Mysteries and Discoveries of Archaeoastronomy

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From Giza to Easter Island

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COPERNICUS BOOKS
An Imprint of Springer Science+Business Media

in Association with
Praxis Publishing, Ltd.

Published in the United States by Copernicus Books,
an imprint of Springer Science+Business Media.

Copernicus Books
Springer Science+Business Media
233 Spring Street
New York, NY 10013
www.springer.com

Library of Congress Control Number:
2009921135

Manufactured in the United States of America.
Printed on acid-free paper.

9 8 7 6 5 4 3 2 1

ISBN 978-0-387-76564-8 e-ISBN 978-0-387-76566-2

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Introduction

Introductions are perhaps best left unwritten.

The fact is, if you really want to read this book, it's pointless for me to introduce it, since you're going to read it anyway. If instead you don't want to read it, there's little I can do to convince you otherwise (assuming, of course, that you read the introduction). So I'll just try to tell you, in as few words as possible, why I subjected myself to the task of writing this book, and why I'd like to subject *you* to the task of reading it.

Reading has become our habitual mode of learning, and writing is what comes naturally to us as the most effective means of passing on knowledge. Oral tradition does not exist anymore, and when for some reason there is a lacuna in the written sources that *narrate* something that is otherwise right there beneath our noses, we tend to go mad trying to figure out what we are looking at.

For example, let us consider the dome of Santa Maria del Fiore in Florence. By the end of the 14th century, Giovanni di Lapo Ghini had brought construction of the cathedral to the point where the octagonal drum, the base for the cupola, was complete. In 1420 Filippo Brunelleschi won the competition to build it with a project (perhaps already outlined by Ghini) based not on the traditional rounded arch (which would form a hemispherical dome), but on the nearly insane idea of a pointed arch on a polygonal base, which effectively meant conjoining eight colossal vaults, one for each side of the octagonal drum—a project that posed technical difficulties so enormous as to be deemed impossible.

The great architect, as can be plainly seen, pulled it off. Yet he did not leave behind a single written word about his insights or methods—or, more accurately, nothing has been found. Consequently, seeing as the cupola cannot be dismantled and reverse engineered, modern scholars have had quite a time trying to reconstruct the techniques used by Brunelleschi for his masterwork, conducting innumerable experiments and publishing reams of studies. And this is hardly the empty academic exercise it may seem, given its necessity for the conservation and restoration of the dome.

Santa Maria del Fiore is a monument that remains a symbol of the intelligence and tenacity of every person who constructed it, from the master architect Brunelleschi to the humblest stonemason who worked on it. It was built less than 600 years ago, yet scholars of today had to work arduously and patiently, and above all with due respect for the intelligence behind the structure, before understanding its secrets.

In this book we will be sifting through the clues of knowledge far more ancient than this. One could say that the aim of this book is to search for a new way of reading the past, a way that would enable us to meet the challenge of understanding the minds of people who conceived, engineered, and built monuments as grandiose as Stonehenge, the Great Pyramid of Giza, and the Pyramid of the Sun of Teotihuacan, without leaving us any descriptions or plans, without even having written language in some cases—a challenge that one might define as *predicting the past,* building the study of the past as a science capable of developing models and testing its predictions in the field, and from these proofs build new models. Nothing radical, just doing what all the other sciences do.

One concrete possibility for exploring the thought of our predecessors is analyzing the relationship they had with the sky, which in fact is the guiding thread of this book. But do *not* mistake this for an original idea. Norman Lockyer had already thought of it in the late 19th century, after which it remained more or less forgotten until the 1960s, when the famous work on the astronomy of Stonehenge by Gerald Hawkins and on the astronomical connections of various other megalithic sites by Alexander Thom helped establish a new discipline, most often referred to by the rather unfortunate term *archaeoastronomy*. It is a science that has not yet found, at least in my view, its true conceptual identity. It is still rough around the edges, knocking about in that limbo between "exact sciences," particularly physics, and "human sciences," the salient one for our purposes being archaeology. This is an opportunity, then, from which we might draw advantage, and try to build a methodology that would in some way be new, free from the majority of existing schemas and devoid of the customary prejudices that often encumber our vision of the past.

To accomplish this, I will take you on a virtual trip around the world in search of the traces, almost always both spectacular and enigmatic, of the astronomical knowledge possessed by the ancients. Dealing in depth with *all* the ancient civilizations that studied astronomy would be impossible, given that they all seem to have done so. Instead, we limit ourselves to prehistory, the megalithic cultures of Northern Europe, Malta, Egypt, Mesopotamia, India, China, Japan, North America, Mexico, Peru, and Easter Island, visiting such extraordinary sites as Karnak, Ggantija, Abu

Simbel, Newark, Chaco Canyon, Teotihuacan, Chichen Itza, Cusco, Machu Picchu, and Nasca.

Since this book is not a technical treatise, the purpose of the journey we are about to take is not to catalogue in detail all of the astronomical achievements of the past so much as to try and see them as a whole, in a comprehensive way that would show the depth and breadth of the thought behind them. Because the thought of the ancients—and particularly the scientific thought—has often been misconstrued, maligned, or, worse, dismissed. To understand the extent to which this has occurred, just open any volume written by the renowned historian of science Otto Neugebauer, according to whom: "The requisites for the applicability of mathematics to problems of engineering were such that ancient mathematics never found any practical application." I do not agree, and in the first part of this book I will endeavor to convince you that I am right, and I will do so in an unusual way: by relying only on facts.

Once we have the facts, we will interpret them, look within them for models that will enable us to evolve our knowledge of the past, even if just a little. This is what the second part of the book is about. Our point of departure is the pact that we make to stop seeing the past through prejudices and preconceptions, to rely as little as possible on our tendency to schematize reality, on that whole set of mental habits that often pop back up even as we are trying to eliminate them. We will then see emerge a possible interpretive model that is founded on the relationship the ancients had with nature, intended in the sense of everything that surrounded them—the *cosmos*. The numerous astronomically aligned monuments of the past then become interpretable as acts of will, expressions of power on the part of those who held it—the will to replicate the heavenly plane here on earth, the will to build sacred landscapes.

Consequently, in the closing chapters I will take you on another journey—an in-depth examination of the most compelling, the most intensively studied, certainly the most famous and, until recently, the most misunderstood sacred landscape on earth: Giza, Egypt.

Author's Note

As we shall soon see, the ancients had very clear ideas about what goes on in the sky, and consequently, in order to get the most out of this book, the reader will need to know at least the basics. Unfortunately, though, we hardly ever raise our eyes to the sky nowadays, and while the annual solar cycle and its relative terminology (solstices, equinoxes, etc.) are more or less familiar, once we start talking, for instance, about the 18.6-year lunar node cycle, we enter into an area of knowledge that, if we ever studied it at all in grade school, has most likely been long forgotten. For this reason, I had originally thought to put the appendix, "The Sky with the Naked Eye," at the beginning of the book, but a unanimous chorus of opposition from those unfortunate souls who were subjected to reading the early drafts of this book made me change my mind. So whenever a term is unfamiliar, be it *Milky Way* or *precessional cycle*, turn to Appendix 1 at the end of the book for an explanation.

I should also point out that, in the interest of further easing your reading, I have chosen to forgo footnotes completely.

1 Thirty Thousand Years of Silence

> Gradually, we are told, step by step, men produced the arts and crafts, this and that, until they emerged into the light of history. Those soporific words ''gradually'' and ''step by step,'' repeated incessantly, are aimed at covering an ignorance which is both vast and surprising.
>
> —Ugo de Santillana and Ertha Von Dechend, *Hamlet's Mill,* 1983

1.1 Twice Perplexed

This book deals with how humankind experienced its relationship with the sky and the stars. It should therefore begin with the moment the first human started thinking for the first time about the natural world, about the sky above, attempting to keep track of its cycles and attribute meaning to them. The problem is that we do not know when this happened. Until just a few years ago, anyone would have taken it for granted that this date fell *not before* early humans began establishing permanent settlements, at the end of the Upper Paleolithic age, around 8000 BC. This is when, according to every text on prehistory, the hunter-gatherers became sedentary farmer-herders and started forming villages and then cities, and the need to perform certain agricultural procedures at the right time led them to keep track of the celestial cycles and thus to fashion a calendar. In addition, the need to store food and provisions led them to discover how to bake clay for making vessels, which led to the flowering of the early trades, which led to further steps in civilization's development.

No one would have challenged this hypothesis, including Karel Absolon, director of the archaeological excavations at Dolni Vestonice, in Moravia, a site dating from c. 24,000 BC. That is, until one fine day when the soil at Dolni gave forth a little baked clay figurine.

Think about the immensity of *sixteen thousand years*. That figurine was sixteen thousand years older than it should have been. So Professor Absolon decided, naturally, that it simply could not be true. He

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_1,

formulated a theory whereby the figurine had been modeled with organic material, clay and fat, and then left to dry in the sun. That is a neater fit, is it not?

If you go to Dolni Vestonice today, you can visit a factory, a 26,000-year-old ceramic factory, with two high fire pottery kilns. The pottery from Dolni Vestonice, of which there have emerged thousands of exemplars since its discovery, was crafted with a technique of joining of small blocks of clay that are then fused by firing.

Is there a mystery here at Dolni Vestonice? Obviously not. Someone imagined, modeled, and baked a clay object, inventing pottery, not because of the need for vessels to conserve seeds or grain, but for another reason; indeed, many of the statuettes found there were deliberately broken after firing, through some "ritual" procedure. This example shows that the history of human thought, prehistory included, is neither linear nor global. If we look at 24,000 BC from a bird's-eye view, we do not see anyone baking a clay figurine. But if we get a magnifying glass and look in Moravia, we will. Perhaps we would see them in other places, too. The earliest studies of prehistory constructed a simple "evolutive scheme" that was comfortably reassuring in its linearity, marking out the progress of *homo sapiens* who, after thirty thousand years of silence, somehow appeared at the dawn of history in the "cradle of civilization," the Mesopotamia of the Sumerians, whence civilization itself spread like a cloud of fairy dust throughout the world.

This ridiculous and fundamentally sloppy hypothesis governed prehistorical studies until the 1970s, as we will see in the next chapter. We can say for now that letting oneself be lulled to sleep by the "cradle of civilization" mentality makes no sense today; leaning on the facile assumption that humans "first did this, then gradually did that" is risky at best, and often just plain wrong. The world that surrounds us is not linear. Sure, macroscopic physical processes follow deterministic laws where cause is followed by effect, but those very laws themselves are not linear, and it is often impossible to predict how a system will evolve in the future, even when one knows everything there is to know about its present. Many physical processes are *chaotic*: they reproduce themselves on an ever-smaller scale, such that if we put them under a microscope we find that the part corresponds to the whole in an orderly and frighteningly complex way.

So it is only now that we are beginning, very laboriously, to realize that these past thirty thousand years that constitute our history are anything but the slow and steady march of progress.

For example, art is without doubt an expression of thought and, as we will see in the next paragraph, of astronomical thought as well. It would thus be important to establish when art "begins" and how it progresses. The answer, however, is extremely difficult. First of all, there is the strong suspicion that art is not the exclusive prerogative of our species, and that the Neanderthals made art, too (Neanderthals, we will recall, were not our ancestors but occupied the same ecological niche in Europe and Asia that *homo sapiens* occupied in Africa, and went extinct for reasons that remain unclear when we, *homo sapiens*, colonized Europe between 36,000 and 30,000 BC), as demonstrated by the recent discovery of a stone mask at the La Roche–Cotard site, on the banks of the Loire in France. The history of Neanderthal thought is therefore still to be written (Arsuaga 2001), maybe even including astronomical thought. In any event, the art of *homo sapiens* appears more or less in the same period in which the Neanderthals disappear (c. 32,000 BC), after which, it was customarily assumed, an inexorable "evolution" gets gradually underway, starting from the first, timid attempts at figuration and arriving at the extraordinary masterpieces of the famous caves of Lascaux and Altamira, in France and Spain, respectively, both dating from about 15,000 BC.

But in the spring of 1994, archaeologist Jean-Marie Chauvet, poking around in the Ardeche Gorge in southeastern France in the company of some friends, discovered a painted cave. Chauvet, whose name the cave now bears, was not on duty when he made the discovery, and he went through a long legal battle with the French government, which refused to recognize the legal rights of the discoverer. This slowed down scientific study of the cave, but it is now fully documented. The spaces reveal signs of long habitation, perhaps thousands of years. The artist or artists who worked there painted more than four hundred figures of animals, mostly lions, horses, oxen, and rhinoceros. The painting technique is splendid and makes knowing use of perspective in the representation of herds of mammoths and some of the bear figures. It is tempting to interpret the Chauvet cave as a site where the prehistoric cave bear was worshiped, thanks to an abundance of bear's skulls there, but it is a dangerous leap because the presence of bones in a prehistoric cave might simply mean that bears and humans lived there in two distinct historical moments. In any case, Chauvet is a magnificent and valuable example of Paleolithic cave painting, like Lascaux and Altamira, which, as I said, date from around 15,000 BC.

In this book we will encounter many perplexed faces, like that of poor Professor Absolon as he puzzled over that first baked clay figurine. But perhaps none will equal the expression that must have overtaken the features of Dr. Helene Valladas of the Gif-sur-Yvette research center one day in July 1994. For Dr. Valladas had been given the task of analyzing some samples from the Chauvet cave, and the results were unequivocal: the paintings had been executed sometime around 30,000 BC.

Let's stop and think about that for a moment. Think about the immensity of *fifteen thousand years.* As at Dolni Vestonice, there is no mystery at Chauvet. Someone imagined a painted wall, developed their drawing ability and portrayed the salient aspects of the nature around them, perhaps for ritual reasons, perhaps merely for a love of beauty. And they did it fifteen thousand years before the alleged "succession of styles" of Paleolithic art would allow us to imagine.

We are accustomed from childhood to allocutions such as "the cradle of civilization" and "the flowering of culture and the arts." Our intellects are shaped in the soft and comfortable swaddling of linear development, where everything proceeds in chronological subsequence, where humans did this, then that, then the next.

But that is not how history happens. For this reason we must be careful with the words we use to describe the past. Though they're sometimes the only ones available, many words are often overly charged with meanings and implications that extend beyond what we really know about that to which they refer. For example, all statements that suggest an inexorable process of "evolutive becoming" are dangerous, and it is for this reason that I must urge readers not to make the usual assumptions when reading this book. If I write "the Olmec civilization developed in the ceremonial center of La Venta," by *ceremonial center* I simply mean a place where something happened that was related somehow to the sphere of thought, whether magical, religious, or scientific (see how I am compelled to use words charged with meaning to explain how words can be charged with meaning...). We do not know what the "something" is that took place there, and it could be very different from what we might expect. If I write that a civilization "develops" or "flourishes," I mean only that, in point of fact, in a certain period, in a certain place, certain people to whom we have given a name (which is often itself a pure convention, such as Olmec or Inca) did something interesting. It does not necessarily mean that they first did a less evolved version of that interesting thing and later a more evolved version. It does not mean that it could not have all just started there and ended there, without any evolution whatsoever.

1.2 Astronomical Thought in the Paleolithic

Until recently few people would have been inclined to admit that the thought of Paleolithic man was anything more than an inchoate tangle of superstitions, which were in turn reflected in his art. Fortunately, this view began to dissipate when it was realized that the animals represented in the caves constituted a negligible part of the inhabitants' diet, and are rarely represented as wounded or dead, making it difficult to argue that the figures have a "magical" purpose, as in a propitiatory rite for the success of the hunt, for example. Analyzing the spatial distribution and frequency with which certain subjects are represented, it became possible to establish correlations between specific sites within the cave and specific figures and genres, in a spatial distribution whose meaning escapes us but which nonetheless demonstrates that Paleolithic humans conceived and organized their space according to rules (Leroi-Gourhan 1970), a fact that had never dawned on earlier scholars of prehistory. Today we also know that, among the things Paleolithic man thought about, celestial phenomena were unquestionably right up there.

