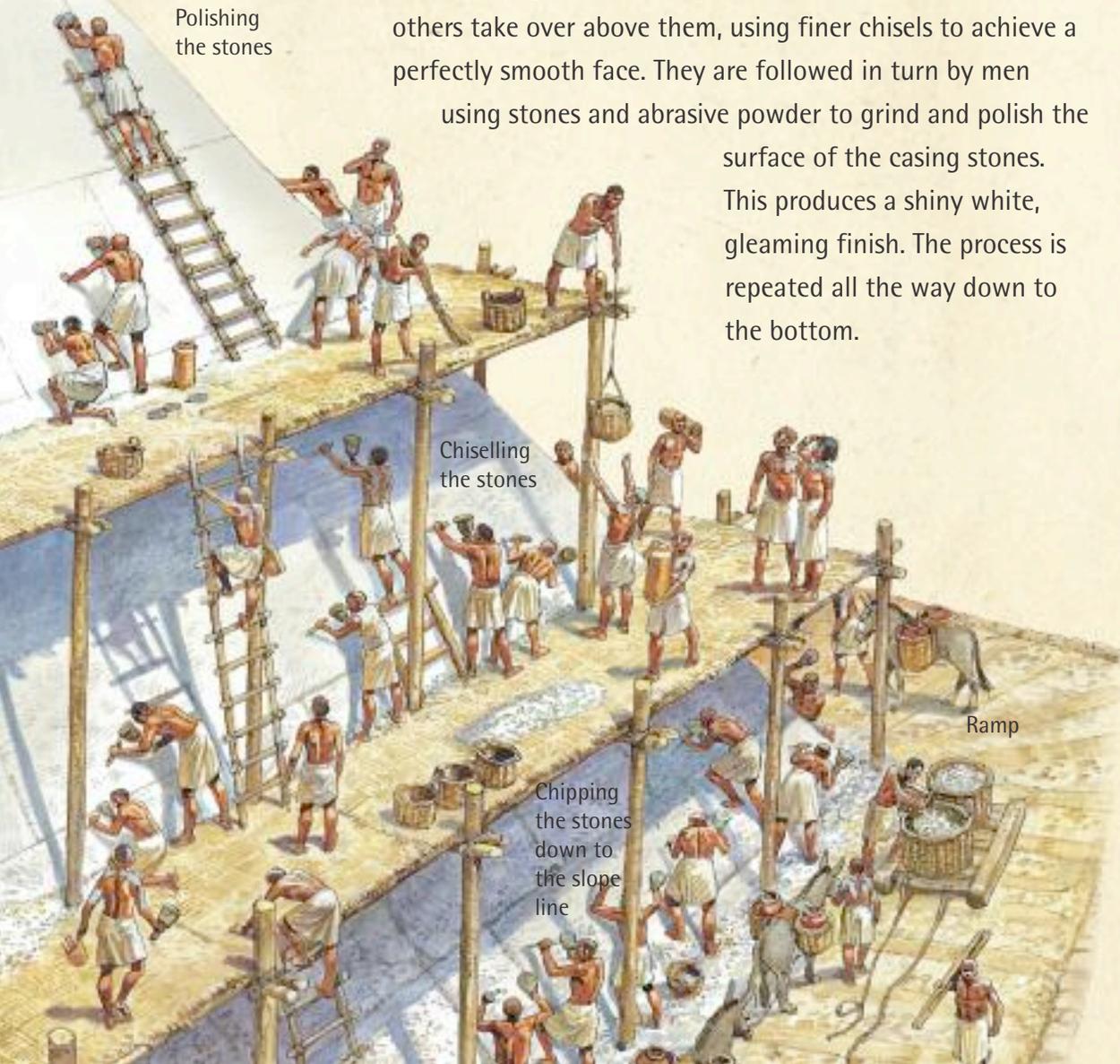
The casing stones of the Great Pyramid of Khufu were fitted so perfectly it is impossible even to get a knife blade between them. Over the years, most of the casing stones have been removed for use in other buildings. Some of the casing stone is left at the top of Khafre's Pyramid.

