### ANCIENT EGYPTIAN ASTRONOMY

Gerald O. Dobek 16752 Wrightwood Terrace Drive Traverse City, Michigan USA 49686 jdobek@nmc.edu

#### ABSTRACT

The ancient Egyptians masterfully constructed a vast array of monuments and temples along a 1,300 km stretch of the Nile River in Egypt. These temples are thought to be the final resting places for the Great Kings that ruled Egypt beginning over 5,000 years ago. Some researchers have said that these temples point to specific celestial objects. Others are believed to be aligned with the Sun's rising or setting. Many of the pyramids and other temples are aligned with the cardinal axial points of the Earth. The reasons for these alignments are thought to be an early understanding of astronomy. Speculations on the solar alignments of passageways and the stellar alignments of pyramids are written in recent books and presented in numerous television shows. What we have learned of the ancient Egyptians come to us in the form of hieroglyphics; picture writings. These hieroglyphics tell us that the ancient Egyptians never really understood astronomy, at least in the form that we associate with other ancient cultures. What these temples were meant for are recorded in the Pyramid Texts. What the ancient Egyptians saw as their astronomy was purely religious. But for ancient Egyptian astronomers, it was astronomy.

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## 1. INTRODUCTION

For the purpose of this presentation, it is important to establish some definitions to terms. In doing so, Ancient Egyptian shall refer to that time period from 3000 B.C. to 1 A.D., and be confined to the area along the Nile River in Egypt. The term "astronomy" needs a more thorough definition. According to Webster's Dictionary, astronomy is defined as "the science that studies stars, planets, and other bodies in space and the phenomena that involve them" (Bailey 1997). In the text Manual of Astronomy, Charles A. Young defined astronomy as "the science which treats of the heavenly bodies, as is indicated by the derivation of its name" (1902). One can clearly see where the definition of astronomy has changed over time. Since the beginning of the twentieth century astronomy has been a physical science. The physics is concerned with the structure of stars, their formation and evolution, black holes and quasars. In the period from the renaissance to the twentieth century, astronomy was an age of discovery. The advent of the telescope allowed astronomers to view fainter stars, discover new planets and moons, and catalog nebulae in searching for comets. From the time of the early Greeks and Ptolemy until Galileo, astronomy was an era of scientific understanding. Observations of the motions of planets, the constellations and their mythology, and predictions of eclipses helped to formulate vast catalogs of information. For the period of this paper, astronomy was nothing more than social and cultural; the establishment of a calendar and mystic wonder associated with

deities. There is no evidence that the Egyptians understood the motions of stars as we do today. Even the movements of planets are not recorded as any scientific event. Let us then treat astronomy in ancient Egypt as the study of celestial bodies above the Earth.



Map of Egypt.

## 1.1. IN THE BEGINNING

It is often mistaken that Egyptians were highly advanced at engineering and mathematics. We will explore these areas later. What we know of ancient Egyptians comes from written texts. Not text in the form of paper, but rather stone carvings referred to as hieroglyphics. Papyrus manuscripts were found near the city of Thebes and are dated around 1200 B.C. Jean-Francois Champollion finally broke the hieroglyphic code in 1822 (Harvey 2000). From hieroglyphic inscriptions, dating back to around 3200 B.C., the Egyptians believed that the world took on a form of a rectangular box, with the long sides running north and south. There is a flat ceiling, supported by four pillars at the cardinal points, and the pillars are connected by a mountain chain, below which runs a ledge carrying the celestial river Ur-nes. Along this river, boats sail carrying the Sun, Moon and other gods. When a corner is reached, the boat makes a right-angle turn, then heads in the next direction. The Egyptians claimed that the goddess Nut formed the heavens. Her body held the objects of the sky, bent over backwards with her hands and feet as the four pillars. Egypt lay in the centre of the flat Earth, called Geb, and rested below Nut. Geb was surrounded on all sides by a vast body of water (Moore 1983).



Egyptian goddess Nut arched over the god Geb.

In an attempt to understand the great mysteries of life and death, what could not be explained by direct observation and reasoning was left to the "gods". The Egyptians believed that certain gods ruled life, death, the Sun, Moon, planets, stars, and everything that occurred on Earth. The ancient Egyptian's life was centered on surviving and service to the Pharaohs. Egyptians worshiped a pantheon of gods and goddesses; some universal, and others local. Their belief in the afterlife pervaded religion, and gods took the form of humans and animals (Strouhal 1992). Along the 1,300 km Nile River in Egypt, this civilization was so taken with the sky that imprints of astronomical objects or gods of such remain imbedded in stone after 5,000 years. To the Egyptians, the sky was rich in metaphor. Its patterns of life, growth, death, and even rebirth were stenciled onto the Earth. The cycles of human life resonated with the sky (Krupp 2000).

## 2. EGYPTIAN LIFE

To have a greater understanding of ancient Egyptian astronomy, we must first look at what ancient Egyptian life was like. This period in ancient Egypt is often referred to as the pharaonic civilization. By divine right, monarchs ruled the land. This land was divide into two parts, Upper Egypt and Lower Egypt. These divine monarchs, called pharaohs, ruled everything. They also owned everything; the land and all that was in it. During the period around 3000 B.C. the Egyptians could be considered as hunters and gatherers, but they were also agricultural. Their mainstay was bread and beer. Meat was scarce and often reserved for the higher monarchs. The Egyptians grew wheat and barley along the banks of the Nile River. Wheat was ground and baked into bread, and barley was brewed into beer. It is unknown if this beer had any alcohol content. They also drank wine, but again this was saved for the rulers of the land. Since the land belonged to the pharaohs, all the food grown on the land belonged to him as well. To eat, the common peasants had to do service to the pharaoh. This was considered a fair exchange. This exchange of work for food is probably how the great monuments were built. Not by slaves, as is often depicted in movies. The wheat and barley that was grown along the Nile River could only be planted after the waters receded. Each year, the Nile River would rise and flood the banks along its sides. With this flooding came the rich silt soil that would be deposited and left after the waters receded. The flooding was referred to as Inundation and began every year around mid-July and lasted until mid-November. The receding waters left rich soil to plant in. This period was called Emergence and lasted from mid-November until mid-March. It was during this time that they worked the fields. The last period, or season as we call it, is from mid-March until mid-July and is called Summer or Dryness. It marks the end of the harvest and is the period when the Nile River is at its lowest. It was during the Inundation period that the ancient Egyptians served their pharaohs and honored them by building great temples and monuments (Strouhal 1992).



The Nile River from the Space Shuttle.

# 2.1. ASTRONOMY IN ANCIENT EGYPTIAN LIFE

Because of the bounty gained in the harvest, the Nile River was thought to have life-giving

powers. Since the Egyptians were not able to explain why the Nile River rose each year around the same time, they choose to proclaim that the gods commanded it to occur. In that the pharaohs ruled this land, the pharaoh was thought to be god-like. The ancient Egyptians had a god for everything that could not be explained. Astronomical implications began to appear in ancient Egyptian life with the naming of gods for particular objects seen in the skies. Events that could not be fully understood were thought to be the results of divine interventions. The Sun was born in the east and died in the west (Strouhal 1992). The god who ruled the Sun was called Re. Re took on many forms. The god Horus, a falcon-headed deity, ruled the sky. Re is often depicted as the eye of Horus (Stardate 1998). The image below is a depiction of Re and Horus.



Egyptian god Re above the head of Horus

The mystery of life was followed by the mystery of death. It was thought that when life ended, the soul would continue into the afterlife. The god who ruled this afterlife was called Osiris. Ancient Egyptians saw the constellation Orion and associate this with the heavenly image of Osiris (Stardate 1998).



#### The god Osiris.

The image above illustrates the god of the "Underworld" Osiris. When the pharaohs died, a grand funeral was performed to honor the Great King. His body was mummified in a ritual that lasted 70 days (Strouhal 1992). This designated length of time has a direct association with astronomy, and will be illustrated in the sections to follow. The mummy was then placed inside a tomb where the god Osiris would ferry the dead pharaoh on to the afterworld. A son or other sibling of the deceased pharaoh would then take over ruling the land. This culture continued for more than 3,000 years. Their religion was steeped in mystic gods and traditional rituals (Krupp 1979). It is clear to see that the ancient Egyptians had a very religious culture. The astronomy that they used in their lifestyle was focused on their funeral rituals.