The first scholar to find documentation of prehistoric observation and study of natural cycles was Alexander Marshack (1972). Hired by the National Aeronautics and Space Administration (NASA) to write a history of humankind's relationship with the moon, Marshack was struck by the profound knowledge that the ancients possessed with regard to the movement of the stars (we will be getting to this soon ourselves) and became convinced that this knowledge had to have been formed over the course of many previous millennia. Despite this highly debatable progressionist premise, Marshack went on to make some surprising discoveries.

His attention was first captured by a group of bones dating back to the Upper Paleolithic that had been notched at more or less regular intervals. Studying these marks more carefully, he realized that the notches were not made casually, but grouped in sequences, and moreover that they were made using different cutting tools. This meant that we were not dealing with someone who sat down one afternoon and, having nothing better to do, whittled a few notches in a bone: these marks were made separately and successively and, above all, systematically. The next step was to determine if the number and way in which the cuts were grouped had a broad, macroscopic meaning, or if instead it was localized, limited to the marks a hunter made for each kill. When Marshack realized that they were grouped in sequences of 15 or 16, he hypothesized they might have been used to record the phases of the moon. To make sure this was not just coincidence, Marshack analyzed a huge number of other bones with notch clusters as well as sticks with decorated handles. His sample was large and covered a time span of more than 20,000 years. And what he invariably found were similar numerically grouped signs, the most plausible explanation for which was that someone had used them to measure time by recording the phases of the moon. In other words, this someone had observed the celestial cycles and

Figure 1.1: The Ishango Bone

made what is, essentially, a calendar. For instance, one of the artifacts Marshack studied is the Ishango bone, a carved bone discovered near Lake Edwards in equatorial Africa in the 1970s, conserved today in Brussels at the Royal Belgian Institute of Natural Sciences. The site of the discovery was originally dated to c. 6500 BC, but it is now thought to be much older, perhaps by as much as 20,000 years, which would make the Ishango bone the oldest "mathematical instrument" ever found. The artifact has a total of 168 notches grouped in sequences that seem to record the cycle of lunar phases over a period of 5½ months.

What interest would Paleolithic man/woman have had in the cycles of the sky? As for the seasons, for instance, it has been sometimes claimed that interest in the seasonal cycle was born with the dawn of agriculture, and therefore with the evolution from nomadism to sedentarism of that human community commonly referred to as the hunter-gatherers. However, Marshack found abundant proof that this interest predated agriculture. For example, he noticed, in a representation of two bisons painted side by side in the main chamber at Lascaux, that one is shown with its full winter coat and the other in summer molt. Marshack studied other objects where the representation of the seasons is unequivocal, such as a bone knife found at La Vachè, in the Pyrenees, which has carvings depicting spring on one side (for example, flowering plants) and autumn on the other.

Marshack's discoveries and interpretations were pioneering—actually the first attempt to attribute a form of "mathematical" thought to Paleolithic humans, and some of his results have been later disputed (see, for example, D'Errico 1989). However, at least in my view, it should be obvious that "scientific" thought, in the broad sense of the will of understanding nature, and "symbolic" thought, in the broad sense of connecting nature with human existence and religion, are two intrinsic aspects of the human thought that cannot "evolve" from a primitive state, and Marshack was among the first to put in evidence this "obviousness," which however, to put it mildly, remained undigested by the community of pre-historians.

Anyway, it seems that these same prehistorians should prepare themselves to accept the fact that Paleolithic *thought* was expressed in forms rather more complex than a few notches on bones.

1.3 An Enigmatic Scene

One of the more curious characteristics (at least for us today) of Paleolithic art is the near-total absence of pictorial representations of men and women. The exceptions are precious few, and many of them are not much more than thoughtless doodles. The most interesting images depict creatures that are half-man and half-animal, such as the so-called "bison-man" of Trois Frères and, particularly interesting for our purposes, the famous "bird-man" at Lascaux.

The Lascaux cave undoubtedly has many features that would induce one to call it a "sanctuary," starting with the fact that it is basically a large frescoed hall with chapel-like recesses in the back. We will resist the temptation to go down that road, however, for it leads nowhere. We will take instead a more "aseptic" point of view. The fact is that the images found in the main chamber, genuine masterpieces of figuration, represent only animals, the most famous being a marvelously lively herd of bulls. The only "human" representation anywhere is the one mentioned earlier, which is painted in one of the small rear recesses, not easy accessed and visible to no more than a few people at a time. (Plate 1)

In what is perhaps the most enigmatic image in the entire history of humanity, a male creature with the head of a bird and body of a man with an erect phallus gives us his profile. His right hand seems to be holding a stick, though they are not in contact. The handle of the stick is carved in the form of a bird, perhaps a dove. On the bird-man's left, a large bison lies dying, shot full of arrows. A woolly rhinoceros (an animal which is now extinct) and a horse complete the scene.

The scene has been interpreted as describing a hunting scene, a funerary commemoration, worship of the dead, hallucinogenic visions, sacrificial and even sexual rites. Obviously this just means that we haven't the vaguest clue what it represents, and probably will never know with certainty. However, the German scholar Michael Rappenglueck (1998) has proposed a reading that is in many ways revolutionary. He addressed the problem by insisting

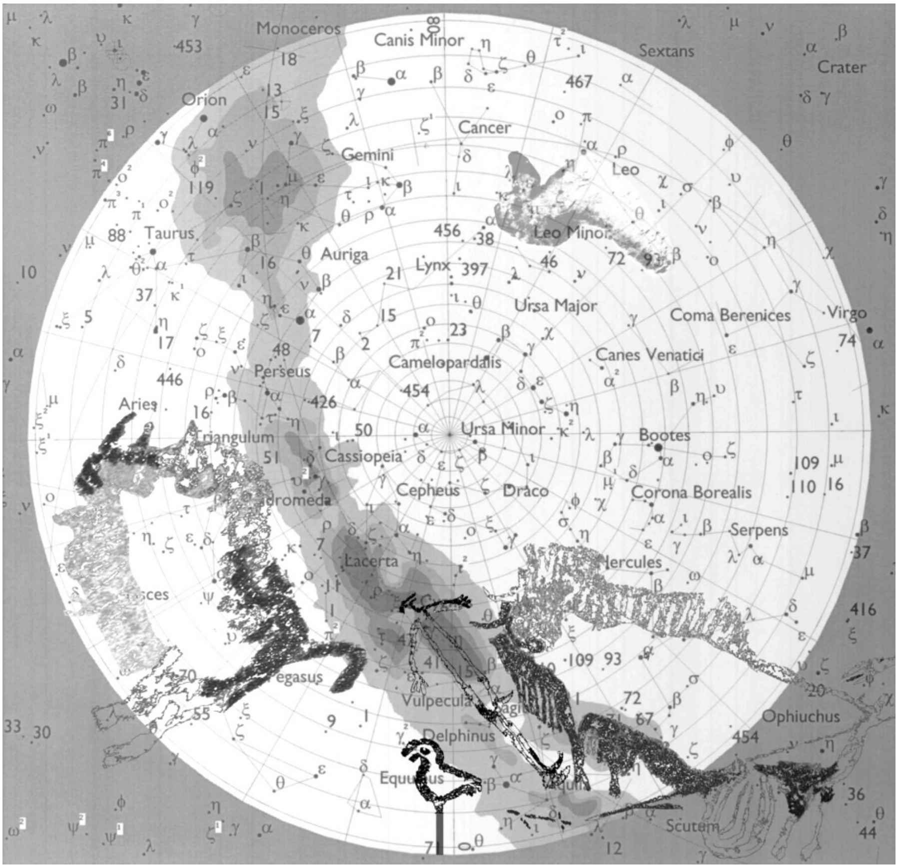


Figure 1.2: The "bird-man" of the Lascaux Cave in the Milky Way (from Rappenglueck 1998, with kind permission)

that his analysis be based on the most objective data possible. To do this he took accurate measurements of the images in the cave and logged them into a computer; that way he'd have all the time he needed to look for eventual connections, whether visual or spatial, between the painted images. Then he conducted an operation that we encounter here for the first, but certainly not the last time during the course of this book: he sent the sky back in time.

Because of a phenomenon known as precession, the sky is not always the same night after night. Precession is a slow movement of the earth's axis that describes a complete cone over a period of about 26,000 years. Since the north celestial pole is the projection of the axis of Earth's North Pole into the celestial sphere, as a result of precession the pole describes what we see (or rather, what we would see if a human life span were not so brief as to render these movements imperceptible) as a circumference. Between 19,500 and

12,000 BC, the North Pole crossed our galaxy, the Milky Way. The polar region of the sky in 15,000 BC was therefore not the same as that of today, which is dominated by the constellations Ursa Minor, Ursa Major, and Draco, but was situated in the area of the Milky Way that today we associate with the constellation Cygnus. Back then, the pole star, that is, the visible one closest to the pole, was Delta Cygni, and the great bird of the night sky was therefore seen to rotate, as if tethered to the North Pole. Cygnus thus had the same polar function back then as Ursa Minor has for us now, and not surprisingly that is precisely where our polar star is located (for further information and clarification on the astronomical concepts introduced here, such as precession and the north celestial pole, see Appendix 1).

What Rappenglueck did was use a computer program to reconstruct the sky above Lascaux during the epoch in which it was painted, and then looked for correspondences in the image of the bird-man. He observed that, entering the recess, the stick is inclined at an angle of 45.3 degrees with respect to the vertical of the bird-man himself, which, at Lascaux's latitude, corresponds rather neatly with the North Pole (45.1 degrees). He also found that the eyes of the bird-man, the carved bird on the staff, and the bison form a triangle, and if this triangle is superimposed on a map of the polar region of the sky as it was in the epoch of Lascaux, the figures come to life as *constellations*. Obviously, they are different from the ones we are familiar with, and include stars that for us belong to other constellations entirely. But back then, the bird-man appears to have been a major constellation stretched across the Milky Way. The upper part is composed of stars from the constellations we know as Cygnus and Vulpecula, while the lower part includes stars from our Aquila, Serpens, Hercules, and Sagitta. The bird-man rotates around the pole, indicated at the time by Delta Cygni, and the bird-headed staff represents the polar axis. The three animals that surround the scene—a bison, a woolly rhino, and a horse—are recognizable as three large constellations connected, respectively, to the northwest (autumn), northeast (spring), and south, with the horse corresponding to the constellation we call Leo.

Rappenglueck went further and proposed an interesting "cosmographic" interpretation of the scene, identifying the bird-man as an intermediary who put humans in communication with the divine, like a shaman or priest, and the rest of the scene as a representation of his "cosmic voyage." This is an interesting example of an ethnological-analogical reading, an approach we'll be investigating in great detail in Chapter 15.

The data presented by Rappenglueck are fairly convincing. However, we still do not know when people started grouping stars into constellations. All we can say is that it remains quite possible that it dates back to remote prehistory (Gursthein 1997, Frank 2000), which leaves us having to admit that we will probably never know for certain whether the intention of the Lascaux artist was to create a complex cosmographic image, or something else entirely.

But if we move ahead to the fifth millennium BC, we can begin retracing the ancient skies and man's relationship to them, this time clearly and unequivocally.

Forests of Stones, Rings of Giants

2

> We do not know the extent of Megalithic man's knowledge of geometry and astronomy. Perhaps, we never shall. He was a competent engineer. Witness how he could set out large projects to an accuracy approaching 1 in 1000, and how he could transport and erect blocks of stone weighing up to 50 tons.
>
> —A. Thom, *Megalithic Lunar Observatories*, 1971

2.1 The Radiocarbon Revolution

There are places on this planet where the intellect vacillates and common sense protests, places that unsettle and overwhelm, where sometimes the only response is that odd indifference which is the mind's last defense.

Well, we had better get used to it, because these places are exactly where this book is taking us. The first such places we will visit are also chronologically among the first where humans set out to erect monumental stone constructions, for reasons we will get into presently. We are talking about the megalithic sites of Europe, the places where people expended significant amounts of time and energy extracting, shaping, moving, and erecting gigantic hunks of rock, or megaliths. There are single stones (menhirs), two upright stones capped by a third (dolmens), stone corridors covered by earthen tumuli (barrows), stone circles (cromlechs), and larger circles or ovals delimited by a ditch contiguous with a raised bank (henges). People moved giant stones in Brittany, Ireland, England, Scotland, Spain, Italy, and Malta. We call their civilization "megalithic" because their distinguishing characteristic is this extraordinary skill in handling stones whose size range from the merely massive (several tons) to the enormous (several tens of tons) to the colossal (up to 300 tons) (an in-depth discussion on the problem of transporting megaliths in ancient times can be found in Appendix 2).

It is important to remind ourselves that these stones were extracted from quarries, shaped, and transported *without the use of metal tools.* This is true,

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_2,

by the way, not only for the megaliths in this chapter but for practically all the stones from all over the world that we will encounter in this book (the few exceptions are in Egypt, where it is thought they used copper saws with the help of abrasive sand). So, the quarrying and shaping of the stones was done with tools made of stone. If the quarried stone was relatively soft, like limestone, one could easily use tools made of harder stone. However, for stones like granite or andesite (which is similar to granite, and found in the Andes), one had to use "percussors," which were chunks of the same material worked roughly into spheres and then violently thrown against the area to be removed.

We know precious little about megalithic civilization. The ceramics of the megalithic peoples of Great Britain, for example, are classified in three main styles—Peterborough, Grooved Ware, and Beaker—with the first being very similar to the third and all three sharing overlapping characteristics for long periods. These people did not have written language as far as we know, and until just a few years ago it was thought that the structures they built and the objects they made were nothing more than feeble attempts to mimic the splendors of the Near Eastern and Aegean civilizations, inept imitations made by "howling barbarians."

Until the 1970s, archaeologists had no method of absolute dating. This meant that even if you had a stratigraph, which is archeological data from successive layers at the same site, the best you could build was a *relative* chronology (e.g., ceramic objects with a square pattern are older than ceramic objects with a diamond pattern), but you had no way of determining the absolute dates (e.g., the square pattern is from 1800 BC and diamond pattern from 1600 BC). But the inability to know for certain proved to be no obstacle for archaeologists and historians who, instead of prudently suspending judgment or at least qualifying their claims, embraced the nefarious dogma that human civilization was *born (sic)* in Mesopotamia and Egypt around 3000 BC and then slowly, gradually spread through Europe in ever-widening concentric circles, this model being valid for both the diffusion of ideas and the physical migration of populations. The main exponent of this "diffusionism" was Gordon Childe, according to whom civilization passed first through the Aegean and then spread into Iberia and Italy, crossing the Danube into northern Europe and finally reaching the British Isles. One of Childe's specific theses was that the great Mycenaean tombs called *Tholos* (long corridors with vault-roofed terminal chambers) were the inspiration for the chamber tombs and other megalithic structures that appeared first in Spain and later in northern Europe.

It was only logical, therefore, to date megalithic civilization to the middle of the second millennium BC. That is, until the revolution. No other word, really, except *revolution* can describe the fallout of the discovery, around 1950, of carbon dating.