SMOOTHING THE SIDES

With the capstone in place, the rough structure of the pyramid is now complete. Each of its faces is made up of a number of steps and work must now begin to shave away the edges of these steps to produce the smooth-sided pyramid.

Workers start to dismantle the ramps from the top downwards. After 10 metres or so of rubble has been removed, scaffolding is erected and the chiselmens get to work. They chip away at the casing stones down to the slope lines (see page 33). As they work their way down the sides, others take over above them, using finer chisels to achieve a perfectly smooth face. They are followed in turn by men using stones and abrasive powder to grind and polish the surface of the casing stones.

This produces a shiny white, gleaming finish. The process is repeated all the way down to the bottom.

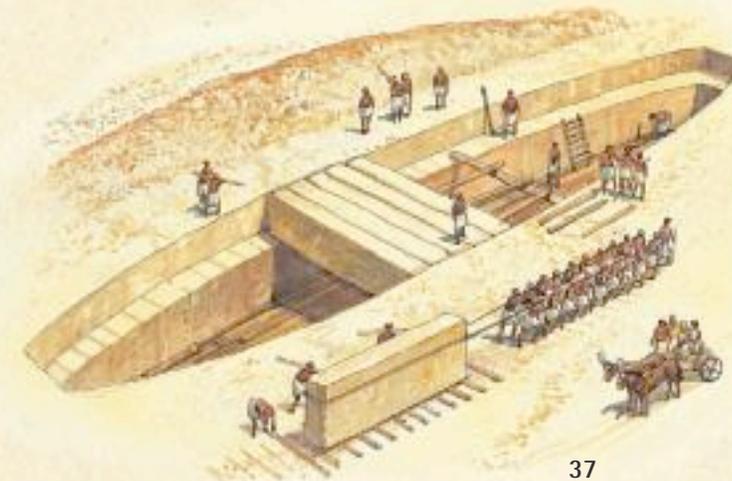


◀ The tops of the temple columns are carved by skilled masons to represent lotus buds, papyrus reeds or palm leaves. They will later be painted. As the rubble is removed, the masons work their way down the columns.

FINISHING TOUCHES

While the pyramid is being completed, work begins on the temples and causeway. As the walls go up, a ramp of rubble is built up inside them, allowing the various stone blocks to be hauled up into position, in exactly the same way as the pyramid was built. When the walls and roof are complete, masons use the rubble as a platform for carving fine details at the tops of the columns (above).

The pharaoh will need boats to carry him to the heavens in the Afterlife to be buried close by his pyramid. The workers dig two long, boat-shaped pits in the ground, place the parts of a funeral boat carefully inside each one and lay a series of limestone beams to cover them over.



▼ Several statues carved in the likeness of the pharaoh are completed by sculptors and placed in both the mortuary and valley temples.