## 2.2. THE PYRAMID TEXTS

Hieroglyphics and paintings covered the walls of pyramids and temple monuments. But the walls of the burial chambers of the pharaohs remained barren. That was until the pharaoh Unas, of the Fifth Dynasty. Around his black sarcophagus are white slabs incised and painted to resemble a divine purification tent. The gabled ceiling was painted a deep blue and decorated with golden stars. Intricately carved all around this were hieroglyphics; words of the oldest religious literature in the world. These "words" are called the Pyramid Texts. They tell us of spells and rituals that are drawn from a body of sacred knowledge. These Pyramid Texts chart the journey of the pharaoh into the afterlife. The five pyramids containing these hieroglyphic inscriptions are located near Saqqara, Egypt. In these Pyramid Texts are sacred literature referred to as "books" containing instructions for everything from birth rites of Kings, to death and burial rituals (Harvey 2000). It is from the Pyramid Texts that we have knowledge of astronomical influences in ancient Egypt. These are the written records.

### 3. MATHEMATICS IN ANCIENT EGYPT

Whether astronomy in ancient Egypt need be mathematical or scientific hardly matters. Astronomy was deep in Egyptian culture. But mathematics was dealt with in a simpler fashion. This is understandable, given that it was not necessary to sustain everyday life. But what the ancient Egyptians lacked in qualitative mathematics, they more than made up for in the use of astronomy. The greatest contribution from this is the calendar we use today, and the formation of a 24-hour solar period. The ancient Egyptian astronomers were timekeepers.

#### **3.1. SIMPLE NUMBERS AND OPERATIONS**

As far as an advanced mathematical society, the ancient Egyptians were not one to example. Their numbers were very simple and basic. A single line represented the number 1, and multiples of lines represented the numbers 2 through 9. The number 10 was represented by a hobble for cattle. They used multiples of tens to represent those factors. The number 100 was a coil of rope, again with multiples of those factors. A lotus represented 1,000. A single curved finger for 10,000 and a tadpole for 100,000. In early use, was a seated god with his arms raised to represent 1,000,000. For other than multiples, the images would be combined to form the necessary number. As an example, the number 1,243 would be represented by one lotus, followed by two coils of rope, then four hobbles, and lastly three lines. This is read left to right beginning with the largest number. Where the numbers are vertical, the largest number was above. Their mathematics was centered on addition. It followed a base ten rule, that being the easiest to use (Gillings 1972).



#### Egyptian hieroglyphic numbers.

In reference to the close symmetry of the pyramids, there is no documentation to prove that the ancient Egyptians knew about right triangles. The theory that they laid-out the pyramids according to the Pythagorean theorem, using a rope with knots tied at lengths 3, 4, 5, is unfounded (Gillings 1972). Clearly, the ancient Egyptian had no need for an advanced mathematical system. Their society was not an investigative one. What they really needed was a calendar. A method of knowing when the Nile River would flood and recede.

## 3.2. A CALENDAR FOR THE SEASONS

The Nile River flooded each year at nearly the same time, around July 19th. Each flooding began after a period of about 365 solar risings, or days. Since there were three cyclical periods of the Nile, the Egyptians held to a three-season year. Each season was four months long, and contained three 10-day weeks called "decades". This accounted for 360 days of the year. The remaining five days were called "epagomenal" days, and were added to the end prior to the rise of the Nile River. These epagomenal days were celebrated as the "days of the gods". The New Year would begin with the rising of the Nile River and end after the epagomenal days. In that the solar year is closer to 365.25 days, one would have to add one day every four years for the calendar to match. The ancient Egyptians simply ignored this and never made adjustments for this. This calendar would align again in about 1,461 years. Their early calendars closely followed the lunar cycles. But the solar year contains twelve complete lunar phases, with the addition of about eleven days. This would change as well, as the start of each lunar month follows a 25-year cycle. From this solar calendar comes our current system, which was adapted after Julius Caesar visited Egypt. Caesar met an Egyptian astronomer named Sosigenes, and brought him to Rome. Once there, Sosigenes helped to establish the new Roman calendar (Krupp 2000).

#### 3.2.1. A STELLAR METHOD

Since the lunar calendar could not closely be matched with the solar calendar, civil matters in ancient Egypt followed the solar cycles. The Egyptians also noted that the flooding of the Nile River, the beginning of their New Year, coincided with the heliacal rising of the star Sirius. As the Earth orbits around the Sun, the Sun appears to move eastward relative to the background stars. This eastward motion causes stars to disappear in the western skies, over time, only to reappear in the eastern skies. As the Earth eventually travels far enough around the Sun to permit a star to rise, just briefly before the Sun rises, this is termed its heliacal rising (Krupp 2000). Sirius is the brightest star in the nighttime skies. To the ancient Egyptians, Sirius was part of the god Isis. From inscriptions in the Dendera Temple, Sirius is "a feminine sun which appears in heaven at the beginning of the year as a divine star, whose rays light the earth like the morning sun. She is the mistress of the year's beginning, and entices the Nile out of this source hole to provide life to the living people" (Krupp 2001b). Sirius was a very important star to the ancient Egyptians. Their New Year began with the heliacal rising of Sirius. Surely there must have been someone watching the skies, to know when the heliacal rising occurred. The ancient Egyptians called such a person, imy-wnwt, or "hour watcher" (Krupp 2001b). These were true astronomers. They noted that they could fix the rising of the Nile River with the heliacal rising of Sirius. They also noticed that in following days, or rather nights, Sirius would rise sooner. After a period of ten nights, it was difficult to affix the rising of Sirius with the rising of the Sun. A new star or group of stars was used for this. It soon became noticed that a different bright star, or pattern of stars, could be used. These stars or patterns of stars were separated by ten nights. These patterns were called "decans" and separated the sky into 10 degree increments. Thus the skies contained 36 decans. After the heliacal rising of Sirius, which signaled the beginning of the New Year eleven days later, a new decan would rise. After another ten days, another new decan, and so forth. This accounted for 360 days and there may have been a group of epagomenal stars for the remaining five days. This counting of decans and monitoring their heliacal rising can be

seen on coffin lids of the pharaohs. These "diagonal calendars" clearly show the procession of patterns associated with the decans (Neugebauer 1955). Although the depicted patterns may or may not represent those constellations we see today, there is a definitive pattern present as illustrated below.



Decans on a coffin lid.

#### **3.2.2. RELIGION AND THE STARS**

There is a direct association with the religion of ancient Egyptians and the stars in the night sky. As the Earth orbits the Sun, stars will be lost in the glare of the Sun for a period of about 70 days. When a decan star, or stars, disappears for this 70 days, it is said to die and enter the house of the underworld. Sirius is one such star that follows this pattern. These stars remain there in this "embalming house", and lose their impurities. After the 70-day period, the stars are reborn (heliacal rising) in the eastern skies (Neugebauer 1969). The ancient Egyptians followed this pattern of time in their embalming rituals. A deceased person was embalmed and then mummified before the final burial. This process took precisely 70 days. It was thought that this same period of time would strip the body of all impurities before being carried on to the afterlife.

## 3.3. STAR CLOCKS AND SHADOW CLOCKS

One of the most significant legacies that is left to us from ancient Egyptian astronomers is the 24-hour day. Time keeping, like the calendar, was a basis for an organized culture and society. Since the ancient Egyptians knew how to measure the passage of night by these decans, and separated the sky into 36 parts, they were able to keep track of time by the stars. The division of night and day would, of course, lead to 18 hours of daylight and 18 hours of darkness (Neugebauer 1955). The extreme significance of Sirius prompted the Egyptians to mimic the patterns seen by Sirius. This is where the decans began and ended. At any given time of year, only a certain number of decans would rise during the course of the night. Each decan's rising would signal a new hour of time. Since the heliacal rising of Sirius occurs in mid-July, this period is of least darkness. The period of complete darkness varies with the seasons (Krupp 1979). The summer nights are about 8 hours long, if one accounts for only the period of total darkness. This 8-hour time period would contain 12 decans. We can then assume that each decan would actually rise in periods of about 40 minutes apart. As these "decanal hours" varied during different times of the year, the ancient Egyptians instituted a more symmetrical division of the decans. Since the ancient Egyptians had no reference points to the decans (stars) in the daylight, they assumed that the Sun would also hide 12 decans. Hence, from this, we have our 24-hour system of time. We can thank the ancient Egyptians, or curse them depending on one's point of view, for the 24-hour clock system we have today.