The story of the so-called radiocarbon revolution is also the story of how a single, ingenious idea caused the complete upheaval of an entire discipline; I recommend reading the classic (if dated) book by the historian and archaeologist Colin Renfrew (1973), which also contains an exhaustive introduction to the technical aspects of carbon dating. A simple explanation will suffice here: carbon 14 (C-14) is a radioactive substance, meaning that it decays into another substance by emitting particles according to a simple and constant physical law. C-14 is present in the air and accumulates in organisms through respiration; when the organism dies, the accumulation stops. So, by measuring the C-14 present in the remains and checking it against the constant rate of radioactive decay, it becomes possible to establish when the organism stopped breathing (I am breezing right past all the technical problems involved here). The results were slightly variable when it was first used in 1949, but it was later perfected by calibrating C-14 data with that of dendrochronology, the dating technique that uses the growth rings of trees to reconstruct historical wood sequences.

C-14 dating of organic remains from megalithic sites melted away diffusionist ideas as the sun does snow. The Kercado tumulus in Brittany, for example, turned out to be one of the oldest stone structures on the planet, dating all the way back to 4700 BC. And who would have thought that the megalithic civilization of Malta was building temples 700 years before the Pyramids? In England, Stonehenge was already underway by 2800 BC, more than 1300 years *before* the Mycenaean tombs of which it was allegedly a pale imitation (kind of makes one wonder if the Mycenaeans weren't the copycats...).

The diffusionist dogma is, in my view, a perfect example of how history and archaeology have habitually underestimated the thought of civilizations that were inconsiderate enough as to leave us with no written accounts. In fact, every scholar who adhered to that dogma assumed that the great megalithic monuments were built by barbaric people in emulation of their superiors, never asking seriously what purpose they might have served, to the extent that we still do not know much more now than they did then. To demonstrate this, let's take a trip to the realm of the giants.

2.2 Stone Forests

The first site we will visit together is Carnac, in Brittany. Here, sometime between 5000 and 7000 years ago, someone built a forest. The forest is made

Figure 2.1: The alignments at Kermario

of giant stones, or menhirs, disposed in three main alignments: Kermario (10 lines, 982 stones), Le Menec (11 lines, 1100 stones), and Kerlescan (13 lines, 540 stones). The megaliths were selected and arranged so as to create a perspectival effect, such that their dimensions increase with distance.

The ancient inhabitants of Carnac knew what they were doing when it came to big rocks. The largest stones in the alignments reach several dozen tons, and they're not all simple menhirs; there are also other, more complex structures. Circles above all, like the one at the western extremity of Le Ménec, or the two cromlechs of Er Lannic in the nearby gulf of Morbihan, one made of 28 megaliths and the other of 32 (half of the north circle and the entirety of the south one are underwater, proof that the sea level was lower at the time of construction). In addition to circles they also built large, corridor-like structures used as tombs, and dolmens. Some of the corridors are still covered by massive earthen mounds called tumuli, circular or oblong in form, others are not and thus reveal their extraordinary internal structure, while still others were perhaps never meant to be covered. Among the most important of these corridor-type structures are St. Michel, an oblong tumulus measuring 125 meters and more than 10 meters high, the aforementioned Kercado from 4700 BC, Locmariaquer, originally more than 170 meters long, and lastly Gavrinis, a little island in the gulf of Morbihan 4 kilometers from Locmariaquer. Upon it was built a round tumulus 50 meters in diameter and 9 meters high. Inside runs a long corridor whose walls are splendidly decorated with spiral motifs that suggest the whorls of a fingerprint (similar motifs are found at various other megalithic sites, as we'll soon see).

The sheer quantity of monuments in the Morbihan area is impressive. The entire territory is literally bristling with stones that pop up unexpectedly in the woods or pose fetchingly in the planted fields. Among the isolated stones that one encounters, "Le Manio," at more than 6 meters tall, is particularly striking, but the largest stone ever moved in Brittany is the Grand Menhir. The Grand Menhir could not be more appropriately named. It was originally a truly gigantic object, more than 20 meters tall and weighing at least 300 tons, made from a type of stone that is not found in the immediate area, the nearest source of which is the Quiberon peninsula, a good number of kilometers away. Today the great megalith lies on the ground, split in four pieces (it is not clear when this happened). But when it was standing, it was visible from great distances, announcing itself as the heart of the entire territory.

The few dozen square kilometers around Carnac, then, was the site of a frenetic, even obsessive building program that radically transformed the landscape. It is obvious, of course, that the overall purpose of these operations had something to do with some sort of thought, and no doubt with some form of religiosity, with a particular bearing on death and the dead. Which is why I am strongly tempted to call the complex at Carnac a *sacred landscape*.

The term *sacred landscape* will accompany us throughout this book, and I have to say I am not all that thrilled by the prospect. While the word *landscape* expresses exactly what I'd like to talk about, that is, the "plane of man," the level (as opposed to above or below ground) to which humans have full access, free to study it, model it, build, invent, and think, the word *sacred* is too easily misunderstood, too quickly classified according to the established schemas that make up our culture and tradition and knowledge, our methods and measures of thought and judgment. I would therefore like us to agree that by sacred landscape we mean an environment in which people live, which has been studied, selected, considered, and constructed in accordance with an idea, a religious, scientific or philosophical mental construct, but whose specific methods and forms of both thought and construction can be completely different from culture to culture. I would also like to agree that having a name to call this thing does not mean we have understood it. I will return to this topic in Chapter 15, where we will see how the sacred landscape was connected to power, to the extent that it could alternatively be called a "powerscape."

In any case, names aside, the only thing we really know is the dumb truth of facts, and the fact is that at Carnac, there are thousands upon thousands of tons of giant stones that were quarried, transported, and erected. We have nothing written, no book of instructions. We do not know why people did this at Carnac and in many other places—places like, for example, Ireland.

2.3 Spirals and Mounds

It is difficult to say what Newgrange, in the Boyne Valley just outside Dublin, really is. It is definitely another one of those places where the intellect protests, the mind reels. In fact, we will have to resign ourselves for now and postpone any attempt at understanding it until the second part of the book. For now, let's be satisfied with simply accepting it as a tomb used numerous times over a long period, and try to get a basic idea of what we are dealing with. (Plate 2)

Around 3200 BC, a corridor about 30 meters long was built from enormous stone slabs on the steepest slope of a small natural hill. The structure, oriented toward the southwest, ends in three little alcoves. Additional slabs were placed on top of the corridor to isolate the interior from water, and then the whole thing was covered with a tumulus in the shape of a heart. The external walls of the tumulus are dry-stacked and incorporate blocks of white quartz, which make the structure gleam so as to be visible from many kilometers away. It is surrounded by what remains of a circle of megaliths. Many of the stones, both inside and out, are engraved with delicate spiral or diamond motifs.

Newgrange is the cardinal point of a sacred landscape that includes two other major complexes, Knowth and Dowth. Knowth, a kilometer away, though less famous than Newgrange, is in fact much larger at 95 meters wide. Here we also find an abundance of marvelous incised designs, including those on the slabs that make up the 18 smaller structures surrounding it, forming a sort of archipelago.

Dowth, which derives from the Gaelic word for "house of darkness," is a structure very similar to Newgrange. Dowth has two passageways with two terminal chambers; one of the two passageways is aligned with the corridor at Newgrange, the other oriented toward the north. The internal chambers at Dowth are built with enormous megaliths, and even more impressively, the ceiling consists of a single slab. Here, too, the walls are decorated with spiraliform motifs, and they have a strange, almost hypnotic effect in the penumbra of the chamber. There is one slab in a corner that is the most unsettling of all, in that the incisions seem to combine to form a human face.

Numerous other subsidiary structures complete the sacred landscape of the Boyne Valley. There are traces, though not readily apparent, of a cursus, that is, a concave roadway with high banks. This earthwork, 20 meters wide, connected two lesser mounds with a U-shaped area in the proximity of the main tumulus. Just a few dozen kilometers from Newgrange is a second concentration of tumuli, at Loughcrew. Once again the mounds are disposed in groups, the largest of which hosts the so-called T tumulus, which is extraordinarily similar to Newgrange.

2.4 Rings of Rock

On the Salisbury Plain in Wiltshire, England, stands the third megalithic site we will discuss in this book. Its most famous component is Stonehenge. But that's not all that's there. Describing Stonehenge is not difficult, but one must keep in mind that what we see today is the result of a long process of successive phases of construction and reconstruction that spans nearly a millennium.

At first, around 3000 BC, Stonehenge was just a henge, that is, a big circular ditch about 2 meters deep and 114 meters in diameter, to which corresponded a concentric ring made from the earth removed from the ditch (the fact that the ditch was normally on the *inside* with respect to the earth-ring of the henges excludes *a priori* any hypothesis of a defensive function). Within this circle was another circle of 56 holes placed at regular intervals, called Aubrey holes after their discoverer, which were perhaps used to anchor big wooden posts.

Some centuries later, wood gave way to stone. The outer ring of the complex structure was a large circle of 30 trilithons, each composed of two vertical megaliths capped by a third, strung together in an uninterrupted circle. Inside this ring were erected five enormous free-standing trilithons, disconnected from one another. The weight of the vertical stones of the inner group is more than 50 tons each, with the horizontal architraves tipping the scales at a mere 20 tons. The architraves are not, as it may appear, simply placed there but rather fixed with mortise and tenon joints, meaning that cavities were carved into the caps to accommodate corresponding protrusions on the top surfaces of the bearing stones. The big free-standing trilithons in the center are disposed so as to form a U (customarily called a horseshoe). The central geometric axis that divides the horseshoe in half corresponds to the axis of symmetry for the monument as a whole. If we project this axis outside the circle, it meets a single menhir known as the Heelstone, clearly placed there explicitly to define this alignment.

Also belonging to the complex are four megaliths traditionally called station stones, which define a rectangle inscribed within the outlying ring of

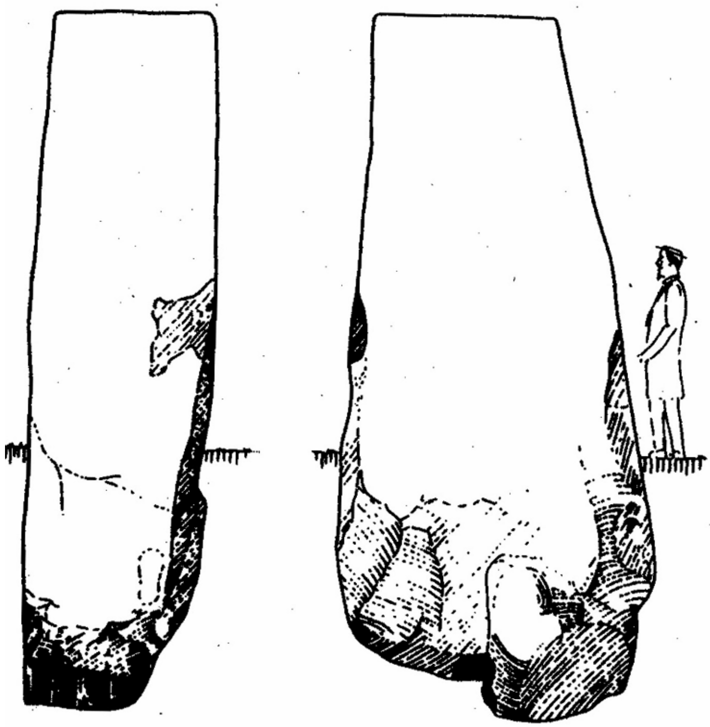


Figure 2.2: A Stonehenge Sarsen stone

Aubrey holes. All the blocks used here are made of local sandstone, called sarsens, and come from an area near Avebury, about 30 kilometers away. These huge sarsens were carefully shaped in the parts that were to remain above ground, while the parts to be buried were crudely “flaked” with a technique similar to that used for making flint tools at the time (remember that Stonehenge is from the early Eneolithic, or Copper Age, and that the only tools available were made of stone, wood, or horn). The result of this flaking method, whether intentional or not, is that these enormous sarsens look an awful lot like macroscopic replicas of hand tools of the Neolithic Age.

Stonehenge also has a secondary perimetral circle and secondary horseshoe made of monoliths much lighter than the monstrous sarsens (3 to 4 tons each on average). There is something curious about them, however; these monoliths are of a type of dolerite known as bluestone, which is not native to the area. In fact, the nearest source is in the Preseli Hills in modern-day Wales, well over 200 kilometers distant.

Scholars have long and strongly doubted that the megalithic people were capable of organizing the transport of dozens and dozens of these stones (each one about the size of four or five washing machines laid end to end and weighing the same as an adult elephant) along a route as long as it was full of obstacles, to the point where some even posited the preposterous idea that the bluestones were already there at Stonehenge, transported by glacial movement during the previous ice age. Since there is not a trace of even the smallest fragment of bluestone in a radius of many kilometers, this theory was wisely discarded and today it is agreed that the stones were quarried from the Preseli Hills, transported to the banks of the Bristol Channel, transferred onto pirogues, and then floated, first by sea and then up the River Avon to a point as close as possible to Stonehenge.

In that sphere of experimental archaeology that is enjoying so much success of late, one amateur group, the Menter Preseli, managed to get financing for a modern-day attempt to repeat the process of transporting a bluestone, an undertaking that was given the humble and unassuming name of *Millennium Stone Project*.

At first, the volunteers who hauled the stone (which weighed an absolutely reasonable 3½ tons) breezed through the heroic enterprise as if it were a weekend outing. The only problem was that they were going so slowly that it soon became clear that the "millennium" part of the production, which

Figure 2.3: Stonehenge from inside

Figure 2.4: The huge Sarsen trilithons at Stonehenge.

would have seen them arrive triumphantly at Stonehenge on New Year's Day, 2000, was not going to happen. Forging nevertheless onward, they finally got to the hard part: transporting the megalith down Bristol Channel on a wooden pirogue. The pirogue in question, evidently displeased with the monumentality of the task assigned to it, promptly tipped the millennium stone into the drink. The water was deep enough that navy divers were called in to find it, after which it was deftly fished out by a decidedly post–megalithic-era crane. In the meantime, enthusiasm (and the remaining funds) were running out as quickly as the millennium itself. To make a long story short, the millennium stone now lies forlornly, with a little placard that cruelly reports its name, in the Carmarthenshire Botanical Garden, despite the belief of many—myself included—that it belongs back home in the Preseli Hills.

Except for a few ax-shaped engravings on some of the sarsens and maybe a couple of human profiles (which, however, could be of natural origin), Stonehenge is a completely anonymous monument. The reason why the site itself was chosen to erect a structure requiring such enormous time and effort remains unknown to us. What is certain is that the entire plain was conceived as a sacred landscape incorporating dozens of other monuments in the course of many centuries. Among them are two long cursuses. One, called the Avenue, starts in the vicinity of the Heelstone and runs northeast for 400 meters before veering off toward the River Avon. Another, at least as old as the first phase of Stonehenge, 100 meters wide and more than a

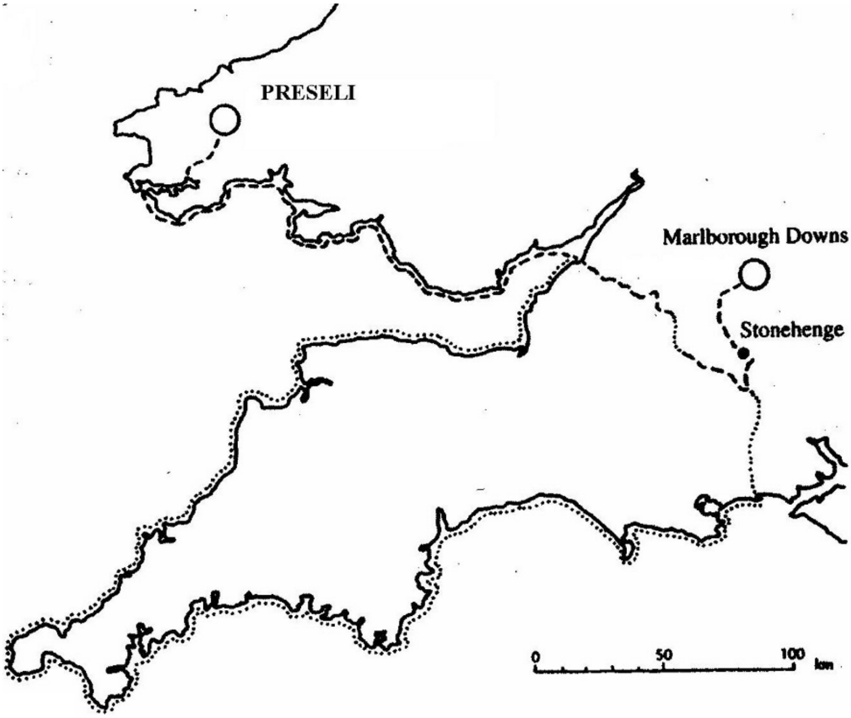


Figure 2.5: The possible paths of the Bluestones from Preseli to Stonehenge

kilometer long, connects it with a group of tumuli. Finally, about 3 kilometers east of Stonehenge there are two other henges, Durrington Walls and Woodhenge.