BOAT KIT

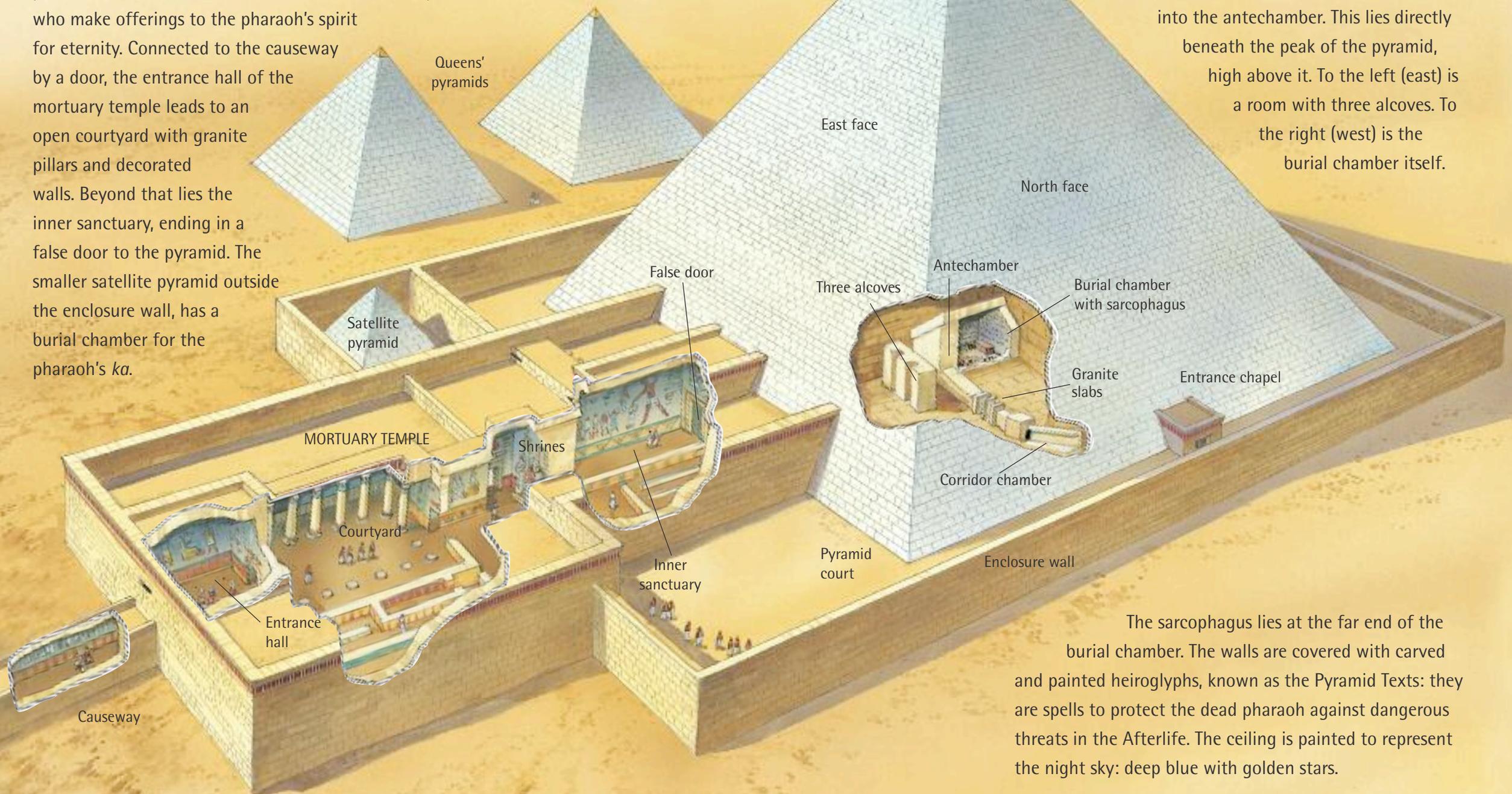
A boat pit at the Great Pyramid of Khufu contained 1224 separate parts, each made of cedarwood. They formed a kit from which a real boat could be made. The parts included holes so that the boat could be stitched together with cords made of vegetable fibres.

THE PYRAMID COMPLETE

The pyramid complex is now complete. This illustration shows the interior of the mortuary temple, the causeway and the pyramid itself.

The mortuary temple is built against the eastern face of the pyramid. Here, daily rituals are to be carried out by priests, who make offerings to the pharaoh's spirit for eternity. Connected to the causeway by a door, the entrance hall of the mortuary temple leads to an open courtyard with granite pillars and decorated walls. Beyond that lies the inner sanctuary, ending in a false door to the pyramid. The smaller satellite pyramid outside the enclosure wall, has a burial chamber for the pharaoh's *ka*.

▼ Lying outside the enclosure wall are boat pits, mastaba cemeteries, where the pharaoh's relatives and officials are buried (not shown here) and the Queens' pyramids. These are where the pharaoh's mother and queen are entombed.