For keeping track of time during the day, the Egyptians used shadow clocks. The early shadow clocks were small and portable. It consisted of a main shaft that was inscribed with marks to indicate the hours of the day. This shaft was usually less than 1 m long. A shorter raised crossbar shaft was attached to one end of the main shaft. In the morning, the shadow clock was placed on the ground with the long shaft pointing to the west. The short raised shaft would face the rising Sun. As the Sun rose higher into the sky, the short crossbar would cast a shadow on the main shaft. The time was kept by noting when the shadow aligned with the inscriptions on the main shaft. After the noon Sun, the shadow clock was rotated so that the long shaft now pointed east, and the procedure was reversed. Later, large permanently placed "obelisks" were used. One such obelisk is the so-called Cleopatra's Needles, which now stands on the Thames Victoria Embankment. Similar obelisks are erected in Rome, Italy and London, England (Krupp 1979).



#### Shadow clocks.

Around the Twelfth Dynasty (2000 B.C.) the Egyptians began to use decan transits instead of heliacal rising as a method of keeping time. A new type of star clock, called the Ramesside star clock, was in place by about 1500 B.C. This clock required the observation of decanal stars in transit and on either side of the meridian. The selected stars were sighted using a merkhet (plumb line) and a bay (forked stick). Using this method, two observers would sit facing each other on a north-south line. The northernmost observer would watch a particular decan progress until it transits in the sky behind the southern observer. The northern observer would superimpose his plumb line upon a star. For exact meridian transits, the southern observer would hold his plumb line above his head. Examples of these devices are illustrated below. The northern observer would use the slit in his bay to align the plumb line with the star's meridian transit (Krupp 1979). To know which stars represented which decan, the observers must have been well versed in the night sky. In that motion of the stars are only discernible over long periods of time, these observers must have sat in this alignment for hours. One might say that these were the first true astronomers of ancient Egypt.



Merkhet and Bay with observers below.

### 4. ANCIENT EGYPTAIN CONSTELLATIONS

Ancient astronomy is often referred to as the observation of the sky and its constellations. Constellations are patterns of stars in the sky, and astronomers today recognize 88 such patterns. Most of these constellations are passed down from the Greeks and Babylonians with a few from modern times. But one might ask what the ancient Egyptians saw as their constellations. Were they the same ones? Were the patterns and the names similar? Popular legends credit the ancient Egyptians with profound wisdom and engineering skills. Much of the archaeological discoveries do not confirm this, but as we saw in the Pyramid Texts, there were certain astronomical ideas. From the study of the Pyramid Texts and other inscriptions, the results are that the ancient Egyptians may have seen only three specific constellations associated with the sky. These three ancient Egyptian constellations are; Ursa Major, or more closely the asterism we call the Big Dipper, Sirius, but not necessarily all of Canis Major, and Orion. The Big Dipper was depicted variously as an adze or finger, the foreleg of a bull or the foreleg with a bull's head, and lastly as the complete bull. This bull was named Meskhetiu. Sirius was associated with the goddess Isis. Orion is a representation of the god Osiris. Identifying our currently recognized constellations with those from ancient Egypt has proven very difficult. There apparently was never one specific sky map for their constellations, but rather two partial sky maps, whose positions in relation to one another were not specified (Gingerich 1983). The only information that can be gained from these early sky maps is that one represented the

"northern group" and the other, presumably, the "southern group". This comes from the locations of the maps found on the northern and southern walls in the temples. In the Pyramid Texts there is mention of "two skies" and frequent mention of "northern sky" and "southern sky", but no mention of eastern or western skies. There is occasional mention of "two horizons" and reference to "eastern horizon" and "western horizon", but once again no mention of northern or southern horizon. The texts also state that the Sun god along with his son, the deceased King, will cross from south to north passing the waterway. This waterway that they crossed, in the sky, may have been the Milky Way. It is the dividing line between the two skies. The Sun does appear to cross the Milky Way once a year from south to north. This passage is when the Sun is in the constellation of Scorpius. Separating these two skies, one would associate the northern group with those near the North Celestial Pole (NCP) and the southern group with those near the ecliptic (Davis 1985).

## 4.1. THE NORTHERN GROUP

Images associated with the "northern skies" centered on the Big Dipper, or more appropriate for ancient Egyptians, the bull's foreleg. Other images depicted a very round hippopotamus form, one that was perpetually pregnant, and is believed to represent the sky goddess. In that this sky goddess was in the "northern sky" makes perfect sense, since these stars were called the "undying" or "imperishable" stars, never rising or setting. This is where the deceased pharaohs rose, to join with the afterlife and continue their reign with these stars. The Sun would be swallowed by the hippopotamus as it crossed the Milky Way from south to north, only to be reborn from her when it passed once again from north to south (Davis 1985). This image of the hippopotamus appears in various temples and tombs, and is sometimes shown holding a rope attached to the foreleg of the bull, and at other times she is leaning on a mooring post with a crocodile on its back. The tip of this mooring post is said to represent the North Pole of the sky (Krupp 2000). During this period, about 2500 B.C. Thuban was closest to the NCP, whereas Polaris is now nearest. The seven brightest stars in Ursa Major were believed to represent the foreleg of a bull. As these stars rotated around the NCP, the mooring post, they appear to be attached. Hence, the symbolization of the rope from the bull's leg to the mooring post that was sometimes held by the hippopotamus (Krupp 1997c).



Hippopotamus and the bull's foreleg.

The image above is a relief from the Temple of Horus at Edfu and is dated around  $200\,$ 



B.C. The seven bright stars of the "Dipper" can be seen surrounding the bull's leg.



From the lid of the coffin of Tefabi.

The illustration above is from the lid of the coffin of Tefabi from Asyut, Egypt and is dated between 2134-1991 B.C. The female on the left is the sky goddess Nut standing next to the foreleg of a bull. One can see that the seven stars represented inside the leg take on the configuration of the Dipper. The two gods on the right are Osiris and Isis. Another image illustrating the hippopotamus and mooring post, with a rope attached to the entire bull this time, is found on the ceiling of a burial chamber of the pharaoh Sethos I in the Valley of the Kings. Sethos I ruled Egypt between 1306-1290 B.C. In this image, dots on all the figures are said to represent stars. The man holding onto the bull has four

dots, which may represent the Dipper's bowl, and the Dipper's handle is the dots depicted in the bull (Krupp 1997c).



## The Northern Sky group.

In the illustration above, the falcon-headed human may represent Ursa Minor. The other images are said to represent Leo the Lion, with an outline of stars, and the bird above him as Leo Minor. The crocodile below them may be Hydra, and the smaller crocodile in front of Leo would represent Cancer. The man between the larger crocodile and the falcon-headed human is believed to be Gemini (Gingerich 1983). Since there is no written record

to accompany this, one can only speculate that these are the aforementioned constellations. As we return to the single recorded constellation of the northern group, namely the Big Dipper, we see this constellation represented in several fashions. What we see as a Dipper, are the seven bright stars of Ursa Major. Other cultures around the world see this as a plough or wagon (Krupp 1997b). To the ancient Egyptians, they saw these stars as a sacred. The shape of the Dipper was also represented by a sculptor's tool called an adze. This tool had a sharp blade attached to a handle at a right angle. For ancient Egyptian culture, the sculptor was held in highest esteem. Armed with this great tool they would carve out statues. These statues were believed to come to life in the afterworld with magical powers and incantations. During the burial ritual, after the dead pharaoh was mummified, the adze was touched to the area of the lips and eyes in what is termed "the opening of the mouth" ceremony. This was thought to give new life to the decease King in the afterworld. The illustration below is from the tomb of Inherkau and shows a hawkheaded god touching the mummy with an adze. The god is believed to represent Horus and the mummy may be Osiris (Krupp 1997b).