Durrington Walls, which today is in ruinous condition, was a big henge measuring a formidable 520 meters. The perimetral mound alone was 27 meters wide and the corresponding ditch 6 meters deep. Evidence of post holes indicates that monument was a wooden structure, with two openings at points northwest and southeast onto the banks of the Avon.

Woodhenge owes its name to the fact that it was originally an enormous construction made of wooden posts—stripped trees, basically. Discovered only in 1920 by a reconnaissance flight, it was a ring 85 meters in diameter, open at the northwestern quadrant like its lithic neighbor, Stonehenge, and encompassed six other concentric rings of which there remain only the post holes. Though not very impressive today, the complex must have been quite a sight, with posts which, judging by the diameter of the holes, must have been a good 8 meters tall and weighed at least a few tons; it was thus made of *megadendrs* instead of megaliths. The excavations of Woodhenge have given us little to go on: the tomb of a child and some potsherds.

2.5 Picnic of the Giants

Another sacred landscape, even more powerful and complex than Stonehenge, can be found just a few dozen kilometers to the north.

Imagine a family of giants having a picnic. The parents polish off the wine and then have a nap while the children play in the meadow. The children make two circles with pebbles, and then a third circle around both. They dig a little moat around the pebbles and then fill it with water. They model mounds and bridges, they scratch roads and channels into the ground. At sundown, the family goes home and the traces of the children's games remain.

This is the impression you get when visiting Avebury, one of the most complex monuments erected by any megalithic civilization, anywhere. Avebury is an enormous ring mound 400 meters in diameter with the customary corresponding internal ditch, impressively deep here (I will resist the temptation to urge you to stop and think about how many meters 400 are, or how many tens of thousands of tons of earth were moved to do this). Inside is a circle of preposterously large megaliths; I say "circle," but the stones are not disposed along a true circumference (that would be too easy), but rather on a geometric figure obtained by superimposing the arcs of several circles. Inside are two smaller rings of megaliths, each about 100 meters in diameter. Various other giant stones are distributed here and there, and there were two double rows of standing stones conducting away from the structure, making for a total of about 600 megaliths. One of these rows, called West Kennet Avenue, was originally 2.5 kilometers long and connected Avebury with a smaller stone circle known as the Sanctuary.

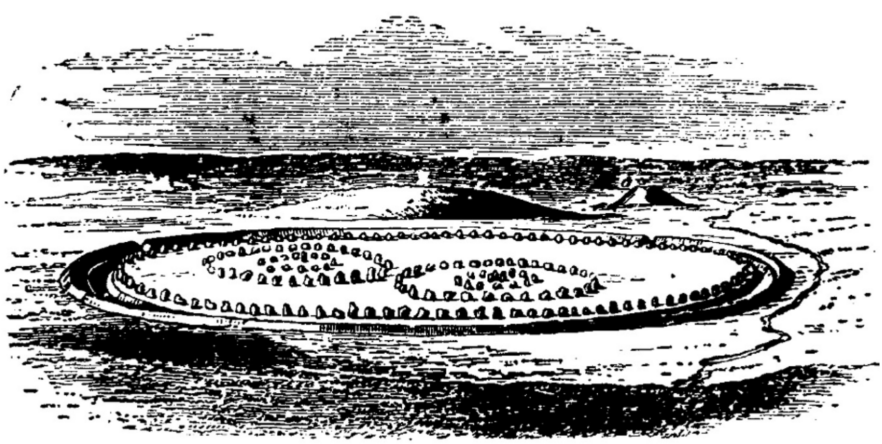


Figure 2.6: Avebury in a reconstruction of the 19 century

Figure 2.7: One of Avebury's megaliths. Do you see a human profile on the right, on the left, or on both sides?

The date of Avebury is more or less the same as the first phase of stone construction at Stonehenge, around 2800 to 2700 BC. You get a different feeling at Avebury, though. There is an intimacy with the monoliths, and what's more, there is a living, functioning, modern-day village inside the outermost circle, the construction of which unfortunately involved the removal of a number of stones—all of which makes it more immediate. A popular game there consists of finding human faces and profiles on the stones, with "game" being the operative word. While no one will deny that some of the configurations of bumps and fissures and pores thus "discovered" are interesting, that is a far cry from assuming they were created deliberately. Nevertheless, the stones here seem to have lives and histories of their own, like the "Barber Stone," which fell in the 14th century upon a man, probably during an ill-conceived attempt to remove it, killing him. The body, exhumed in modern times, turned out to be that of a barber, accompanied as it was by scissors and a razor, the signature tools of the trade.

Looking south from Avebury, one's eye is drawn to a hill—a strange hill, disturbingly regular, similar to one of those monovalves that cling to ships' hulls and coastal rocks, a great big barnacle. It is Silbury Hill, which is not, of course, a hill at all. It is a man-made structure, the largest of its kind in Europe, 40 meters high (equivalent to an 11-story building) and 160 meters wide. To build it, not less than 300,000 cubic meters of material were displaced. I say "material" because I want to distinguish it from mere "earth," for it is a mistake to think of Silbury as a pile of dirt.

An object as massive as Silbury, had it been conceived as an accumulation of soil, would not have stayed there very long. After a while it would have begun to erode, to wash and wear away, such that within a few hundred years it would not have been much more than an amorphous lump.

Yet there Silbury stands, intact, as if it had been built last week, wearing its minimum of 4300 years remarkably well. It would be more appropriate to call Silbury a pyramid rather than a hill, because when it was built it would have been as resplendent as the pyramids of Giza, similarly faced in limestone cladding. To ensure its stability, its builders made stone foundations and a core of alternating layers of impermeable mud. They almost certainly proceeded in an upward spiral rather than using the

Figure 2.8: Silbury Hill

method of stepped terraces, as was thought up until recently. In any case, no one knows why this object, unique in all the world, was built. One thing is for sure: Silbury is not a tumulus—that is, it was not built for funerary purposes (or, should I say, no tombs have ever been found there).

Not far from Silbury, however, is West Kennet, a large chamber tomb. West Kennet is extremely ancient, built around 3700 BC, and consists of an oblong corridor built with huge sarsens and then covered with earth. The corridor ends in a system of three chambers, one central and two lateral, which were used over a long period of time, as the many remains found there attest.

Avebury is thus the center of an extremely complex sacred landscape constructed over the course of the centuries. Because it is composed of separate and distinct monuments that nonetheless are clearly harmonized between them, there is the strong suspicion that the whole thing was developed according to an overarching design. This suspicion was first voiced in the 18th century by the antiquarian William Stukeley, who proposed that the complex seen from above represents an enormous serpent coiled on a ring. Despite the fact that this image probably has *nothing* to do with the aforementioned overarching design, it is right to credit Stukeley with the originality of his idea to interpret an ancient sacred landscape as a monumental replica of an image—an argument that, as we'll see, is central to this entire book.

2.6 Skara Brae

Visiting these enigmatic places, the obvious question is, why were they built? Until now, though, we really have not seen anything that tells us much about the builders. At Stonehenge some deer-horn tools were found that enabled us to date the site, at West Kennet a few dozen tombs, and then the inhumations dispersed here and there at Carnac and Newgrange. That's all. To try to understand a little more, we move further north, to the Orkney Islands of northwest Scotland.

In the winter of 1850 a singularly violent storm slammed into the Orkneys and the winds stripped away enough earth to reveal a group of structures buried in a hill known as Skara Brae. A summary excavation was conducted in 1868, but it was not until the 1920s that a more complete study brought to light a human settlement that, for lack of a better idea, we tentatively call a "village." Obviously, everyone at the time thought they were looking at an Iron Age site, and this assumption remained unchallenged until the early 1970s, when carbon dating blew it, quite literally, back to the Stone Age:

Figure 2.9: Skara Brae: one of the house's furniture.

Skara Brae is a neolithic site, 2000 years older than first thought, already inhabited by 3300 BC.

The village is small, composed of only eight dwellings. These dwellings are connected by roads and configured carefully according to a preestablished plan. A system of drainage ditches not only kept the area dry, but was connected to what are probably history's first toilets, one in each dwelling, thereby also making it history's first sewage system.

One often hears it said half-jokingly that seeing Skara makes you wonder if the Flintstones are going to appear around the corner any moment and invite you to stay for dinner. I don't find this amusing because, as we will see, the people who lived at Skara Brae were not kidding around. In any event, the homes, each about 36 square meters with no internal partition walls, do indeed appear as if they had been just recently abandoned. They all conserve their original stone "furniture," which are objects that resemble the corresponding modern ones, but we have no proof that they had the same function. We thus have a "dresser" with shelves, two "beds," a central "hearth" often coupled with a "bench," and a sort of stone box set into the ground. Simple decorations adorn some of the beds and walls, in which some scholars have even wished to see inscriptions. A number of curious smaller objects were also found at Skara. They are for the most part carved stone balls with a surface like that of a hand grenade for which no one has been able to hypothesize a practical function (similar objects have been found elsewhere in the Orkneys and on the Scottish mainland).

The Skara site was built on a midden, meaning a preexisting mound of garbage, compressed in such a way as to provide a layer of insulation against the brutal weather. Moreover, once built, the inhabitants would pile up their refuse around the perimeter. We have been able to analyze the many strata of refuse accumulated over the centuries, which is why we know as much as we do about everyday life there. We know, for example, that the Skara Braean diet was varied and complete.

Skara Brae presents a number of singular features. First of all, though it was inhabited uninterruptedly for about 600 years, the dimensions of the settlement remained substantially unchanged, which makes it very difficult to imagine it as a true village, inhabited by a self-sufficient community that would be, by definition, subject to demographic variations. The layout of Skara Brae entails a passageway covered with slabs of stone that conducts from the first to the sixth "house" in succession, while the seventh is reached by a deviation from the main corridor, and the eighth is the only one accessed from the outside. Post holes indicate that the entrances to both the village and to the individual dwellings could be closed from the inside by stone doors (the seventh unit, however, closed from the outside, and was thus perhaps a storeroom or prison). The modular, repetitive disposition of furnishings inside each dwelling is clearly indicative of planning, of a governing order to which each space had to conform. Skara Brae looks like a recently remodeled hotel, all its rooms identical.

But upon further reflection, we realize it looks like other things, too. It looks like a monastery, an ordered system of identical cells. Or better still, a guest house for a university, built in a sacred landscape. The Orkneys are in fact scattered with numerous megalithic monuments, particularly the area around the gulf of Stenness, not far from Skara, a dozen or so square kilometers that encompass the Stenness and the Brodgar stone circles, the Maeshowe tumulus, the neolithic "village" of Barnhouse, and various other monuments.

The Brodgar circle, perhaps more recently built than Skara (2500 BC) is a ring of megaliths looking out onto the "loch" (saltwater lagoon) of Stenness. Originally composed of 60 upright stones disposed in a circle 104 meters across, the ring is bounded by a ditch cut into the living rock, 6 meters wide and 3 meters deep. The only tools available to cut this rock ditch were other rocks, most likely used as percussors, a method requiring unimaginable time and patience (the only possible alternative would have been to cut holes with other stones and then insert dry sticks that, when moistened, would expand and split the rock; this method, however, is not documented in megalithic cultures). The Stenness stone circle, which dates to around 3000 BC, vaunts the largest megaliths of all the Orkney monuments, some as tall as 6 meters and weighing several dozen tons. The stones, which were quarried about 3 kilometers north of Skara Brae, are sharp, almost cold, and give the visitor a strange feeling of aloofness and distance. Though only four of the original 12 stones remain standing, it is clear that they were configured inside a henge with a diameter of about 44 meters; the surrounding ditch, also cut into the rock, has a north entrance. Curiously, we are fairly certain that the ditches of this and other henges in the area were filled with water for most of the year. The result—large mounds with "rings of water" delimiting the stone circles—was thus an imitation, a *replica,* of the surrounding landscape: the promontory of Stenness itself (Richards 1992, 1996).

The entrance to the Stenness Stones points toward Barnhouse, a neolithic settlement similar to but preserved rather less well than Skara Brae. Discovered by Colin Richards in 1984, it is composed of 15 buildings, the majority of which are analogous to those at Skara, replete with "dressers" and "beds." Two of the structures, however, are markedly different from all the others: structure 8, oriented to the northwest; and structure 2, oriented to the southeast.

Structure 8 is strongly reminiscent of the stone circle at Stenness. It is extremely massive, and surrounded by an external ring. Some sort of ritual use is suggested by a number of features, such as the fact that the central hearth does not seem to have been used to cook food. Structure 2 is divided into two rooms, organized internally much in the same way as the nearby chambered tomb, Quanternass; it is perhaps no accident that a large stone vessel containing human remains was found a few meters from the entrance. As for the building technique, it is identical to that of the Maeshowe tumulus, just up the road.

Maeshowe is a circular mound, 8 meters high and 35 meters wide. Inside is a corridor built with enormous slabs of stone weighing up to 30 tons each. It is oriented to the southeast and terminates in a large central chamber surrounded by three smaller cells, the entrances to which could be closed by slabs that are still in place today. The scarce human remains found in just one of the cells allow us to date Maeshowe to around 2700 BC. Archaeologists agree that it was the communal tomb of the Barnhouse settlement, despite the curious fact that the sole entrance to the corridor was designed to make it easier to close *from the inside.*

Maeshowe is also of interest to medievalists. In fact, during the 12th century the Vikings visited the tumulus and, in keeping with millennia-old tradition of "extemporaneous epigraphy" (i.e., graffiti) that persists to this day, they left signs of their passage in the form of runic inscriptions. Reprehensible a practice though it may be, graffiti sometimes re-humanizes ancient monuments, transforming them from mute objects to living witnesses of the history that has unfolded before them. Anyone who climbs to the summit of the Great Pyramid of Giza, for example, sees that it is covered with inscriptions left over the course of 4500 years of history. At Maeshowe we encounter, among others, a love-struck Viking who wrote, "Ingigerth is the fairest of all women," and a group of Crusaders who signaled the presence of a treasure there. There is also a Viking saga that tells of a certain Harald, who was driven to madness after spending a night in the tumulus.