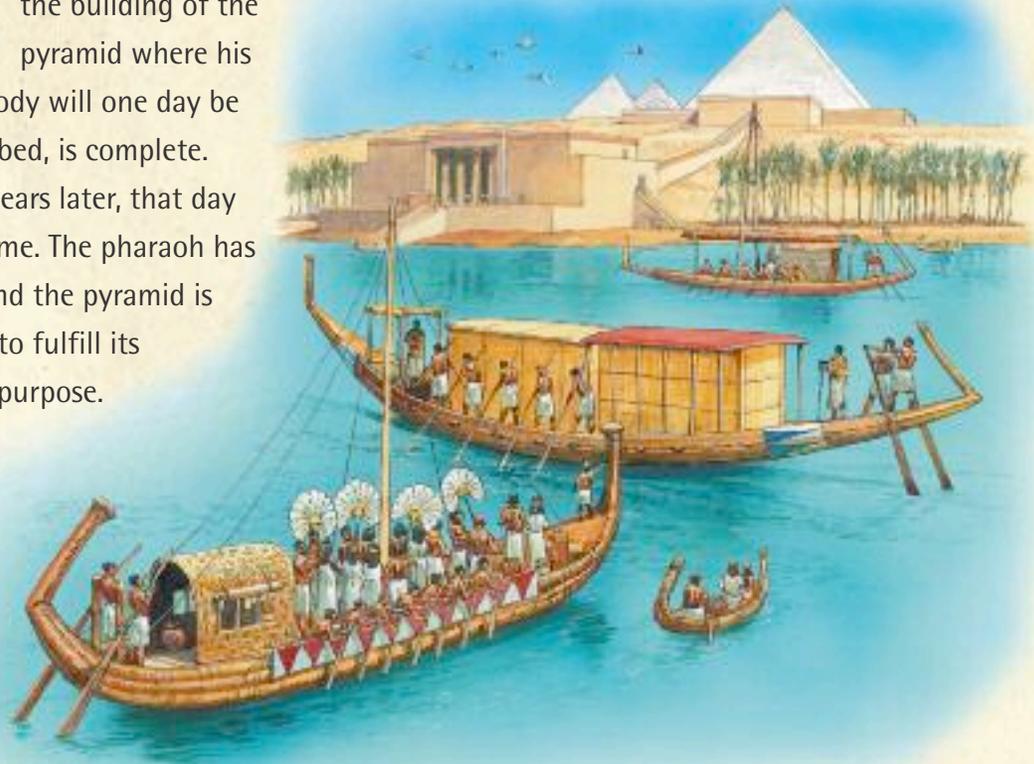


The tomb itself lies below ground level at the centre of the pyramid. From the small entrance chapel in the north face, a passage slopes down to a corridor chamber. This connects to a horizontal passage, sealed by three granite slabs. Beyond the slabs, the passage opens into the antechamber. This lies directly beneath the peak of the pyramid, high above it. To the left (east) is a room with three alcoves. To the right (west) is the burial chamber itself.

The sarcophagus lies at the far end of the burial chamber. The walls are covered with carved and painted hieroglyphs, known as the Pyramid Texts: they are spells to protect the dead pharaoh against dangerous threats in the Afterlife. The ceiling is painted to represent the night sky: deep blue with golden stars.

THE FUNERAL OF A PHARAOH

The pharaoh's life work, the building of the pyramid where his own body will one day be entombed, is complete. Now, years later, that day has come. The pharaoh has died and the pyramid is about to fulfill its grand purpose.



▲ The pharaoh's coffin is taken by a barge on its short journey from the royal palace in Memphis along the Nile to his pyramid. His *ka* statue, the Chief Embalmer, priests, mourners (known as Kites), and other members of his family travel with him. As the boats sail along the river, the Lector Priest reads from a scroll of "magical utterances". The barge bearing the pharaoh's coffin docks at the pyramid harbour.