From the tomb of Inherkau about 1200 B.C.

The Big Dipper's handle stars do in fact take on the curve represented by the handle of the adze. It is also believed that the Big Dipper along with the Little Dipper, Ursa Minor, represents two adzes. These adzes could be considered chasing each other around the NCP, which in ancient Egypt we have seen, would be near the star Thuban. Ancient Egyptian texts mention two claws, or adzes or fingernails, that "hack up the celestial mansion" in the northern sky (Gingerich 1983).

### 4.2. THE SOUTHERN GROUP

The Pyramid Texts depicted two important ancient Egyptian constellations in the "southern skies", Osiris and Isis. Osiris was the god of the underworld and Isis was his goddess consort. The constellation Orion is thought to be the celestial depiction for Osiris (Krupp 1979). So important was this god, that some proposed "ascension shafts" were incorporated into the Great Pyramid at Giza. We shall explore that theory later. Osiris was thought to help ascend the dead pharaohs to the afterlife. The bright star Sirius represents his consort Isis (Krupp 2001b). Recall that Sirius was associated with the rising of the Nile River and responsible for bringing forth new life each year to Egypt. This might be the reason why the decans begin and end with Sirius. In dividing the sky into these ten degree increments, the ancient Egyptians used about ten or twelve constellations of the southern group as their "hour stars", but the fact that there were 36 decans, does not mean the southern sky was limited to the area south of the Milky Way. The whole set of decans are "listed" together in illustrations of the "southern sky", but only those which really existed south of the Milky Way were illustrated there (Davis

1985).

## 4.3 THE EGYPTIAN ZODIAC OF DENDERA

A spectacular representation of the ancient Egyptian sky was found on the ceiling of the Temple of Hathor at Dendera. Dendera lies on the western bank of the Nile River about 483 km south of Cairo, Egypt. This celestial sky map was found by Napoleon Bonaparte's troops in 1799 A.D. and now resides at the Louvre in Paris, France. Called the Dendera Zodiac, for its depictions of the zodiacal constellations, it is a great circle of about 1.5 m in diameter. This was first thought to be as old as 4000 B.C. but a more closely conducted study showed that the temple was built around 30 B.C. Therefore, this Egyptian zodiac was of a more recent time. In early Egyptian depictions of the sky, the zodiac is not present. The symbols found on the Dendera zodiac are of Mesopotamian origin and most likely came to Egypt from Babylon. In an attempt to incorporate the Mesopotamian zodiac into their sky maps, the Egyptians simply "added" the depictions to what was already known. This may have resulted in a "doubling of constellations" in this planisphere (Gingerich 1983).


## Dendera Zodiac.

As one can see from the illustration above, the zodiacal constellations are very evident. There are numerous other symbols that remain to be deciphered. Near the center, the hippopotamus and the mooring post can be found. Next to that is the foreleg of the bull. In a circular fashion around these two, the symbols of the zodiac can be seen. Pisces the two fish are shown attached by a rope and a wavy symbol between them may depict their aquatic association. Moving in a counterclockwise direction, we find Aquarius, Capricornus, Sagittarius, and Scorpius. Continuing in the same direction we come to Libra and then a woman holding what might be a stalk of wheat, representing Virgo. Next is Leo with a god holding on to the tail of the lion. Above the lion is a beetle, which is believed to represent Cancer the Crab. A man and woman holding hands depicts Gemini. Taurus the Bull is easily spotted and Aries the Ram completes the zone. Below Taurus is Orion (Osiris) and is holding a staff. A cow in a boat with a star between its horns, found below Leo and Cancer, is thought to be Sirius. The figures around the outer perimeter are those of the thirty-six decans (Krupp 1979). Various other figures found in the Dendera zodiac have remained unidentified. It is unsure if the twelve gods or goddess holding the circle are to represent the twelve hours of nighttime, or the twelve months of the year. The text that accompanies this zodiac does not explain them. More research is needed before an actual determination is made. There was however the five naked-eye planets found in the circle. Mercury is in Virgo, Venus in Pisces, Mars in Capricornus, Jupiter in Cancer, and Saturn in Libra. It is thought that they were placed where the planet held the

most propitious influence (Krupp 1979). Any attempt to overlay a current sky map, and this author tried to do so, to find which constellation is represented by which deity, is futile. The Dendera Zodiac circle may be the best representation of ancient Egyptian astronomy incorporated with the astronomical influences of the rest of the world.



Dendera Zodiac with Planisphere overlay.

The Illustration above is this authors attempt to locate constellations of the Dendera Zodiac circle. The planisphere was aligned using Orion on the image of the Egyptian god Osiris. From this, Leo the Lion is clearly depicted as the Lion, and Scorpius is aligned with its image. Most of the remaining constellations are not aligned. One example is the great variance for Cancer with the Beetle (Crab).

# 4.4. EGYPTIAN PLANET GODS

It is not known when the ancient Egyptians first recognized the five naked-eye planets, but from the Pyramid Texts and hieroglyphic translations, all of them are depicted on the ceilings of tombs and temples. The three superior planets were considered to be associated with the god Horus. Mars was named Horus of the Horizon (Horus the Red); Jupiter was called Horus Who Illuminates the Two Lands. Saturn was named simply Horus, Bull of the Sky. These three were always depicted with the falcon-head of Horus. Mercury, known as Sbg (a name whose meaning is unknown) and later Seth, was known to be the same object in both the morning and evening skies. Venus was known as "the Crosser" or "the star Which Crosses," and was depicted with the head of a heron. Venus was later pictured with the falcon-head of Horus and sometimes with a two-faced falcon head. This may be a suggestion that Venus, like Mercury, was seen as both a morning and evening star. The Egyptian god for the Moon was called Khonsu (Krupp 1979).



#### Venus and Mercury.

In the illustration above, Venus is the heron-like benu bird and Mercury is the small hawkheaded figure below and to the right of Venus. Again, one can see that for the ancient Egyptian, the astronomical study of the planets was purely religious. They were not concerned with the physical or mathematical science of these objects. It was not necessary for the culture of this period.

#### 5. ALIGNED WITH THE SKY

Much has been written about the pyramids and temples, and how the ancient Egyptians excelled in mathematics and astronomy. Most of this is purely speculative. Facts are that the Egyptians held high homage to their Kings. They constructed monuments, temples, and tombs for their pharaohs, so that they may continue in the afterlife. The fact that the ancient Egyptians were great builders is attested by structures, namely the pyramids, which still exist even after 5,000 years (Andreu 1997). As we have seen, their mathematics was very simple. Recently though, some have speculated that the ancient Egyptians knew how to calculate Pi. Doubling the length of the base of the Great Pyramid at Giza, then dividing this by the height, results in a close approximation to Pi (Gillings 1972). But this is really just a play on numbers. Although it may work for the Great Pyramid, it does not fit for the remaining pyramids. Advanced mathematics was not necessary for their culture and religion in ancient times. This was left for the Babylonians and Mayans to discover. The early tombs of the pharaohs were mud-brick bunkers called mastabas. These mastabas have long since crumbled over time. The ancient Egyptians must have recognized this and soon began building their burial temples out of stone. Revelations of this kind tell us that their engineering skills were learned, similar to the method of trial and error. The earliest such temple is the Step Pyramid at Saqqara, Egypt. About 2630 B.C. Imhotep, architect to the pharaoh Djoser of the Third Dynasty, constructed this block pyramid. Thought to be one of the oldest pyramids in the world, this structure stands 60 m high and has six tiers or steps along its incline (Egyptvoyager 2001).



Djoser Step Pyramid.