While there is no real proof that Maeshowe was a tomb, a communal necropolis was found in 1958 further to the south, at Isbister. Here we have a large rectangular stone chamber divided into three alcoves. Known today as the Tomb of the Eagles, it was used for about 150 years from the date of its construction, around 3000 BC. One of the three alcoves was found intact and full of human remains belonging to at least 342 individuals. The name of the tomb derives from the intriguing fact that beneath these remains was a layer of human bones mixed with white-tailed eagle bones. Traces of ceremonial activities, such as deliberately broken ceramics and bones of animals that may have been sacrificed were also found in the environs. The white-tailed eagle, a magnificent bird of prey with a wingspan of more than 2 meters, was once common in the Orkneys. It is difficult to interpret the significance of the raptor bones in the tomb, but the fact that the human bones were arranged in an orderly manner after having been stripped of flesh has led some to postulate that the eagles were connected to a cult of the dead not unlike that which was present in some communities in India, where the bodies of the dead were left out in the open until the bones were picked cleaned by birds. The hypothesis remains, however, unproven.

So this is essentially what we know about how the inhabitants of Skara Brae lived, which means we know that transporting enormous megaliths, cutting ditches into living rock, and building tumuli and mounds were normal activities for them, until something suddenly happened and changed all that. Gordon Childe, always in search of invaders waving the magic wand of civilization, proposed that Skara Brae was abandoned under dramatic circumstances. There is no proof of such circumstances, or of invasion of any kind, though it is clear that the site fell into disuse rapidly. Some think that neolithic society in general underwent a transformation that saw small rural communities become larger cultural units, with farming families more widely dispersed over territory that had somehow become safer to occupy. This transformation would ostensibly be proven by certain large monuments in the Orkneys built after Skara Brae, such as Brodgar. However, the age of the megaliths comprises an extremely long an arc of time, and Skara, like its sister site at Barnhouse, dates from this period.

But the questions that concern us here are, What can Skara Brae tell us about megalithic builders? More precisely, what can *the stones themselves* tell us about who built them, and why?

2.7 From Norman Lockyer to Gerald Hawkins

Everyone "gets" Stonehenge; all you have to do is look at it. Wherever we happen to be standing, we have an intuitive sense of the cardinal directions, and this is all one needs to realize that the central axis of Stonehenge—that is, the line that splits the "horseshoe" symmetrically—is oriented east of north. And if you check to see at which point the sun rises on the day of the summer solstice, you will not be surprised to find that it corresponds *roughly* with this axis. Stonehenge is the first example we encounter in this book of a monument oriented astronomically: its central axis was aligned such that, on the day we call June 21st, the sunlight would make its way to the center of the circle, with the same phenomenon occurring at the winter solstice sunset. We could argue endlessly about the accuracy of this alignment, which is *not* good, but the fact that the phenomenon occurs, and that it does so because the builders intended it to, is undeniable, and that intention governed *a priori* the design of the monument's most magnificent part, the horseshoe.

This is therefore the only information that the builders left us in writing. Granted it is written in stone, and with stone, in the language of the sun and of the stones. But it is nevertheless written; it is there, forever. Consider this: if it is the only thing they left us in writing, maybe it would not be too heedless of us to assume that it might be important. Perhaps it allows us to read something else there, something we had not noticed.

The first person to think this way was the astronomer Norman Lockyer, toward the end of the 19th century (Lockyer 1906). Lockyer is mentioned quite often in this book, because he is the founder, or at least the precursor, of the study of the connections between ancient monuments and the astronomical knowledge of those who built them. Lockyer tried to date Stonehenge by considering the fact that the position of the point where the sun rises at summer solstice shifts ever so gradually over the course of the millennia, thanks to a slight variation of the *ecliptic,* which is the plane defined by the movement of the earth and the sun (see Appendix 1). He failed, and we will see why in a moment. But what is important is that it was the first time that anyone had tried to *astronomically anchor* the date of a monument, which is to say calculate the date of its construction on the basis of its astronomical alignment.

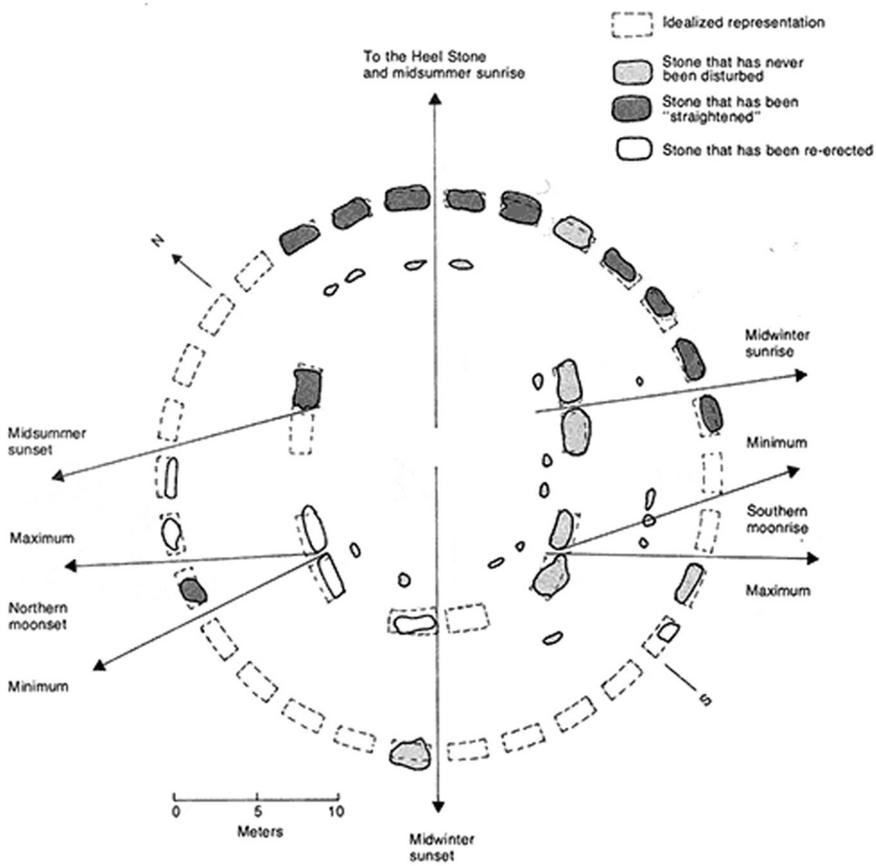


Figure 2.10: Stonehenge alignments according to a famous work by G. Hawkins

The variation of the ecliptic plane is an infinitesimal effect, so in order to determine the dislocation of a solstitial direction over the centuries, we need to know the original alignment with exactitude. Lockyer wrongly hypothesized that the alignment of Stonehenge was calculated using a small hill on the horizon, a hill that we now know is man-made and dates much more recently than the monument. Consequently, Lockyer's attempts have often been fiercely criticized, and still today one runs across sarcastic comments, such as the one present in the Stonehenge "bible"—or so it presumes to be—by C. Chippindale (1994). The authors of these comments, however, would do well to remember that the date of 1800 BC that Lockyer courageously proposed more than a century ago was a lot closer than anyone else was able to come before the era of radiocarbon dating.

After Lockyer (who was also a pioneer in the astronomical alignments of the temples of Egypt; see Chapter 4), the investigations of the astronomical content of ancient monuments were interrupted until the 1970s. Furthermore, as we have seen, anything resembling *megalithic thought* was dismissed out of hand, so the solstitial alignment of Stonehenge was seen as little more than a curiosity. The first person to rekindle interest in the astronomy of Stonehenge was Charles Newham, an astrophile whose work was followed by the "scandalous" studies of a young astronomer, Gerald Hawkins.

In his famous book *Stonehenge Decoded* (1964b), Hawkins analyzed the configuration of Stonehenge partly from the idea that there could be, in addition to the solar alignment of the central axis, other astronomical alignments (see also Hawkins 1963, 1964a; North 2007). And in fact Hawkins quickly found a great number of alignments, especially lunar ones. Being defined by stones only a few dozen meters apart, the alignments are not particularly precise, and today we know that most of them are likely to be casual. However, at that time, the young scholar's enthusiasm and his impetuous manner of presenting his findings made him easy prey for the unanimous criticism of the archaeological establishment, and it was in fact for Hawkins's benefit that Richard Atkinson (1966), one of the most active Stonehenge scholars, coined the historical phrase that its builders were nothing more than "howling barbarians."

2.8 A Satisfied Visage

I do not know whether the builders of Stonehenge were "barbarians" or if they "howled." (When Italy won the 1982 Football World Cup, I painted my face blue and I howled. If that makes me a barbarian in the eyes of some, then so be it.) In any case, Hawkins irrefutably attracted attention to the fact that the celestial cycles held great interest for the builders of Stonehenge. The important point is that Hawkins's work, while controversial and bitterly criticized, sparked a rebirth of interest in the astronomical alignments of ancient constructions and in the concomitant astronomical knowledge the builders must necessarily have possessed, an interest that evolved into what we call today by the somewhat ungraceful—at least in my view—term of *archaeoastronomy.*

One of the most charming examples that fully demonstrates the enormous charm of this discipline is the discovery of the astronomical alignment at Newgrange. As we have seen, the central passageway of Newgrange is oriented toward the southeast, and a simple measurement shows that it is lined up with the point where the sun rises at the winter solstice.

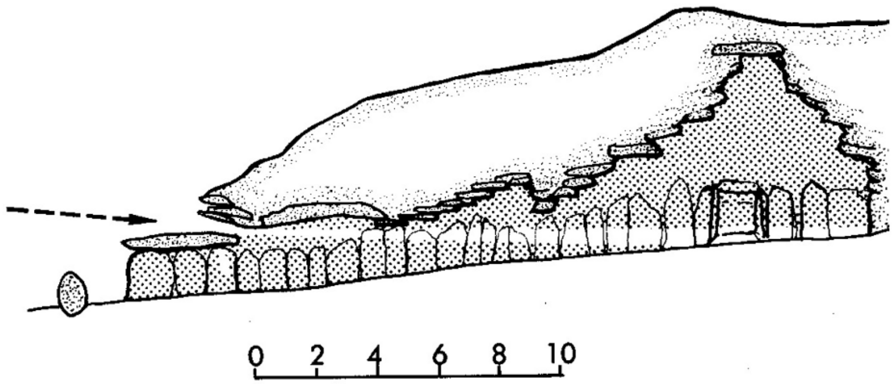


Figure 2.11: Newgrange. Section showing the path of the sun light at winter solstice.

It is natural to assume that this was intentional—obviously so, I would say. However, because of the slightly upward incline of the passage, the sunlight that enters through the door, in alignment with the winter solstice, does not reach the central chamber, stopping short at some point in the corridor. It has therefore been thought that, even if there had been the intention to build an astronomically aligned structure—a dubious notion in itself—the builders of Newgrange just were not up to the task, and failed. This would mean that 5000 years ago, someone built a monument involving thousands of tons of earth and rock, covered it with quartz like a giant jewelry box, carefully measured the direction of the sunrise at winter solstice to line up a corridor built with stones as heavy as many elephants together, but the whole point of it—that the sunlight should reach the central chamber at midwinter—falls apart because the person who designed it miscalculated the inclination of the corridor.

Pity, he must have thought. Maybe next time. But then again, his failure should not surprise us, what with his being a "howling barbarian."

Up until the restoration that took place in 1969, no one had ever realized that there is a narrow window above the entrance of Newgrange. Over the window is a slab inscribed with a diamond motif repeated eight times; on the sides of the opening are two blocks of quartz that served as shutters, and show signs of having been used repeatedly.

The window now freed from layers of sediment accumulated over millennia, on the night of December 21, 1969, Michael O'Kelly, head of the Newgrange restoration, entered the corridor, *closed the door,* found a comfortable spot in the inner chamber and, yes, waited for dawn.

As soon as the sun peeked over the horizon, its rays penetrated the corridor *through the window* for the first time after thousands of years, deftly traveled the length of the passageway—the slope of which, by the way, turns out to have been accurately calibrated with this aim by the architect (sorry, the howling barbarian)—to shine upon the satisfied visage of O'Kelly and illuminate the central chamber, exactly as it had been engineered to do.

2.9 Alexander Thom

In a certain sense, then, one could say that the sun on O'Kelly's face, filtering through that window at Newgrange for the first time after who knows how many years, marked the birth of a new science. If Lockyer was its precursor and Hawkins the pioneer, credit for the first systematic theoretical treatment of this new discipline goes to an affable and very resolute Cambridge professor, Alexander Thom.

Thom began taking an interest in the astronomical orientations of the megalithic sites in Britain and in Brittany during the 1950s. His field studies, in which his son Archibald later joined him, extended over several decades and touched upon thousands of sites (Thom 1967, 1971; Thom and Thom 1978). According to Thom, the purpose of megalithic monuments was mainly, if not entirely, astronomical, and they were intended for the observation not only of the solar cycle but also of the lunar cycle (the lunar stations are the extreme points of the rising and setting of the moon through a cycle of 18.6 years; for more detailed information, see Appendix 1). Because observation of the lunar stations is fraught with practical difficulties, including the rather fundamental problem that the rising of the moon is not always observable, we must allow that megalithic astronomers were able to determine the points where the moon rises and sets on the horizon on the basis of observable intermediate positions. Clearly, familiarity with geometry and mathematics would be indispensable for such operations (even though as recently as the 1970s, archaeologists thought of megalithic man as a grunting, barely human beast, and that there are a few who still think so today). And here we see the second key point to have emerged from Thom's research, which is that the degree of knowledge of these disciplines had to have been at least up to the task of applying them practically. For example, Thom discovered that many large stone henges are not circular but ovoidal, or half circular and half ovoidal. These forms were obtained by using ropes and poles to lay out quite complex geometrical configurations, many of which are based on those right triangles that are called "Pythagorean"—that is, having all integer legs. The Thoms found evidence of their extensive use, particularly the 3-4-5 triangle, but also, for example, one whose sides measure 12-35-37 ($12^2 + 35^2 = 37^2$; try it to believe it).

One of the best conserved sites in which the geometrical constructions discovered by Thom are visible is Castle Rigg. Castle Rigg is a stone circle built in a splendid setting, on a plateau in the mountains around Lonsdale, England. It is made up of 35 large stones arranged according to a rather complex plan that was laid out in the following way. First, an alignment with the southern major lunar standstill was marked off with two monoliths set 32 meters apart. This line was then used as the base diameter for a semicircle

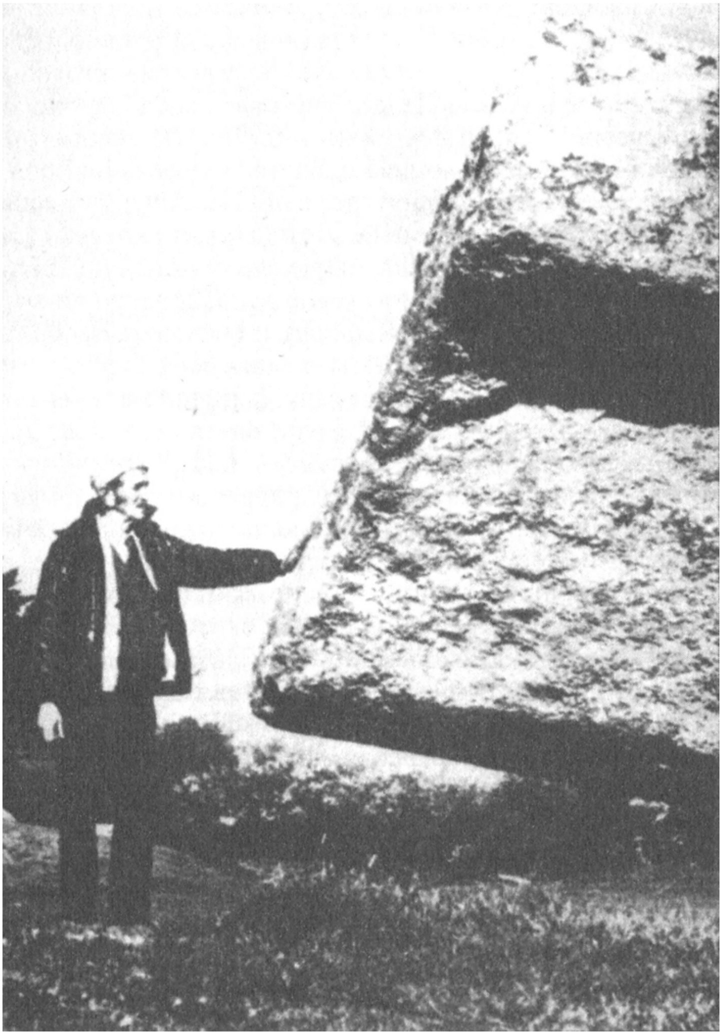


Figure 2.12: Alexander Thom at the base of the Grand Menhir

inscribed onto the southwest side. On the northwest side, the figure was "ovalized" by the intersection of three circular arcs, the outer two with a radius equal to one third of the base diameter, the internal one with a radius equal to the distance from the point of intersection to the center of the semicircle. (Don't ask me why . . .).