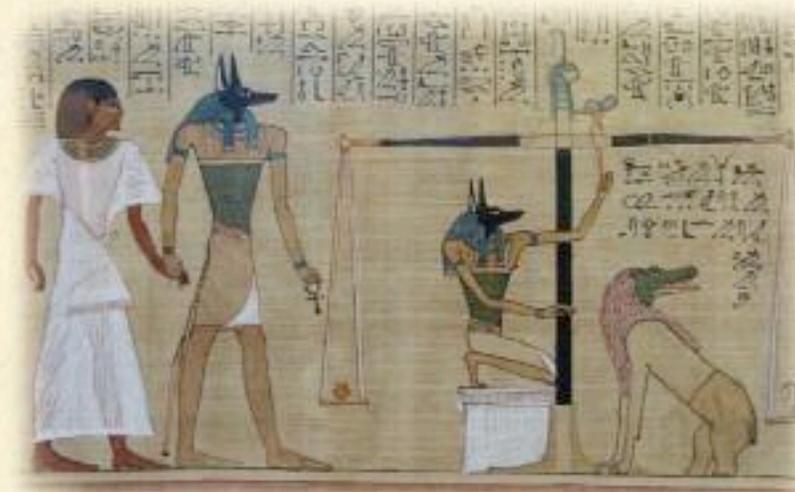
On the death of the pharaoh, the plans for his funeral are put into action. His body arrives by boat and is taken inside the valley temple where it is prepared for burial. This process will take 70 days to complete. The coffin is then mounted on a sledge, which is pulled by oxen up the causeway. It is accompanied by a procession of priests, mourners and men bearing the goods and treasures that will be buried with him. After rituals have taken place inside the mortuary temple (see page 44), priests carry the coffin down the passageway beneath the pyramid to the tomb. After one final ceremony, the coffin is lowered carefully into the sarcophagus. The priests then leave the tomb. Granite slabs are lowered behind them, sealing off the tomb, the priests hope, forever.

5. THE AFTERLIFE

THE ANCIENT EGYPTIANS believe in the Afterlife, a place where they would go to when they died. This is the kingdom of Osiris, god of the dead.

To be reborn in the Afterlife requires much preparation, in particular, finding a way to protect their dead bodies in some way. The wealthy can afford to have a tomb built and their body preserved. The less well-off are simply buried in pits in the sand. All Egyptians, however, agree on the necessity to ensure that their king, the pharaoh, completes a successful journey to the Afterlife. To them, the very survival of their land depends on it.

To the ancient Egyptians, a person's soul is made up of two important parts, known as the *ka* and the *ba*. The *ka* is a person's essential "life force" which needs food and drink to survive. On death, it departs the body. The *ba* can be described as a person's "personality". The *ba* must seek out the *ka*, for if a person is to be reborn in the Afterlife, the two parts of their soul must be reunited. If they do so, a third state of being is achieved: the *akh*, a "spirit". But for the *ka* to perform its crucial role, the body must not be allowed to decay: hence the vital importance of mummification.



THE SOUL



▲ The *ka*, the life force, is represented by upraised arms. The pharaoh is thought of as the *ka* of his people.



▲ The *ba*, someone's personality, is shown by a bird with a human head. The pharaoh's *ba* is his great power.



▲ The *akh*, the spirit, is shown as a crested ibis. The pharaoh, with his *ka* and *ba* reunited, would take his position as a star in the night sky, as a shining spirit.

◀ The god Anubis balances a person's heart against the feather of *ma'at*, truth. If he lived a good life, the heart would be light and he would pass to the Afterlife. If the heart was heavy with sin, it would be devoured by the crocodile-headed Ammut.