What is truly amazing, and may have some astronomical implications, is that this pyramid, and those to follow, are very accurately aligned with the four cardinal points. The sides of the Djoser pyramid, and all nine pyramids at Giza, are aligned with the axial positions north, south, east, and west (Krupp 1997a). The most accurately aligned pyramid is that of Khufu, the Great Pyramid at Giza, where its sides do not deviate from alignment more than three arc minutes on average. The question is how did the ancient Egyptians achieve such an accurate alignment? Surely they did not employ global positioning satellites and transit equipment. Even a compass would show magnetic north and not true axial north. To use the Sun, one would have to calculate solar noon or know their latitude on Earth. If the ancient Egyptians used the stars near the poles, no such star was close enough to provide such an accurate measurement. The reason for aligning the pyramids can be found through their religion and culture. The Sun and other celestial object appear from the east and die in the west (Krupp 2001b). The eternal stars were in the north. Recall their belief that the goddess Nut held the heavens on her four extremities and the Earth was a rectangle.

# 5.1. ONE POSSIBLE METHOD OF ALIGNMENT

To accurately align the pyramids, one could find north by using the rising and setting Sun, then bisect the angle between those two positions. This would have to be accomplished on the solstices, when the Sun appeared to temporarily halt its seasonal trek higher or lower in the skies. The problem with this procedure is in viewing the Sun or other objects near the horizon. Also, one would have to have a level clear view in both directions. To use the stars near the NCP (during this time Thuban was closest at almost two degrees away), you would have to observe them over the course of several nights. From this, one could approximate north by locating the point around which Thuban rotated. If the ancient Egyptians did in fact devise an accurate method of aligning the pyramids, then this

method would have been repeated for all the pyramids. Khufu's pyramid is aligned within three arc minutes and the remaining pyramids show various deviations in the accuracy of their alignments. To explain this deviation, Kate Spence has proposed that the ancient Egyptians used two different stars in the northern skies to located true north. Spence examined eight pyramids beginning with Snofru's Meidum pyramid, built shortly after Djoser's Step Pyramid, through Neferirkare's pyramid. The period of time covered in this examination is from around 2600 B.C. through 2433 B.C. (Spence 2000). The construction of the pyramids would begin shortly after the new pharaoh took over the reign of Egypt. A ceremony that began with "the stretching of the cord" was held, and the construction began (Krupp 1979).



The stretching of the cord.

In an effort to accurately date the pyramids, Spence assumed that the alignment ceremony occurred within two years of the new King's reign. After the burial of his predecessor, a suitable location was found and the site was prepared for the next tomb. The table below illustrates the pyramids selected, the approximate time of the pharaoh's reign, the deviation of the alignment, and the recalculated dates (Spence 2000).

Ruler	Currently accepted accession date	Orientation - west side of pyramid	Orientation - east side of pyramid	<ul> <li>Receibrated accession data</li> </ul>
Djoser	2640 BC		- + 180' (mf. 3)	
Snohu-Meidum (1)	2600 BC (-2/+17)	~18.1" (ref. 11) ±1.0	-20.6" (ref. 11) ±1.0	2526 BC ± 7
Snohu-Bent Pyramid (2)	[2583 BC] (-2/+11)	-11.8' (ref. 12) ± 0.2	-17.3' (ref. 12) ± 0.2	
Snohu-Red Pyramid (3)	[2572 BC] (-2/+9)		-8.7" ± 0.2	
Chudu (4)	2564 BC	-2.8' (ref. 1) ± 0.2	-3. 4' (ref. 1) ± 0.2	2480 BC ± 5
thatre (5)	2522 BC (-1)	-6.0' (ret. 1) ± 0.2	-6.0' (rof. 1) ± 0.2	2448 BC = 5
Venkaure (6)	2489 BC (-4)	Average: +14. 1' ± 1.8' (ref. 2)	+12.4' (ref. 2) ± 1.0	2415 BC ± 10
Sahure (7)	2446 BC (~15)			2372 BC ± 25
Neferinkane (5)	2433 BC (-16)		~ + 30' (ref. 3) ± 10	2359 BC ± 25
Unas	2317 BC	+ 17. 4' (rot. 1)	+ 17.1' (rat. 1)	
Seriwosret I	1966 BC		90' (ref. 13)	
Amenemhat II	1853 BC		+ 15.7' (ref. 14)	

Stademan<sup>100</sup>. Error margins in parentheses given for these dates reflect curvative differences in regin length to these in acting chronologies and are calculated index to the beginning of Khut's segn. For Brindhi any near near got 20 is 40 years is about in these tables reflect curvative differences in regin length to the error margins when differences between two standard scholarly drivnologies <sup>100</sup>. For promise got the distribution of the standard to the error margins when differences between two standard scholarly drivnologies <sup>100</sup>. For promise got the distribution of the standard to the error margins when differences between two standard scholarly drivnologies <sup>100</sup>. For inargins for the orientation of the standard with the wooppone of the Stant and Heat promise these that agreements, and a standard scholarly drivnologies <sup>100</sup>. For inargins for the orientation of the weat and as takes of the parential are estimates based on the explorent used to measure the adgreements. ± 2.2 accretionals is advected for rescurate the orientation of the weat and as takes of the reparential accounts the tools and starks are significated <sup>100</sup>. A normal 10 exercision accounts the obstandard to measure the adgreements. ± 2.2 accretionals is advected for rescurate the explorence accurvation to accurate theorements and the theorements and the to rescure theorem accurate theorement accurates theorem accurates the accurates theorement accurvates theorement accurates theorement accurement acc

Table 1. Spence's sample pyramids.

The dates and measurements for these alignments were then plotted. All but two

pyramids, Khafre's and Sahure's, appear to have a linear association. Four of the pyramids

from the above table were plotted, but appear not to be associated with this grouping.

The next two graphs illustrate the connections with these eight pyramids and their deviation of alignment. There appears to be some correlation between the two pyramids that lie below this linear plot. Spence suggests that the alignment of the pyramids was performed on the western side of the structures. The western sides show the least amount of deviation from true north (Spence 2000).



#### Graphs from Spence's table.

Noting that the six pyramids that do lie on the line all appear to have an error that changed over time, Spence tried to find a reason and method of alignment that could explain this. This accurate alignment method suggests stellar positioning rather than solar positioning was used. A likely explanation for the deviation from north could come from increasingly inaccurate results caused by the precession of the Earth's axis (Spence 2000). Precession

is the wobbling of the Earth's axis, much like that of a spinning top as it slows down, and appears to trace out a circle in the sky. It takes about 26,000 years to complete one cycle. Since the movement is very slow, it would go unnoticed in one's lifetime. Today, the Earth's axis is pointed towards the direction of Polaris, ? Ursa Minoris, and is within one degree of this star. When the pyramids were constructed, about 4,500 years ago, the Earth's axis pointed near Thuban, ? Draconis, in the constellation of Draco. This star was about two degrees from the NCP. A method proposed by Spence is that the ancient Egyptians used two stars, one on either side of the NCP, to find true north. One star would be in upper culmination and the other star in lower culmination. An imaginary line drawn between the two stars would pass through the NCP. If these two stars were sighted at precisely their exact upper and lower culmination, a time when both stars transit the meridian, then a cord drawn between them would align with true north. By using a plumb line or sighting post, the Egyptians could have used this method to align the sides of the pyramids. Spence used SkyMap Pro 6, an astronomical program for computers, to test this theory. Setting the program for the time period around 2467 B.C. showed that two stars, Kochab, ? Ursa Minoris, and Mizar, ? Ursa Majoris, would produce such an alignment. This was tested with two other stars, again one in Ursa Minor and the other in Ursa Major, but did not produce as accurate a result. If this were the method that the ancient Egyptians used, it would then account for the deviations in accuracy of alignments. As the Earth's axis wobbles, precession would cause the measured errors that are found. This would also date the time of Khufu's pyramid at around 2478 B.C. and is very close to the accepted period (Spence 2000).



Spence's Computer graphs from SkyPro 6.

To account for the two pyramids that lie off the line of the graph, Spence proposed that

the same two stars were used, but at different culmination periods. As these two stars processed, the line between them would shift east or west, depending on which star was at upper or lower culmination. If the ancient Egyptians used the same two stars at different culmination, this would account for the deviations of the other two pyramids. The second line on the above graph shows the linear association between these two pyramids. The change in precession would again account for the slope of the line (Spence 2000). Clearly, one can see that the ancient Egyptians did use astronomy. The alignment of the pyramids, and even the Great Sphinx, with the four cardinal points could not have been accomplished without the use of stellar positioning. If this aforementioned method was the one used, they certainly did not record it. The process is not written in either hieroglyphics or the papyrus. The mathematics of the ancient Egyptians was far too simple to derive a solar or geometric method. If the ancient Egyptians employed astronomers, perhaps they wanted to retain their methods in secret. The use of a plumb line to locate true north could be the reason for "the stretching of the cord" ceremony that preceded the construction of the monuments.