Another point that emerges from the enormous mass of data collected by the Thoms is the probable recurrence in the design of a great many megalithic monuments of a unit of measure equivalent to about 41.5 centimeters. It would be worth it to be able to officially name this unit of measure a "Thom," as scientists do in physics, where units of measure take the names of the people who discovered the laws of the phenomena they measure (the newton, the ohm, etc.). Unfortunately, however, Thom let himself be swayed by the fact that the double of the unit he had discovered, 82.96 centimeters, is very close to the value of the modern English yard. This is probably coincidence, since all units of distance are vaguely similar because they derive from measures that are naturally available to us—the length of an arm, a forearm, the spread of both arms, a stride. Thom was obviously aware of this, but he nevertheless decided to call this unit of

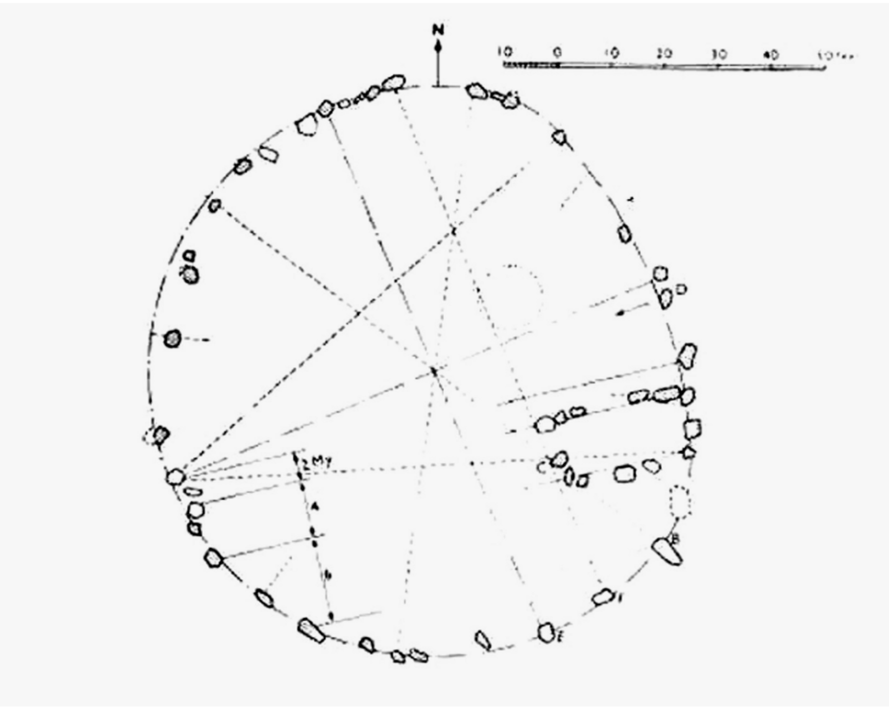


Figure 2.13: Castle Rigg in Thom's survey

82.96 centimeters a megalithic yard, probably in the interest of making it more easily legible (for British and American readers, anyway). He also introduced the megalithic inch, equal to 1/40 of a megalithic yard.

As a consequence of choosing this value for the yard, double of the unit probably utilized by the megalithic cultures, all the measurements consisting of odd-numbered multiples of the real unit come out with a fraction dangling clumsily off the end, not only compromising clarity but also encouraging the pettiness of those would present it as proof that Thom was a mad fool for thinking that megalithic man used the English yard. So, despite several pieces of evidence found by Thom, many scholars continue to doubt the existence of the megalithic yard. Even worse, I myself have listened firsthand to an archaeologist (whose shall go unnamed) maintain that Stonehenge was built "using the length of a stride." If this is so, we can imagine the following exchange (Stonehenge, 4500 years ago):

"Would you mind moving that 50-ton trilith just a bit to the right? I'm concerned that the solstice sun may not get through."

"How much? An arm? A stride?"

It is abundantly obvious, or should be anyway, that any architect of any period would need a precise unit of measure in order to plan a monument as complex as a henge, and the notion that something like, say, Avebury could have been built "by eye" is patently absurd. Thom's idea, however, goes well beyond this, for in his view megalithic societies used the *same* unit of measure in a large variety of monuments, and this has far greater ramifications than the relatively simple problem of designing a specific monument. There are many sites, some quite distant from the others, where the use of the megalithic yard looks convincing, though it is difficult to ascertain whether a "standard" was used or whether it was the similarity of some human-related measures (e.g., the arm) that influences Thom's measures. At Woodhenge, for example, though all that remain are the post holes, it is still possible to make measurements as to how the oval rings of wooden posts were laid out. There are six such rings with circumferences of 40, 60, 80, 100, 140, and 160 megalithic yards and whose axes of symmetry are oriented toward the summer solstice (perhaps one day someone will figure out why there is no 120-yard ring). Other examples can be found on Lewis Island, in Scotland, home of Callanish, a complex megalithic structure composed of a stone circle 12 meters in diameter with a large monolith and the remains of a burial chamber in the middle. Two parallel lines of stones run east of north for 80 meters, while other lines marked by stones point east, south, and west, giving the site the aspect of a bent cross. The interest in astronomy of the builders of Callanish is apparent in both the north-south alignment and the northeast arm, which indicates the direction of the

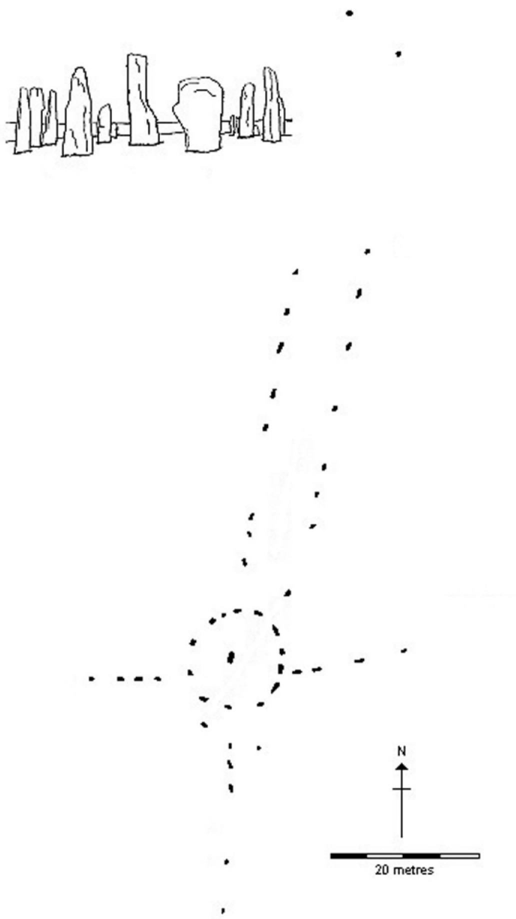


Figure 2.14: Callanish

moonset azimuth at the southern major standstill (Hawkins 1965, Ruggles 1999). Twelve kilometers from Callanish is the beach at Dalmore where a neolithic village was discovered in 1982, yielding a number of interesting artifacts. Among them was a piece of bone 3.4 centimeters long with notches between 4.9 and 5.1 millimeters apart, which might have served as a ruler for megalithic inch measures (Ponting 1988).

The results of Thom's surveys can be summarized as follows:

1. Megalithic builders had a complete and somewhat sophisticated knowledge of solar and lunar astronomy, and their monuments included observational purposes; in many cases Thom found monuments built on sites chosen specifically for their relation to pronounced irregularities of the horizon line, which facilitated

astronomical observation (astronomical use did not, of course, exclude other uses and meanings—religious ones, for example—of which, alas, we are unaware).

2. The megalithic builders' understanding of geometry and mathematics was enough to enable them to build quite sophisticated geometrical constructions, such as oval rings plotted with intersecting circular arcs. Often the starting point for these constructions was a triangle with all integer legs (the reasons for this remain unknown).
3. There is a remarkable uniformity in the planning of megalithic sites; there are also hints at the widespread use of a common unit of measure that Thom called the megalithic yard.

Let us look at how astronomy was used, according to Thom, in the places we have visited thus far. In Thom's view, Carnac was an astoundingly large and ambitious grouping of lunar observatories. The heart of the Kermario complex was the Le Manio Menhir, the departure point for a number of long alignments. The Grand Menhir also served as a reference point for long, precise alignments that parted from Locmariaquer, passing among various tumuli and menhirs to indicate the limits of the lunar stations. It is possible that this great interest in the moon exhibited at Carnac, apart from the likely purpose of predicting the eclipses, arose from its builders having made the connection between the moon and the tides, which in Brittany are an extremely significant natural phenomenon (recently, the Thoms' astronomical interpretation of the site has been strongly criticized, particularly with the thesis that the Grand Menhir could have toppled while it was being erected; however, there is no other available reasonable explanation today for having transported tens of thousands of tons of enormous stone blocks to Carnac, and the whole question fully merits a complete reexamination from scratch).

In Ireland, every element of the sacred landscape of the Boyne Valley was designed to serve some astronomical end. At Newgrange, in addition to the winter solstice alignment we have already seen, there are numerous aspects of the carved inscriptions that suggest the study of both the solar and lunar calendars. One of the corridors at Dowth is oriented toward the winter solstice, while the presence of 18 tumuli in the Knowth group seems to indicate a connection with the lunar cycle; in fact, Knowth 2 and 4 are aligned with the northern major lunar standstill, and several of the figures carved into the stones can be interpreted as lunar calendars. Finally, at Loughcrew, "Tumulus T" bears a striking structural resemblance to Newgrange, though its east-west orientation suggests that its meaning was probably different.

In the Orkneys, the main focus was on the solar cycle. Maeshowe, for

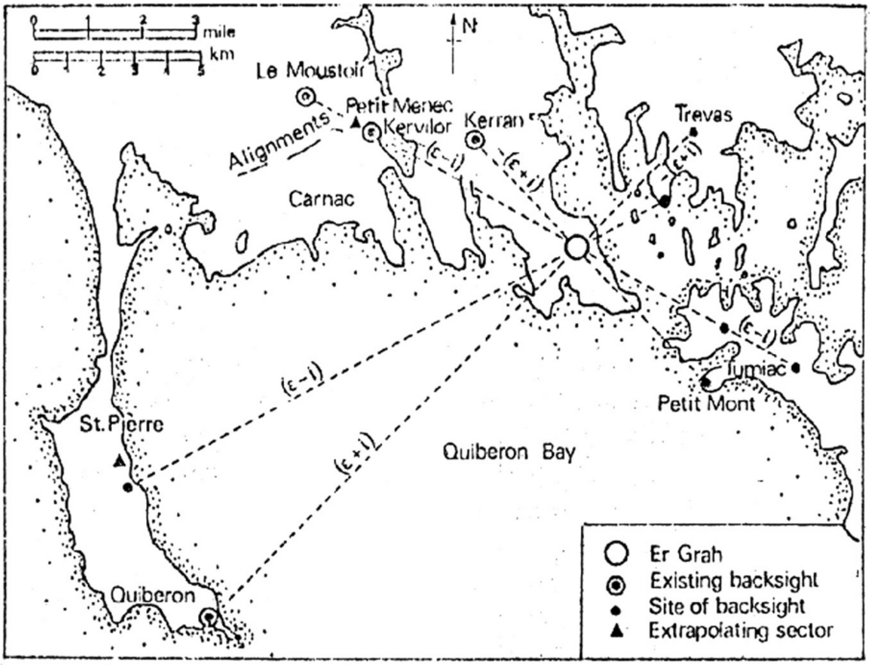


Figure 2.15: Alignments in the Carnac landscape according to Thom

example, is aligned with the setting of the winter solstice. The last rays of the setting sun filter through the complex to illuminate the central niche, immediately after which the sun disappears behind the Barnhouse Stone, in alignment with a tumulus several hundred meters away. Structure 2 at Barnhouse is aligned with the rising of the sun on that same day, while structure 8 is aligned with the summer solstice. As we have already seen, these two structures are probably contemporary and played complementary roles, the exact nature of which continues to elude us. We find at Maeshowe a phenomenon that I personally have always found exceptionally intriguing—as certainly did the neolithic astronomers who built it: looking from Maeshowe toward the western horizon, for some 20 days on either side of the winter solstice, the setting sun disappears behind the crest of Ward Hill, and then rises again for several minutes at the base of the hill. This extraordinarily beautiful event occurs because the sun's trajectory takes it behind the hill's shoulder-like protuberance, interrupting the line of sight from Maeshowe. (Plates 3 and 4)

As far as Avebury is concerned, oceans of ink have been spilled in its name, not to mention rivers of inanity that run from "telluric currents" to the "representation of the human egg cell." In truth, very little is certain about this monument. The Thoms, discouraged by the incompleteness of the remains (Avebury had been used for centuries as a ready-made deposit of quarried blocks), preferred to concentrate on how the complex geometry of the three circles was determined, one of their conclusions being that it had been necessary to inscribe a circular arc fully 750 megalithic yards long—that is, 723 meters. This is a colossal measurement to plot when all you have to work with is rope and poles, if only for the fact that it would have been impossible for the persons on opposite ends of the arc to communicate by voice. Finally, the purpose of Silbury Hill remains utterly mysterious, although the prospect of reading it as an astronomical observatory is rather tempting.

2.10 The legacy of Thom's Work

The work of Alexander Thom has had a profound effect on the way that many scholars, myself included, look at megalithic civilization. Indeed, it is difficult to imagine that the homogeneity of methodology and purpose, the precision of calculation and observation, and the likely use of a shared standard of measure do not point to a complex network of communicating civilizations, cohesive in certain ways despite the absence of any central power. The archaeologist Edward Mackie (1977, 1981, 1997), basing his work on Thom's findings, developed this idea into a comprehensive theory that frames ancient astronomical activity in a social structure of megalithic builders. Mackie maintains that there is sufficient archaeological evidence at Skara Brae, to name just one example, to hypothesize the existence of a hierarchical social structure at the top of which was an elite class of astronomer-priests, for lack of a better term, whom he likens to Mayan priests (see Chapter 8). They would have had their own residences, as well as spaces where they would teach their apprentices, an example being the "guest house" at Skara. The level of knowledge possessed by these individuals was necessarily high, as Mackie demonstrates by evoking the studies of Thom.

Mackie's thesis sounds convincing, and I will explain why in the more general context of Chapter 15. Nonetheless, in the 1980s and 1990s, the work of Thom and, by extension, Mackie's interpretation of it were subjected to heavy critical revision, exemplified in a volume published in honor of Thom, *Records in Stone* (Ruggles 1988), which contains a number of contributions that are critical about many aspects of Thom's work.