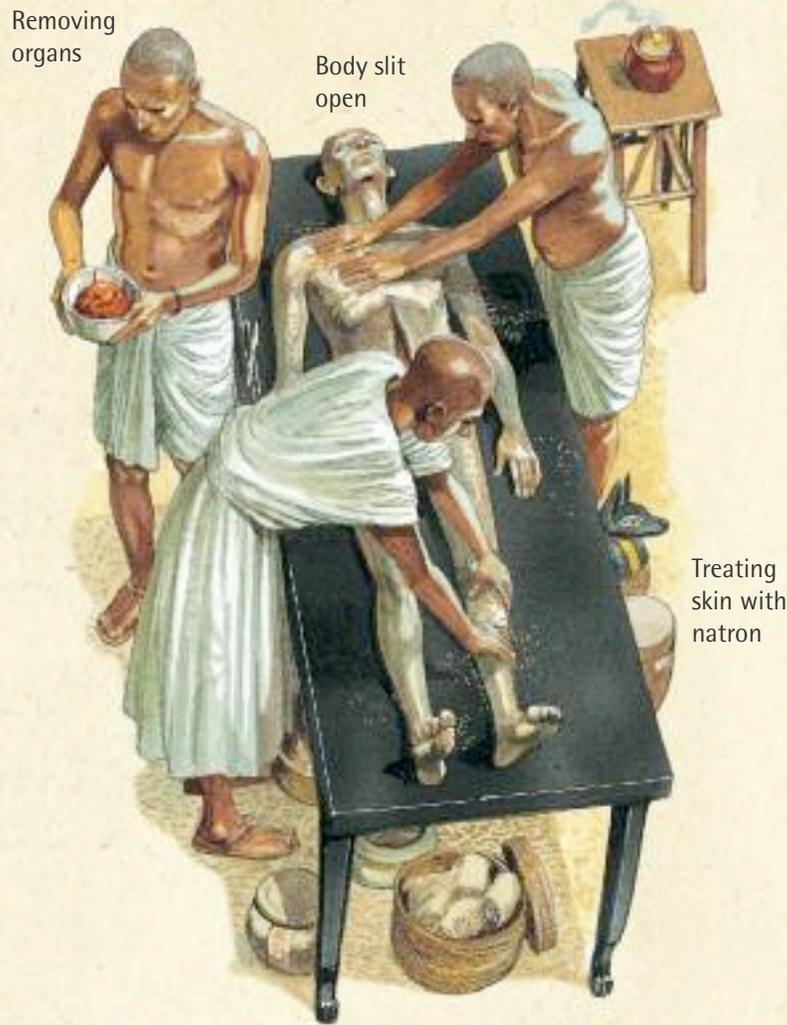
► Great care is taken by the embalmers to preserve the natural appearance of the body as much as possible.

KING TUT

Tutankhamun, whose likeness we know from this gold mask found on his mummy, is called the Boy King.



His mummy bandages contained 150 jewels and amulets (*below*). Each had its own special place on the body. The vulture amulets placed on the neck were exclusive to kings alone.