# 6. THE PYRAMIDS AT GIZA



The pyramids at Giza.

Nowhere in the realm of ancient Egyptian astronomy is there more astronomical

speculation than those associated with the pyramids at the Giza plateau. From books,

television programs, and even astronomical software, implications involving the alignment of the three pyramids at Giza with Orion's Belt stars abound.



#### Cover from a computer program.

In examining this area closely, one finds no direct astronomical association with alignments of Orion's Belt stars. To understand their true meaning and function, some background must be presented. We shall first look at the physical properties of each pyramid at Giza.

Like the previously mentioned Pyramid Texts, inscriptions on the interior walls tell of the destiny of the pharaohs for whom the pyramids were built. The Great Pyramids at Giza are centered on three large four-sided structures. Of the eighty pyramids in Egypt, these three are the largest known. The Giza Plateau is located about 11.25 km southwest of Cairo, 17 km north of Saqquara, and 8 km south of Abu Rawash. It is part of the necropolis of the ancient capital of Memphis, Egypt (Egyptvoyager 2001). The desert plateau is just west of the old course of the Nile River. Even though the oldest known tomb is a mastaba dated around the First Dynasty (3000 B.C.), some jar-sealings have been dated to the Second Dynasty near Giza. The Giza pyramids were constructed to be monumental tombs for the pharaohs of the Old Kingdom period, Third Dynasty through the Eighth Dynasty (2650-2134 B.C.). The ancient Egyptians associated the western side of the Nile River with death. This is where the setting Sun and other celestial objects disappeared below the horizon. All of the pyramids were then constructed along the western banks of the Nile River. When the pharaohs died, they were ferried across the Nile River on boats and entombed in the pyramids. Rituals were arranged in temples constructed next to the pyramids. Many smaller pyramids and tombs are located next to the larger pyramids in an elite cemetery complex. These smaller tombs are thought to be

those of higher-ranking officials and family members of the pharaohs. The three large pyramids were constructed for the pharaohs Khufu, Khafre (one of Khufu's sons), and Menkaure (a son of Khafre). All of these pharaohs are of the Fourth Dynasty. It is not known why Khufu, the second pharaoh of the Fourth Dynasty, decided to build his funerary monument at Giza. His father, Snofru, built two pyramids at Dashur, about 27 km south of Giza. It is believed that a third pyramid, located at Meidum south of Dashur, was also built by Snofru (Krupp 2001b).

# 6.1. THE GREAT PYRAMID

The largest of the three pyramids at Giza, known as the Great Pyramid, was built for the Egyptian pharaoh Khufu. During the reign of Snofru, the shape of the royal resting tombs had evolved from a Step Pyramid to a true geometrical pyramid. The pyramid at Meidum began as a step pyramid, but Snofru must have decided to fill up the steps and build a true pyramid. At the same time, the Bent and Red Pyramids were being constructed at Dashur. The shape of Khufu's pyramid is the result of evolution that began generations earlier and continued for generations to come. Khufu's pyramid is unique to previous pyramids in that the burial chamber is not underneath the pyramid, but located inside it. An unfinished room found beneath the pyramid suggests that the original designed changed during construction. Khufu's funerary complex includes a mortuary temple, four smaller pyramids, five pits for his royal boats, and a valley temple. The purpose of these boats may have been intended for travel to the after-life or to accompany the pharaoh on his journey. The boats are constructed of cedar wood and held together with ropes and pegs, but no nails. The Great Pyramid, as it is known today, is constructed of over 2,300,000

blocks of stone, with an average weight of 2.5 tons each. It rises to a height of 146 m and is 230 m on each side at the base. The sides of the Great Pyramid are inclined at an angle approximately 52 degrees. This massive structure covers an area of about 13 acres. It is believed that it would have taken over 100,000 servants 30 years to construct this massive monument. This construction would have occurred during the flooding of the Nile River, the period from July through November, when they could not work in the planting fields. The pyramid was covered with marble, which has since then eroded or has been removed over time. The sides of the Great Pyramid are aligned with extreme accuracy with the four cardinal points. The original entrance is 15 m above the entrance used today. From the original entrance, a passageway descends down at an angle of 26 degrees, 105 m below the Earth. The passage is only 1.1 m wide and 1.2 m high. This passage leads to the aforementioned unfinished chamber. From the entrance passage is another ascending passage, again rising at an angle of 26 degrees. This passage is of the same dimensions and is 39 m long leading to a horizontal leveling-off. From this point, one can continue to the Queen's chamber or into the Grand Gallery. The Grand Gallery is 48 m long and 8.5 m high and is at the same 26-degree angle as the passages. The Grand Gallery is only 1.6 m wide at the bottom and 1 m wide at the top. This leads into the King's Chamber, where the large sarcophagus made of Aswan red granite resides. The sarcophagus is much too large to have been moved through the passages, so this must have been placed inside the chamber during construction of the pyramid. The King's Chamber is 5.8 m x 10.8 m and is 5.8 m high. From the King's chamber extends two shafts, one to the northern face and the other to the southern face of the pyramid. It was once believed that these shafts were

for ventilation, although their true reason is still unknown. The shafts begin in the King's chamber horizontally, then extend to the face of the pyramid at different angles to each other, only to exit the pyramid once again horizontally. The exit points are at the same elevation. The northern shaft rises at an angle of 31 degrees and is 12.7 cm high by 17.8 cm wide. The southern shaft rises at an angle of 44.08 degrees and is 20.3 cm high by 30.5 cm wide (Krupp 2001b).

# 6.1.1. THE PURPOSE OF THE SHAFTS

When these shafts leading from the King's chamber were first discovered, they were thought to be ventilation shafts. But these shafts were sealed at the ends, and a better method of ventilation, not to mention a shorter route, could have been constructed. One astronomical theory has been proposed that these two shafts were sighting shafts to specific stars. Again, this is false, since the shafts begin and end in horizontal positions. The same reasoning would hold true if the shafts were meant for sunlight to enter the King's chamber. For the shafts to attract sunlight, they would have been better placed on the eastern and western faces. The most probable reason for these appears to be associated with the belief that the dead pharaoh would rise to the stars in the heavens. The Egyptians held greatly to the belief that Osiris, god of the underworld, would carry the dead pharaoh or guide him onto the afterlife. From the Pyramid Texts, they describe the dead pharaoh's destiny. He is to ascend to the imperishable stars and manage their appointed rounds. He is also to ascend to the sky to join Osiris, the god of resurrection. If we closely examine this theory, one can see the association with this astronomical function (Krupp 1979). First, the northern shaft extends at an angle of 31 degrees. From

the location of Khufu's pyramid at Giza, which is just 2.1 km south of the 30-degree parallel of north latitude, this shaft would have pointed very close to the NCP. Close, but not exact. Since the northern stars were associated with everlasting life, never rising or setting, it was believed that the pharaoh would rise to join them and forever watch over the lands. From the precession of the Earth's axis over a 26,000-year period, the star nearest the north celestial pole has changed. If we account for this precession, and assume that the pyramid was constructed around 2500 B.C., the star closest to the NCP was Thuban. Thuban is the brightest star in the constellation of Draco the Dragon. This star shines at visual magnitude 3.5, and would have been within 2 degrees of the NCP in 2500 B.C. Thuban would have be closest to the NCP in 2840 B.C. at about 0.2 degrees. Today, Polaris, at 2.0 visual magnitude, is near the NCP. Polaris comes closest to the NCP in 2100 A.D. and will be within 0.5 degrees. Since this shaft does not align with the NCP, it is improbable that it was intended as a sighting shaft for Thuban. As an ascending shaft for the soul of the dead pharaoh, this is a likely purpose, although the size is rather small for a person to pass through. The lower shaft, near the entrance of the pyramid, rises at an angle of about 26 degrees. It has been proposed that this is an alignment with the lower culmination of Thuban. Such an alignment of lower culmination would have occurred around 2100 B.C., long after the construction of the Great Pyramid.