The position from which Thom's work was criticized holds that he had overestimated the technical capacities of megalithic builders grossly enough as to have upgraded a "symbolic" interest in the sky to scientifically based astronomical practices. In particular, Clive Ruggles (see Ruggles 1999 and the references cited therein) rigorously reexamined many of the sites studied by Thom. When the new measurements are plotted on a histogram, Thom's "peaks," which indicate noteworthy alignments, are dramatically blunted, the science of the megalithic builders shrinking along with them to become a matter of "purely symbolic interest." Lying at the root of these discrepancies is, for instance, the fact that Thom occasionally committed technical errors (understandably, given that he studied thousands of sites). But the discrepancies are mainly owed to an "amplification" effect resulting from the data selection criteria used along with the involuntary prejudices intrinsic to such choices. This effect can manifest itself in a number of ways. For example, if there are five possible horizon alignments in a group of megaliths and two prove to be astronomically significant, recording only these two gives the site a statistical weight that it would not have if all five were recorded. If an alignment incorporates a monolith 2 meters wide, the direction it defines will change (and can be made to appear more or less accurate astronomically) if the line is run through the center as opposed to off of the upper left or right corner. And so on. In some cases Thom considered intentional certain alignments that are in fact lacking any common archaeological context, inventing connections between, for example, standing stones of the Neolithic Age and tumuli of the Bronze Age.

The critical revision of Thom's work certainly casts serious doubts on many of his extreme ideas, such as his conviction that megalithic man used a calendar divided into eight seasons that survived, in modified form, to this day, filtered through the Celtic calendar (this included the feasts Beltane, around May 5, today's May Day; Lammas, early August, today's Feast of the Assumption; Samahin, early November, today's All Souls' Day; and Imbolc, early February, today's Candelmass). The widespread and accurate use of the same unit is challenged as well, together with the precision of many alignments. What concerns us most here, however, is the fact that the technical criticisms of Thom's work may have profound consequences for anyone attempting to base even a part of the study of ancient thought on archaeoastronomy, for to dismiss the observation of the skies in megalithic times as a matter of "purely symbolic interest" entails negating the possibility of an astronomical thought, which in turn dismisses any scholarly insight, via archaeoastronomy, about the megalithic thought as a whole. Thus, although I agree with most of the technical critics, I tend to disagree with the "reductionist" position they might imply.

First of all, the equation "low precision = symbolic knowledge" is somewhat misleading. There is, indeed, no absolute definition of precision. A clock that loses two minutes per year is very precise with respect to our daily requirements, but terribly imprecise if it is being used to program a Space Shuttle mission. Any definition of precision must be conditioned upon the purpose for which the measurement is made. The sun, for example, is very close to the solstice point for a period of several days, which could have led people to believe that the inversion of the movement of the sun's rising point at the horizon was predicted for a certain day, without necessarily knowing whether the exact day had been predicted or not. Even if the degree of precision in such a case is not high by modern instrumental standards, it was precisely what was needed to establish the authority of those who made the predictions (see Chapter 15 for more on this point).

This preliminary observation aside, we then have the strictly technical problem of determining if the criticisms of Thom's research are applicable to *all* the monuments he studied. Indeed, as Mackie has pointed out—and I tend to be in agreement with him—it would be sufficient to provide a thorough demonstration (e.g., by including analyses not only of the astronomical aspects but of the complete archaeological context) of the existence of just a single site in which Thom's "high criteria" for precision had been met, and the "purely symbolic" argument would have to be reconsidered, without taking anything away from the importance of the critical studies of Thom's results.

As an example, Mackie studied an isolated and rather unspectacular megalithic site, Kintraw, on the west coast of Scotland. Kintraw is home to a small tumulus and a single menhir. It is difficult to imagine Kintraw as a gathering place, as the site of rites and ceremonies, so there must be another reason why the megalithic builders chose it. Thom had discovered a curious phenomenon that allowed Kintraw to lend itself to extremely precise measurements of the sunset azimuth of the winter solstice, a phenomenon similar to the one we encountered at Maeshowe: the "double sunset." Seen from Kintraw, the sun sets behind a rocky pinnacle on the island of Jura, then *rises again* for a few moments after having passed behind the pinnacle, finally setting definitively at the horizon. The thing is, you cannot really see this from ground level; you have to climb the tumulus. How, one might ask, did they know where to build the tumulus? Well, on the other side of the complex, on the side of a hill, Thom had found a natural clearing with a half-buried boulder that, when he stood on it, allowed him to calculate the alignment with precision. To test the validity of Thom's results, Mackie studied Kintraw with the aim of establishing whether there was any archaeological proof that would confirm the significance of this particular alignment. Although he did not find any datable archaeological material, he did discover that the aforementioned boulder which had appeared to be natural was in fact a pair of hewn slabs configured like a V: the slabs had likely been placed there deliberately to mark the exact point from which to view the "double sunset" of the winter solstice. In addition to Kintraw, Mackie also studied other sites, such as the lunar observatory of Ballinaby, where "precise" measures are likely to have been performed (Mackie 1974; for discussion see Mackie 2002, Ruggles 1999, Ruggles and Barclay 2000).

New results on megalithic astronomy accumulate year after year, and though the debate on accuracy and megalithic science remains open, I think it has become impossible to deny the central role played by astronomical observations in the planning, construction, and use of megalithic monuments, so that Thom's work will always stand at the foundation of this important achievement. An especially significant example of astronomically related megalithic monuments that has been well studied in recent years is that of the so-called *recumbent stone circles,* which can be found by the dozens in northeastern Scotland. They are circles of stones, all standing except for one, which is laid horizontally on the ground between two vertical elements to form a sort of altar. This singular disposition gives the circle a main axis of symmetry, creating a resemblance to the megalithic "sanctuaries" of the Balearic Islands, which we will discuss in the next chapter. As a rule, the axis of the recumbent stone circles is oriented west of south, and the archaeoastronomical studies of these monuments (Burl 1976, Ruggles 1984, Ruggles and Burl 1985) demonstrate beyond all doubt the interest of the builders in the azimuth of the southern major lunar standstill. The monuments were therefore used for rites that included observing the setting of the moon, which would have appeared to "sit" upon the recumbent stone, framed by the flanking vertical members.

Together with the problems of interpretation goes the question of the date of the earliest expressions of astronomically based architecture, which is continually being pushed further back into the past as archaeologists steadily make new discoveries. The last one was in 2003 in Gosek, Germany, where aerial photography revealed what remains of a henge of wooden posts approximately 75 meters in diameter, with three openings aligned, respectively, with north and the sunrise and sunset azimuths of the winter solstice. Carbon-14 testing of remains from the site gave a date somewhere around 5000 BC.

3 The Island of the Goddess

> Clearly the builders saw some significance in their alignments, though unrelated to the movements of the heavenly bodies. Whatever the reason for their choice, it is quite impossible for us now to discover what that significance was.
>
> —D.H. Trump, *Malta: Prehistory and Temples,* 2002

3.1 An Untroubled Sleep

She sleeps, serene, pleased by her own exaggerated sensuality, exaggerated by *our* aesthetic canons, of course, to the extent that many call her by the rather disrespectful name of "the Fat Lady."

No one knows if the sculptor who carved her was inspired by his own beloved or was simply following an established model of an idealized female form. I lean toward the first hypothesis, because the sculpture is a masterpiece, the infusion of a creative soul into 12 centimeters of statuette. This little gem, today at the National Museum of Archaeology in Valletta, on the island of Malta, was unearthed in one of the world's most singular and enigmatic places, the Hypogeum of Hal Saflieni. It dates back to the island's prehistory, specifically to the thousand-year span (c. 3500 to 2500 BC) referred to as the Temple Period, during which this small and arid Mediterranean archipelago, composed of Malta, the nearby Gozo, and tiny Comino, all devoid of the natural resources most commonly used at the time (such as flint), its terrain battered by the wind and thus difficult to farm, was home to a magnificent and enigmatic civilization of megalithic builders, one that by 3400 BC was already mature enough to have built one of the greatest architectural marvels of all human history, the Ggantja temple.

Malta's prehistory begins, if we stick with established dates, quite late by comparison to other civilizations in the same geographical area (Trump 1991, 2002). Although it may sound strange, or even unbelievable, Malta appears not to have been colonized until 5200 BC (there have been attempts to challenge this curious doctrine on the basis of the discovery of human

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_3,

Figure 3.1: A map of Malta and Gozo with the archaeological sites cited in the text.

teeth in a island's cave called Ghar Dalam, which may very well be of Neanderthal origin, but they have met with vehement objections). The story line is supposed to go like this: between 5200 and c. 3500 BC, Malta develops a "normal" civilization that produces "normal" pottery (akin to those of the contemporary Sicilian cultures with which there was undoubtedly contact), with an economy based on farming, fishing, and the construction of buildings in brick or small stones (about which we know very little since only one site, Skorba, has heretofore been studied in any depth).

Then, suddenly, as if the island's inhabitants had awakened from an epic sleep, there is a veritable explosion of building activity characterized by the use of giant megaliths in constructions of unprecedented refinement and complexity. The megalithic phase lasts little more than a millennium and ends as abruptly as it began, sometime around 2500 BC. Why, no one knows. It certainly was not the result of an invasion, which would be the easiest explanation. Rather, it was as though the society simply came to a halt, for no apparent reason, like Pompeii minus the volcano. Stratigraphy reveals a thin layer of sterile sand corresponding to the end of the Temple Period, further

Figure 3.2: Malta's ''Sleeping Lady'' (National Museum, La Valletta)

encouraging the impression that the civilization that built those temples just disappeared, took off to heaven knows where, soon after which Malta was colonized by a population with all the typical features of the Bronze Age. These new Maltese knew metals, and may have had superior farming and fishing methods. But they had nothing like the masonry and architectural prowess of their predecessors, contributing to posterity but a few wobbly dolmens that come off as artless approximations of the mighty trilithons that framed the entrances to the astonishing structures they found already built on the island.

3.2 The Place of the Giants

The megalithic monuments of Malta that we are about to investigate are customarily called "temples" (Zammit 1929). However, there are no written sources to support this assumption, and all the evidence we have on the function of these structures is circumstantial, as we shall soon see. To follow custom, I, too, will use the word *temple* to refer to the monuments built on Malta between 3800 and 2500 BC. But we should not allow ourselves to be lulled into thinking that we know what purpose they really served.

The temples of Malta, together with the most ancient megalithic monuments of northwestern Europe such as Kercado, are among the first stone constructions ever built, predating Egypt's pyramids and Stonehenge (very recently, new, exceptional discoveries by the group of Klaus Schmidt of Heidelberg University in the Turkish site of Göbekli Tepe are actually retro-dating megalithic constructions as early as 10,000 BC). Describing the Maltese temples is no easy matter, for we habitually conflate the interior and exterior plan of a building into a single entity, assuming that the exterior plan is synonymous with the outermost walls of the interior floor plan, the only difference being the more or less constant thickness of the walls. On Malta, however, the outside and inside walls are two different things entirely, for they have different shapes and are often positioned at significant distances from one another, such that tens of thousands of cubic meters of earth and rubble were required to fill the voids thereby created (both the exterior and interior walls are made with colossal facing stones). The exterior footprint was plotted by inscribing two circles onto the ground, centered on a line that would become the major axis of the finished building, then cutting away an arc of the outermost circle, and putting the facade in correspondence to this cut.

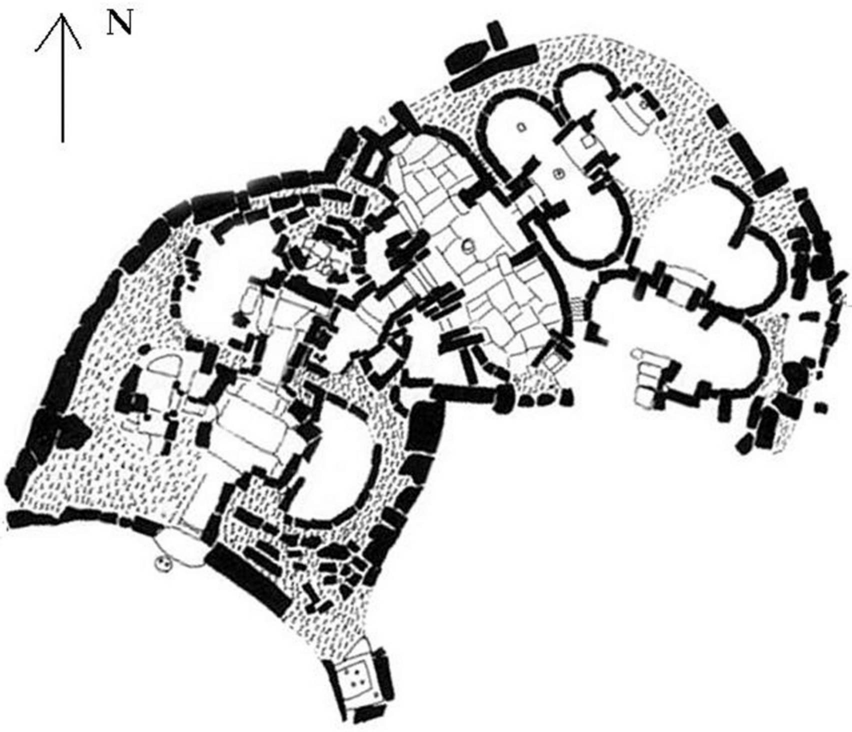


Figure 3.3: Plan of the Tarxien temple.

The interior floor plan is composed of one or more spaces, each configured as twin lobes, or apses, their axis perpendicular to the entrance. The exterior wall thus masks the complexity of the interior, like a simple, sturdy shell designed to contain and protect a more intricate organism within. The sequence of apses can vary in complexity and seems to suggest a kind of modular evolution, one that consists either of the successive addition of more apses while maintaining the overall plan, or of the addition of other temples alongside the preexisting ones. The guiding logic of the interiors of Maltese temples is unique in all the world, and at a first glance seems to elude all attempts at interpretation. It has been suggested, for instance, that it derives from the archaic tombs at Skorba, on the main island. But the argument seems forced, and in any case one would first need to explain the “lobed” floor plans of the Skorba tombs. In truth, however, the solution—written, of course, in the stones themselves—is readily apparent to anyone who knows how to *look* (so readers may figure it out before it is discussed in Chapter 15).

The temples were almost certainly covered by corbelled domes, a masonry technique in which courses of stone are tapered inward as they rise toward the top, eventually meeting in the center. Probably only a few of these roofs used stone for the uppermost courses, while the majority were finished with wood, though we cannot be sure since no roofs have survived. Of the approximately 40 megalithic temples originally built on Malta, only four are well conserved. Each of them underwent various phases of construction, whether it was the addition of apses to existing interiors or the construction of whole new adjacent temples. The oldest of them, on the island of Gozo, dates back to around 3500 BC, and never has a name been more appropriate (and unpronounceable) for describing a work of architecture: *Ggantija,* the place of the giants.

Ggantija is composed of two very similar structures built at a time difference of several centuries from one another. The basic module is a trilobate cloverleaf form, with an ovular entryway that leads inside by way of a small corridor delimited by giant facing stones. The design, execution, and scale of the temples are truly majestic: the interior walls are made from limestone blocks that soar more than 6 meters above the stone slab floors, and both buildings are enclosed by a peripheral embankment wall in the form of a bean, or pinched oval, built with an interesting technique that positions limestone slabs as large as 4.5 meters, alternating them vertically and horizontally. The facade that once connected the two temples has since collapsed, its enormous blocks now occupying the space between the entrances. The interior reveals a number of features common to Maltese temples, most notably the geometric dotted-line decorations chiseled into the stones.