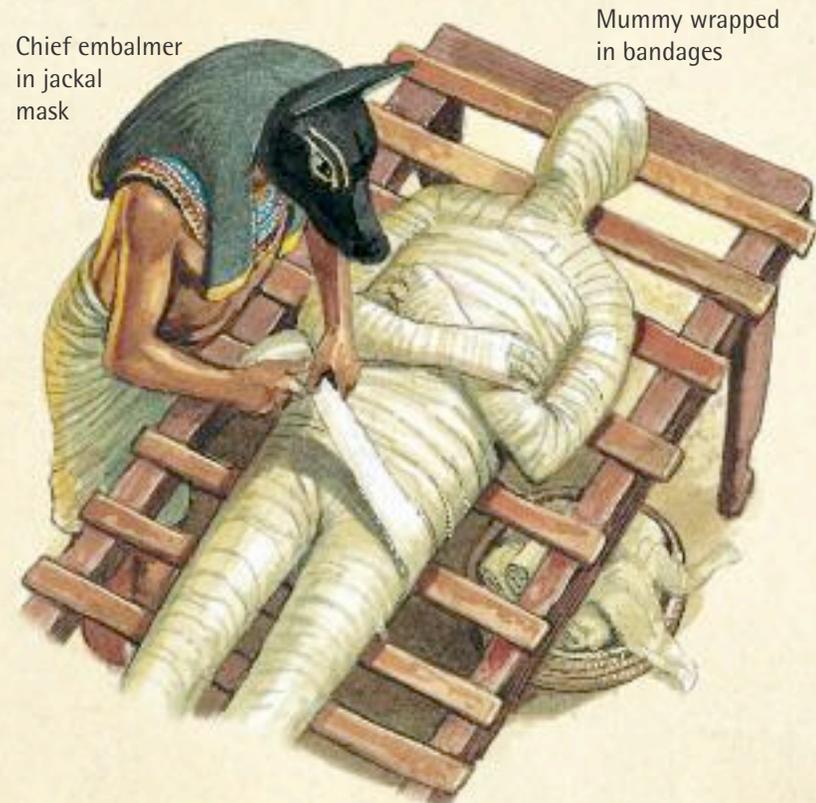
MUMMIES

For the pharaoh to be reborn in the Afterlife, his body must be must not be allowed to rot away. The way to avoid this is by embalming or mummifying it. The process takes 70 days. First of all, the team of embalmers remove the brain, pulling it carefully out through the nostrils using an iron hook. Then the embalmers make a cut in the side of the body and take out the liver, lungs, stomach and intestines. The body is dried out in a salt called natron. This takes 35-40 days. After being washed, resin-soaked linen and fragrant spices are packed inside the body. The embalmers then treat the outside of the body with resin.

The body is now wrapped in layers of linen bandages. Fingers, toes, arms and legs are wrapped separately before being bound together. The bandages are soaked in resin so that the body holds its shape. They are also covered with oils and perfumes. Charms — jewels and amulets — are placed between the layers of bandages. These are to help protect the pharaoh in the Afterlife. Finally, a mask is placed over the mummy's head, a ritual undertaken by the chief embalmer who wears the jackal mask of the embalming god Anubis. He says prayers over the completed mummy. Now it is ready to be placed in a wooden coffin.



◀ After the organs have been removed from the pharaoh's body, they are covered in natron to dry them out, then treated in resin and placed in canopic jars. Each has a different container in the form of one of the four sons of the god Horus. Hapy, a baboon (1) protects the lungs; Qebhsenuief, a falcon (2) the intestines; Duamutef, a jackal (3) the stomach; (4) Imsety, a human (4) the liver.



PHARAOH'S HEART

During embalming, the pharaoh's heart was the one organ to be left inside his body. This is because it would be needed for the god Anubis to weigh it against the feather of *ma'at* as part of the judgement process.

WHY "MUMMY"?

The word "mummy" comes from the arabic *mumiya*, meaning pitch or bitumen. Over time, the resins, oils and perfumes used to soak the bandages became black and sticky, resembling pitch.

BEN-BEN

The pyramids themselves may have been designed to represent the *ben-ben*, the mound that appeared out of chaos from which the first gods created the world. In fact, the *ben-ben* may itself have been a symbol for rays of the sun bursting through the clouds. So building the pyramids may have been the Egyptians' way of ensuring that the creation would never come to an end – that their great civilization would live forever.

OPENING OF THE MOUTH CEREMONY

Ceremony and ritual are important features of a pharaoh's funeral. The Opening of the Mouth ceremony takes place after the mummification process has been completed. While one priest, dressed as the jackal-headed god Anubis, holds the mummy upright, another priest holds out an adze, a kind of hand tool. He touches the hands, feet, eyes, ears, nose and mouth. By so doing, the priest enables the dead pharaoh to breathe, eat and speak in the Afterlife. Then the pharaoh's mummified body is taken to its final resting place in the burial chamber below his pyramid. Buried alongside him are food, drink and other necessities he will need in the Afterlife.



◀ The pharaoh's mummified body is placed inside a wooden coffin, one of several, each placed inside the other and each with ornate lids. After having been carried to the burial chamber, the outer coffin is then lowered carefully into the sarcophagus and a lid laid on top of it.