Inside the Great Pyramid at Giza.

The second shaft to examine is the southern shaft. This small shaft rises from the King's

chamber to the southern face of the pyramid at an angle of 44.08 degrees. Even though it is slightly larger than the northern shaft, it is still improbable that it was meant as a physical ascension passage. Although the Sun does pass the southern face, the horizontal entrance and exit points would prohibit sunlight from entering the King's chamber. A proposed purpose for this shaft was to allow the dead pharaoh to pass on to Osiris, the god of resurrection. In various texts, Osiris is believed to be represented by the constellation Orion. The funerary inscriptions, religious incantations, and magical spells carved upon the chamber walls of the Fifth Dynasty (2465-2323 B.C.) pyramids, known as the Pyramid Texts, identify the stars of Orion and the circumpolar stars as stellar destinations of the deceased pharaoh. Orion was the stellar embodiment of the god Osiris, who governed the resurrection of the souls. Though the depiction of Osiris does not contain any star or star-like images, the constellation of the Dendras shows the image of Osiris in the location of the constellation Orion (Krupp 1979). With this in mind, consider the altitude of Orion as it crosses the meridian to intersect the southern shaft. Currently, the central stars in Orion, called the Belt Stars, are near the Celestial Equator. For the latitudinal location of Giza, the Celestial Equator would be at an altitude of about 60 degrees to the south at the meridian point. But if we once again account for the precession of the Earth's axis, and calculate the time of the building of the Great Pyramid at around 2500 B.C., then the altitude of the Belt Stars would be at about 45 degrees. This is 1 degree higher than the angle of the southern shaft, but still within the constellation of Orion.



Aligements of shafts to stars 0.2600sc as discovered by A. Badawy and V. Trimble. In 1964

Pointing to Constellations

If the Great Pyramid had been built earlier, around 2700 B.C., then the southern shaft

would have aligned with the central star in Orion's Belt, Alnilam. One must also consider

that there is a host of other stars that would pass in front of this passageway. Some examples are the stars in Scorpius and Sagittarius. The central region of the Milky Way would also pass this alignment during this period of time, although at a different time of year. The Sun as well would pass this inclination of the southern shaft during the later portion of February. The ancient Egyptians held great associations with the Sun and the Milky Way. Recall that the Sun God was represented as Re, and the Milky Way was thought to be the reflection of the Nile River. This southern shaft may have been the passageway for the pharaoh to ascend to Osiris. Then again, it may have had multiple alignments. The only true fact is that they exist, and that they served some purpose other than light or ventilation. Their construction is still a marvel of engineering, given the tools and mathematics of the time.

### 6.2. KHAFRE'S PYRAMID

Khufu's successor, Djedefre, decided to move about 8 km to the north of Giza. His burial site is near Abu Rawash, again on the western side of the Nile River. According to some Egyptologists, Djedefre wanted to distance himself from his father's rule. It is worthy to note that Khufu as well choose to be buried at different location than his father, who in turn built his funerary monument at a different location than his predecessor. Djedefre is not totally unassociated with the Giza plateau. During the construction of his monument, stones were quarried from the Giza site and moved north to Abu Rawash. Some scholars have even proposed that it was Djedefre, rather than his younger brother Khafre, who created the Great Sphinx to the southeast of Khufu's pyramid (Egyptvoyager 2001). Khafre, Djedefre's successor and younger brother returned to Giza to build his pyramid to

the southwest of Khufu's pyramid. Khafre's pyramid is smaller than Khufu's is, but because it was built on a higher portion of the Giza plateau, it appears to rise higher. The top of this pyramid still contains some of the limestone that covered the entire pyramid. As with Khufu's pyramid, Khafre's is also aligned with the cardinal points. South of Khafre's pyramid once stood a smaller satellite pyramid, of which only traces remain today. Unlike most other pyramids of the Fourth Dynasty and later, Khafre's pyramid is not accompanied by any queen's pyramid. Khafre's wives Khamernebti and Meresankh III are buried in other locations at Giza. Khafre's pyramid was 143.5 m high and 212 m at the base. The sides rise at an angle of 53 degrees. The pyramid has two entrances, each one opening into a descending passage that leads to a chamber. There is no evidence that anyone was ever buried in the main chamber. Unlike Khufu's pyramid, Khafre's chambers lie below the pyramid and there are no shafts, other than the descending passages (Krupp 2001b).

# 6.3. MENKAURE'S PYRAMID

Khafre's son and successor, Menkaure, built the third and last pyramid at Giza. This pyramid is much smaller than the previous pyramids. Most pyramids built after Menkaure's remain about the same size as this one, and may in fact be the establishment for the standardization of pyramid building. Menkaure's pyramid stands 66.5 m high and is 103.4 m at the base. Like Khafre's pyramid, the burial chamber is below the pyramid. No shafts exist within this pyramid to guide the pharaoh on his journey to the afterlife (Egyptvoyager 2001).

# 6.4. ASTRONOMICAL ALIGNMENTS OF THE PYRAMIDS AT GIZA



### Map of the Giza pyramids.

Having presented the physical properties of the pyramids at the Giza plateau, we are now able to examine what, if any, astronomical meanings are associated with them. Astronomical allegory was a fundamental constituent of the ancient Egyptian religion. Some temples are covered with astronomical inscriptions and imagery. Sir Norman Lockyer, the renowned astrophysicist and founder of Nature magazine, was the first to argue that Egyptian temples had been precisely aligned on the rising and setting of the Sun and bright stars. His measurements were published in 1894 in The Dawn of Astronomy. It has been shown that the two shafts in the Great Pyramid do in fact point to directions in the heavens, which the ancient Egyptians held as sacred resting sites for their pharaohs (Krupp 1979). These astronomical alignments concur with the context of Egyptian culture and their religious belief. One area that has lead to much conjecture and fallacy is that the three pyramids at Giza are a terrestrial representation of the Belt stars of Orion. In the book *The Orion Mystery*, by Robert Bauval, aerial photos of the pyramids at Giza are shown to precisely align with the three stars in Orion's Belt. But the photos are turned around, with the southerly direction pointed up. Another photo, this one of Orion's Belt stars, is shown in the same orientation as the inverted pyramids in an attempt to align them with the Belt stars (Krupp 1997a).





Images from Bauval's book.

Images showing proper orientations.

The images above show the proper layout, with north up, of the pyramids at Giza and the Orion constellation. If one tries to project the three Belt Stars onto the three pyramids, the angle of the stars would form a "cross" with the pyramids. Clearly this is not an alignment. Bauval also suggests that another pyramid, the "Unfinished Pyramid" at Zawyet el-'Aryan, south of Giza, stands for the star Bellatrix. Saiph is supposedly mapped in the pyramid of Djedefre at Abu Rawash, which is north of Giza. The problem here lies in the facts that Bellatrix is in the northern portion of Orion, and Saiph is a southern star of Orion. One may be left to assume that Orion is 'upside down' in this projection onto the Earth. The brighter stars Betelgeuse and Rigel are not associated with any stars in this conjecture (Krupp 1997a). In examining the positions of the three pyramids at Giza, this author finds no alignments with the Belt stars of Orion, or any other three star associations in the sky. To say that the pyramids do align with Orion's Belt, one might argue that they also represent the three stars in Aquila, or Scorpius, or better still, the three stars in the handle of the Big Dipper. All of these alignments are of course purely speculative. The only true astronomical associations with the pyramids at Giza are the two shafts in Khufu's pyramid that point in the direction of the circumpolar stars and in the direction of Osiris (Orion). These shafts are believed to transcend the dead pharaoh to the imperishable stars (the circumpolar) and to join with Osiris, the god of resurrection.

# 7. THE GREAT SPHINX OF GIZA

The Great Sphinx of Giza is surrounded in astronomical assumptions. It is said that this monument is the body of Leo the Lion, infused with the head of Virgo the Virgin. This

speculation would then naturally lead to an assumption that ancient Egyptians recognized those two patterns in the sky as the constellations we see today. According to ancient Egyptian texts, the Sphinx represents Horemakhet (Horus of the Horizon) and is the divine personification of the rising disk of the Sun. The Sphinx is positioned facing east and like the pyramids at Giza, is once again aligned closely with the cardinal points. It represents that of a crouching lion with a human head. Some evidence suggests that the face on the Sphinx is that of Khafre, the son of Khufu who built the Great Pyramid at Giza. This Great Sphinx is said to be the guardian of the Giza cemetery (Krupp 2001a). The Sphinx is about 20.1 m high and 73.2 m long. It rests 518.2 m east of the central pyramid at Giza, Khafre's pyramid. The eastward facing sculpture is carved from a natural bedrock of limestone and may be a reflection of ancient Egyptian ideas about cyclical celestial renewal. The Causeway that connects Khafre's Mortuary Temple on the east side of his pyramid to his valley Temple passes next to the Sphinx. This architectural bond with the Sphinx may support Khafre's claim to it. Khafre's Valley Temple and the Sphinx Temple are adjacent and just to the east of the front paws. Additional astronomical and calendrical implications have been associated with the Sphinx. In its Temple's interior colonnade, 24 red granite pillars have been interpreted as a reference to the 24 hours of the day. Giza Egyptologist Mark Lehner believes the Sphinx was intended to portray a manifestation of Atum, the solarized aspect of the divine creator. Egyptian pharaohs believed the Sphinx was a Sun god and gave it names that expressed that representation. The lion was an emblem of power associated with royalty even before the pyramids at Giza (Krupp 2001a).


The Great Sphinx at Giza.



An illustration of the Sphinx and Orion alignment.

Graham Hancock and Robert Bauval have written about the alignment of the pyramids at Giza with Orion's belt stars, and insist the area around Giza is a representation of the celestial sky. They equate the Sphinx with Leo the Lion, the Nile River with the Milky Way, and the three pyramids with Orion's Belt. Their claim is that the Sphinx faces the rising Sun in Leo during the vernal equinox. Orion would be on the meridian to the south. But the equinox Sun was in the constellation of Taurus the Bull in 2500 B.C. when the Sphinx was constructed. For the Sun to be in Leo during the vernal equinox, this would occur around 10500 B.C., much too early for the Great Sphinx. As for the representations, the Sphinx faces away from the three pyramids, and is on the western side of the Nile River. In the heavens, Leo faces Orion, and the Milky Way passes between them. In an effort to support their theory, Hancock and Bauval refer to the Dendera zodiac (Krupp 2001a). In this relief map of the constellations, a lion is depicted in the proper area of the zodiac, but also near the area of the Dipper Stars. Recall that the Dendera zodiac was dated around 100 B.C. after the Ptolemaic era. Clearly, the speculation of the Great Sphinx as a representation of Leo is unfounded, and the association with the heavens is incorrect. That the Great Sphinx represents a lion with a human head is obvious, and may represent Khafre's royalty and solar deification. In that this Sphinx faces the rising Sun, it is consistent with what is known of Egyptian religion and symbolism of power.

### 8. OTHER ASTRONOMICAL POSSIBILITIES

There are two other possible astronomical associations that may be connected with ancient Egyptian astronomy; the Great Temple of Amun-Re at Karnak and megaliths found in southern Egypt. Both of these examples may be purely speculative.

Along the Nile River near the Valley of the Kings, great monumental structures erected to the god Amun-Re can be found. Amun was thought to be the god of all gods. Joining Amun with Re (the Sun god), this god was ruler of everything. Along both banks of the Nile River near Luxor, Egypt stand the great temples of Ramesses. Ramesses II was known as one of Egypt's greatest pharaohs and ruled Egypt from about 1278-1213 B.C. Known as "Ramesses the Great" he had giant sculptures depicting his image erected all around this area. Ramesses II also erected great monuments here and all along the Nile River. Also known as the "Master Builder", Ramesses expanded previous structures that held honor to the great god Amun-Re (Krupp 2000). One such structure, called the Great Temple of Amun-Re, was thought by Norman Lockyer to be aligned with the setting Sun during summer solstice. Recall that Lockyer believed that many of the temples of Egypt were constructed to be aligned with the rising or setting of the Sun or stars. He noted numerous celestial indications of alignments, one of which is the alignment with the Sun's rising and setting on certain days of the year. Other researchers have said that the "High Room of the Sun" at the Temple of Amun-Re has it main entrance positioned in the direction of the winter solstice sunrise, as depicted in the figure below (Krupp 1979).



KARNAK

The Temple at Amun-re with opening pointing to sunrise at winter solstice.

Another temple of Ramesses II, this one at Abu Simbel, is said to allow the sunrise on

October 18th, and again on February 22nd, to pass through its corridors (Krupp 1980). These solar alignments would occur for only a few days during the year, and the implications that they coincide with specific events in ancient Egyptian periods are speculative. There is no recorded evidence that these alignments are of an astronomical nature.

### 8.1. MEGALITHS IN EGYPT

A recent discovery of stone circles may be the earliest indication of astronomy in ancient Egypt. Found near a site called Nabta, in southern Egypt, slabs of sandstone appeared to be deliberately aligned. A 4 m "calendar circle" of small stones appear to have two sighting windows; one aligned with the north-south axis, and the other with the summer solstice sunrise. The estimated period of this "Egyptian Stonehenge" is around 5300 B.C. as determined from radiocarbon dating of wood found at the site. It is suggested that these megalithic alignments may show an awareness of astronomy, or simply be part of a ceremony circle (Malville et al. 1998). This may be an early form of Stonehenge, but more information is needed. This is not to imply that Stonehenge in England has any astronomical implications, or that the stone circle at Nabta was built as a precedence to Stonehenge, only that the stones appear to be arranged in the same curious fashion as Stonehenge. The image below shows the 4 m stone circle.



#### Stone circle at Nabta.

# 9. SUMMARY

One must admire the ancient Egyptians for their observations and their buildings. The temples and pyramids are a testimonial to their skills. But the ancient Egyptian astronomers were content with just "looking" without putting forth effort to "explain" the celestial skies. To them the idea that the Earth was just one object in a vast universe was far beyond their comprehension. What we have learned about ancient Egyptian astronomy comes to us from written records. This historical record is in the form of hieroglyphic inscriptions called the Pyramid Texts. After Jean Francois Champollion deciphered this hieroglyphic code in the early 19th century, much has been learned about what the ancient

temples were constructed for. The astronomy of ancient Egypt centered on their religion. What could not be explained by obvious facts, was thought to be performed by gods or goddesses. Their world was conceived by the gods and ruled by them. The annual flooding of the Nile River was thought to be performed by a god. The ancient Egyptians held that their Kings were gods. These pharaohs were respected and adorned with all the appreciation of a great god. When these pharaohs died, they were mummified to preserve their existence in the afterlife. They were entombed in great monuments and temples, constructed for this sole purpose. In that the ancient Egyptians also saw their gods as objects of the celestial sky, they felt that the deceased pharaoh would rise to join with these celestial gods. The pyramids and some of the other temples constructed for the Egyptian King's burial are aligned with the four cardinal points of the Earth. This is thought to represent the daily rotation of the sky. The Great Pyramid at Giza contains two shafts that extend from the King's burial chamber to the outside. These two shafts appear to be closely aligned in the direction of important parts of the sky for ancient Egyptians. One shaft points in the direction of the North Celestial Pole where the "Undying Stars" are located. The other shaft is believed to be pointing in the direction of Orion. The ancient Egyptians saw Orion as a celestial representation of Osiris, god of the underworld, who would assist the deceased pharaoh on his journey into the afterlife. From what we have learned about ancient Egyptian astronomy, there is no doubt about its existence. The application of their astronomy was deeply embedded in their culture. There are two things that the ancient Egyptians have left for us; one is the calendar we use today, and the other is the 24-hour clock system. The calendar may not have been as

accurate as the Mayans' or our atomic clocks, but it was much more accurate than the lunar calendars. The 24-hour system of telling time comes from the decans they saw in the celestial skies. Little appreciation is given to these two accomplishments, yet it is because of the ancient Egyptians that people today can make an appointment and meet at the agreed time.

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