KEEPING THE LIFE FORCE ALIVE

Ceremonies will continue at the pyramid for centuries to come, to keep the pharaoh's life force, his *ka*, forever "alive". Every day, priests will lead a procession to the mortuary temple of the pyramid. Here they will make offerings of food and drink before the royal statues and at the false door. Some priests will offer loaves of bread, bowls of wine, milk or water, and various fruits and vegetables on an altar in front of the stela (gravestone). Others offer meat and bowls of blood from slaughtered bulls.



◀ The mortuary temple of the pyramid

THE GIFT OF LIFE



▲ The ankh is a kind of cross. It is the ancient Egyptian symbol for the "key of eternal life". The ankh appears frequently in tomb paintings and temple reliefs, often being held by gods and goddesses. They are shown making the gift of life to pharaoh, meaning that he will live on in the Afterlife.

GLOSSARY

Adze A tool with a blade set at right angles to the handle. A ceremonial adze was used in the "opening of the mouth"

Afterlife Life after death.

Akh To the ancient Egyptians, the soul of a dead person that has been reborn in the Afterlife. The word means "shining spirit".

Amulet An object intended to bring good luck and protection to its owner. These were usually made from precious stones and metals, such as gold or silver.



Architect Someone who designs buildings.

Ba An ancient Egyptian word for someone's personality. The ba had the ability to eat, drink and travel in the Afterlife. But it could not function

Canopic jar A decorated container in which the organs removed from a dead body were stored before mummification took place.

Capstone The pyramid-shaped stone at the very top of the pyramid.

Casing stones The outer layer of a pyramid, usually made from fine limestone. The casing stones were smoothed, polished and painted.

Causeway The covered way that led from a pyramid's valley temple to another temple next to the pyramid itself. The inside walls were often highly decorated.

Civilization A people who have developed laws, trade, arts, monuments and other aspects of a settled way of life.

Conscripts People who are forced to work by the authorities.

Crook A shepherd's curved staff, which was a symbol of a pharaoh's kingship.

Demotic The normal, everyday writing used by the Egyptians in the later years of their civilization.

Dolerite A hard, volcanic rock.

Dynasty A series of rulers in the same family who keep power for generations.

Embalm To preserve a dead body from decay.

Flail A farming tool, and a symbol of a pharaoh's kingship.



Flax A plant with blue flowers, used to make cloth. The fibres from its stem are spun to make linen, which can then be woven.

Hieratic The normal, everyday form of writing used by ancient Egyptians.

Hieroglyphs A form of writing, using signs resembling pictures, on walls and monuments.

Incense A material that gives off fragrant fumes when burnt. It is used on ceremonial occasions.

Irrigation The channelling of water to help with the growing of crops in dry areas.

Ka To the ancient Egyptians, a person's life force or "double". When kept alive by food offerings, it ensured a person would be reborn into the Afterlife.

Magazines Storage rooms.

Mummification The process of embalming—and so preserving—a body, by removing the organs, drying it out, then wrapping it in linen bandages. The word "mummy" comes from the Arabic word *mumiya*, meaning pitch. A mummified body's blackened appearance resembled the colour of pitch.

Next World The place a person's soul went after death.

Opening of the Mouth A ceremony taking place just before a mummy was placed in its coffin. Its purpose was to give back to the dead pharaoh the ability to breathe, speak and eat in the Afterlife.

Pharaoh Another name for the kings of ancient Egypt.

Plumb bob A heavy weight hung on a string to show an exactly vertical line.

Portico An entrance hall with columns.

Pyramid A massive stepped or pointed structure containing a pharaoh's tomb.

Pyramidion Another word for capstone.



Regalia Objects possessed by a ruler that show off his authority.

Resin A sticky substance that comes from the sap of trees and is used for embalming.

Sarcophagus The outer stone coffin in which a wooden coffin was laid.

Stela A slab or stone with inscriptions carved on it.

Tomb A burial place

Vizier An advisor to the pharaoh.

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