While Ggantija is situated a ways inland, on the hills that slope gently down from the center of Gozo toward the sea, the site of the Hagar Qim temple is rather more dramatic, and extraordinarily beautiful as well (Plate 5). Hagar Qim (3000–2500 BC) indeed sits atop a ridge that plummets precipitously toward the coast in the direction of *Filfla*, an islet to the northwest of Malta. Its monumental facade, composed of two courses of megaliths, bears a very close resemblance to a carved scale model that was found at Tà Hagrat, another Maltese temple, today in ruins. The external walls incorporate the largest single stone block of all the island's temples: nearly 6 meters long, 3 meters wide, and more than 1 meter thick, its weight is estimated at over 30 tons. Following along the outer walls, the visitor is struck by other monoliths that seem to have their own distinct "personality" and their own symbolism; one towers over the rest like an obelisk, another is decidedly phallic, while two others abut to create a lacuna at their seam that renders the combined figure strongly reminiscent of a human pelvis, the gateway of life.

The interior floor plan shares the same lobate modularity we saw at Ggantija, though here it is more complex. In a certain sense, Hagar Qim is a double temple, originally built on a bilobate plan, later expanded on the left

Figure 3.4: Entrance of the Hagar Quim temple with phallic megalith

(with respect to the entrance) with the addition of new apses. It is in these spaces that we find what appear to be stone altars whose oddly mushroom-like form may have been inspired (at least in my view) by certain natural features typical of the Gozo's coast. Some of the wall slabs are decorated with dot patterns, others are cut with rectangular "windows" that provide a view or access into other spaces.

As for the matter of the structure's purpose, it is not unreasonable to suspect that it may have been of a religious nature, even if the details elude us completely. What is certain is that a number of female statuettes were found at Hagar Qim that, like the sleeping figure we discussed at the beginning of the chapter, are endowed with highly exaggerated feminine features. Traces of what were probably animal sacrifice rituals have also been found here. Archaeologists find further evidence of religious activity in the so-called oracular windows, round holes cut through certain wall slabs which are thought to have been used toward oracular and confessional ends, the priest on one side, the congregants on the other. It is a nice idea, but it lacks even circumstantial proof. True, similar practices are well documented in Egypt and Greece, but not until thousands of years later.

From the ridge where the temple stands, the panorama encompasses the islet of Filfla, the coast below, and, about halfway down the steep slope, the

Figure 3.5: Exterior wall of the Hagar Quim temple: stones resembling a human pelvis.

Figure 3.6: Exterior wall of the Hagar Quim temple: one of the hugest blocks ever set in Malta

temple of Mnajdra. In ancient times Filfla may not have been separated from the mainland, given the shallowness of the sea floor between them, and was probably part of a small peninsula guarded by the temples; unfortunately, there is little hope of learning more, for the islet has been used for decades as an artillery training target. Mnajdra communicates with Hagar Qim by a footpath that is paved today but that certainly corresponds to an ancient road—the urge to call it *Via Sacra* is strong—that connected the two temples. All along both sides, one can still see the quarry banks from which the monoliths of hard gray limestone were hewn. The temple (3000–2500 BC) is composed of three trilobate structures, two of which share an oviform entrance space and an exterior wall; as at Hagar Qim, we find the same characteristic dot patterns and oracular windows. On one of the entryway stones of Mnajdra 2, there is a carved image of what the temple would have looked like fully intact.

The fourth well-conserved temple on Malta is Tarxien (3000–2500 BC), which consists of three buildings (there was a fourth, the oldest of all, of which very little remains today). The floor plan here is very complex, though fundamentally based like the others on a lobed structure with the addition of oviform apses. Enormous stones are everywhere; even the raised floor is made with huge limestone slabs. The feature that makes Tarxien so unique,

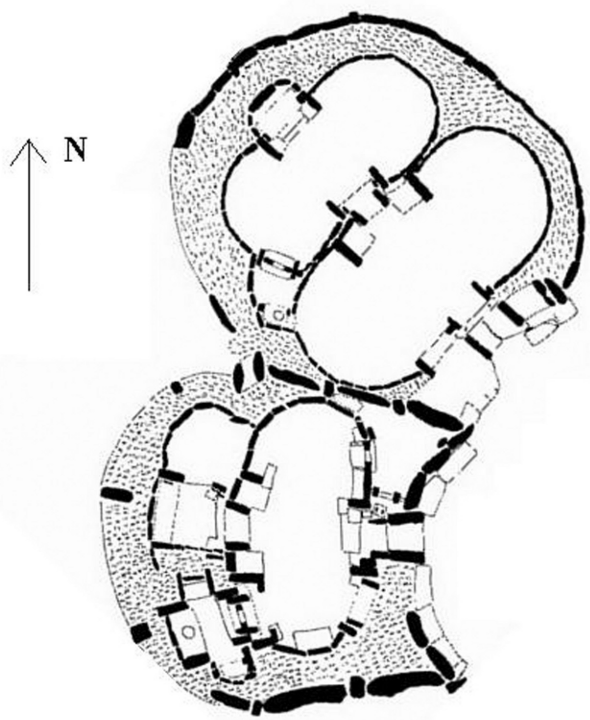


Figure 3.7: Plan of the Mnjandra temple.

however, is in the first apse to the right of the entrance: a larger than life-size statue of a human figure. Though all that survives of the figure is from the waist down, one need only to have seen one of Malta's many other statues of fat women in the National Museum of Archaeology in Valletta to imagine her whole, standing at what would have been about 3 meters tall. Tarxien, like the other Maltese temples, is therefore interpreted as a shrine to a divinity traditionally called the Mother Goddess, with some scholars going so far as to say that the Tarxien statue *is* the goddess, given that it is the only one on such a grand scale that we know of (Plate 6).

The Tarxien excavation also brought to light a number of slabs carved with animal motifs in the dotted line technique we have seen elsewhere on Malta (the originals are conserved at the museum in Valletta, along with the original "Goddess"), as well as graffiti in one of the interior apses representing a bull and a sow with piglets. Evidence of animal sacrifices was detected in the large stone vases found in the temple, and in the concavities of the floor. The full picture, however, is still vague: the fact that the vases contained animal bones does not necessarily prove that animals were sacrificed ritually, for they may just as well have been slaughtered there to be eaten. To understand the difficulties we face when interpreting *mute* artifacts like these, the debate among archaeologists over the small circular holes found in many of the doorway slabs of Maltese temples (much smaller than the "oracular windows") is particularly helpful: approximately half the scholarly literature on Malta's temples claims that these holes were like hitching posts, used to secure animals prior to sacrificing them.

The other half identifies them as rope holes for transporting the blocks.

3.3 A Temple in the Negative

A few hundred meters from Tarxien we come across something quite extraordinary. We can call it a temple because it displays all the features of the Maltese temple—except in the negative. It is a subterranean temple carved into the living rock and its facade has been obtained, under the ground, by *removing* thousands of cubic meters of limestone. It is called *Hypogeum Hal-Saflieni.*

It is no easy task to visit the Hypogeum. In fact, since its careful restoration, only small groups may visit it, one at a time. Reservations must be made well in advance at the Valletta National Museum. Then you have to arrive strictly on time, which is far from simple given the traffic and street signs in Malta. Then you watch a video of what you are about to see. Then the guide explains that you are not allowed to take photos, to film anything, to speak, and if possible even to breathe. (Such precautions seem excessive, but Malta is an island of contradictions; in Bugibba, the remains of a ruined temple are flaunted in the private garden of a hotel, 3 meters away from the swimming pool, and guests use the handy megalithic slabs to drape their towels over to dry in the sun.) Inside the Hypogeum, there is a sequential lighting system so that the light goes on when the guide enters the area and goes off when the guide leaves the area, so the group must follow close behind. Nevertheless, visiting the Hypogeum is worth the effort, as it is without doubt one of the most important prehistoric sites in the world.

The Hypogeum was discovered at the end of the 19th century by workers who were building the foundations of an apartment block. The discovery was kept secret so as not to disrupt the construction schedule, and the construction work caused irreparable damage to the superstructure, which almost certainly included an enclosure giving access in the shape of a megalithic circle. Today only the underground rooms, arranged over three floors, are left. This extremely ancient complex was most likely already in use at the earliest stages of the Temple Period, and in fact it was here that the sleeping lady (cited earlier) was discovered. Each level is made up of numerous spaces, and recalls the features of temples at ground level quite plainly. For example, we can see a room with an “oracular window” and spiral motifs painted on walls that are comparable to those dotted all over the stone slabs of the temple, as well as a veritable facade “in the negative,” splendid with its fake corbelled ceiling, located in a room traditionally called the *Holy of Holies*.

The purpose of this amazing feat of engineering is unknown; one has the impression it that it was a place of initiation, where a ceremony took place. Many rooms were discovered to be filled with the bones of thousands of people, and it has been surmised that the Hypogeum also served as a kind of collective burial chamber. Yet it stretches one’s credulity to imagine (as the guide would have it) that one could only set foot in the place when the corpses were in a state of decomposition. Thus, either the cemetery stage succeeded that of usage, or else the bones were laid there after total decomposition had taken place elsewhere, maybe in the open air.

In the 18th century, in Gozo, another underground hypogeum carved into the living rock was brought to light. The complex was depicted in a watercolor that was painted at the time, but since then all traces of the complex have been lost. In the painting, however, it is possible to make out the temple of Ggantija quite clearly in the background, and it was thanks to this detail that the site was recently unearthed and studied by Anthony Bonanno and his group (1990), who were able to dig it out with modern methods, seeking to set its significance in the context of the island. The site is a few hundred meters west of Ggantija and is known today as Xaghra. The most outstanding of Bonanno’s findings at Xaghra is a statue depicting two “fat ladies” sitting side by side (exactly as the two Ggantija temples are situated). To add to our complete incomprehension of their meaning, one of the ladies is holding on her lap a statuette of herself (see Figure 15.3).

The position of Xaghra in relation to Ggantija is analogous to that of the Hypogeum in relation to Tarxien, and one is strongly tempted to assert that in both cases the pairing is not coincidental. I believe that the pairing of Mnajdra and Hagar Qim might also be ascribed to the same motives, especially if it is true that Hypogea became sepulchers only in the final stages of their usage. But what were these motives?

3.4 An Alignment Not Correlated with Heavenly Bodies

Malta has often been compared to Easter Island. As we shall see in Chapter 12, on Easter Island, a remote islet in the Pacific whose inhabitants had absolutely no prospects of escaping, an apparently crazy building urge led the population to engage in the construction of huge anthropomorphic statues and, it is thought, to the consequent impoverishment of their resources. However, the comparison of Easter Island and Malta holds up only superficially, for various reasons. First, Malta is not at all isolated, and evidence of trade with Pantelleria and Sicily is well documented archeologically. Second, building activities seem to have benefited positively from the demographic and economic resources available, considering that the temples were decorated, enlarged, and renovated over many centuries. Thus, I tend to agree rather with those who make more convincing comparisons with the civilizations of the megalithic builders who flourished in other two Mediterranean islands, Minorca and Sardinia, during the Bronze Age.

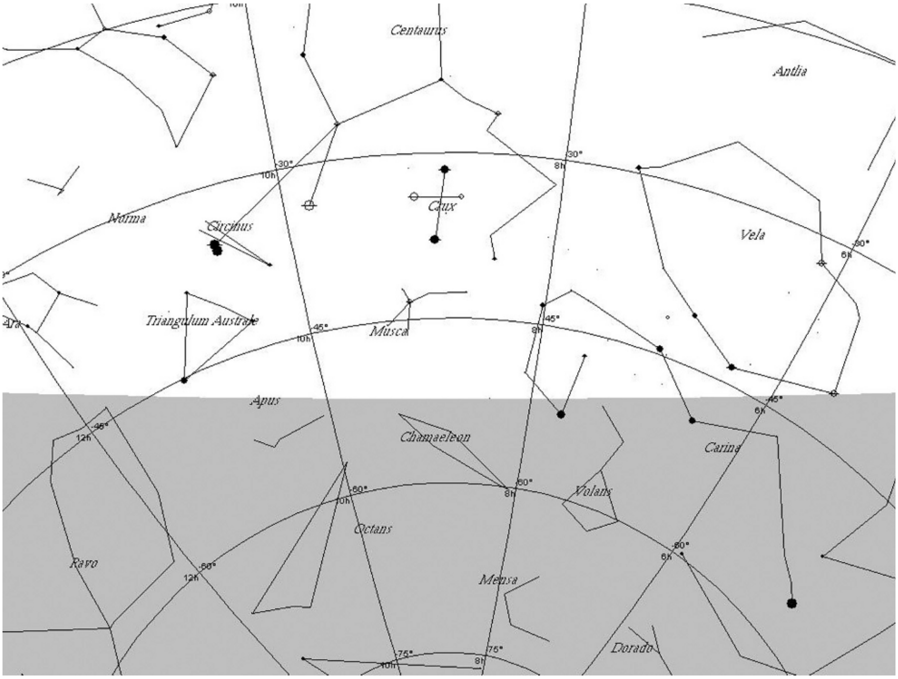
Between 1300 and 800 BC, Minorca, a little island in the western Mediterranean, was subject to a megalithic phase comparable to the Temple Period in Malta. In Minorca, and also in the larger island of Majorca, numerous *Navetas* were built—huge constructions made out of blocks of limestone, resembling military bunkers, which were probably used for burials, and megalithic "sanctuaries," that is, oblong stone enclosures whose function has never been revealed. For some unknown reason, moreover, it is only in Minorca that each sanctuary is centered on an object that archeologists call a *Taula*. A *Taula* is basically an enormous T constructed with two painstakingly finished parallelepiped slabs, one balanced on top of the other. Just as with the Maltese temples, we know nothing about the purpose of the sanctuaries in Minorca and Majorca.

In the 1980s, Michael Hoskin of Cambridge University studied the orientation of all the *Taulas* in good condition, and showed that they were all built in ideal positions for watching the southern horizon, and that all but one are oriented to point in a belt around the south, defined by the rising and setting of the star Alpha Centauri around 1000 BC (Hoskin 2001). Therefore, these monuments point to the stars of the constellations (distinct only in modern times) of the Southern Cross—Centaurus. In my view, it may even be hypothesized that the T-shaped form of the taulas, rather than being inspired by the stylized shape of a bull's skull as has been sometimes proposed, actually resembles the shape of the Southern Cross constellation (the exception to the rule is the Taula of Torralba, which is oriented toward the rising of Sirius).

In Sardinia, between circa 1800 and 1000 BC, a civilization flourished that was obsessed with building massive tower-shaped structures known as *Nuraghi*. Today we have clear evidence of the existence of at least *eight thousand* Nuraghi, divided into simple monuments consisting of just one

Figure 3.8: One of the Taulas of Minorca

tower and complex monuments made up of several structural elements arranged around a central tower, as in the famous and splendid Nuraghe of Barumini. Nuraghi were built with great blocks of stone, often employing highly sophisticated techniques, such as the execution of not one, but two concentric towers, one inside the other, with a stairway running up the cavity wall. These structures have been interpreted in various ways: as defensive bastions (though it has never been clear which enemy they were guarding against so vigilantly), rulers' residences (perhaps a bit cramped and dark?), or places of ritual (though we do not know what rituals). Recent research, however, has at least firmly shown that the builders were extremely interested in heavenly phenomena (Zedda and Belmonte 2004). By analyzing a sample of 272 simple Nuraghi and 180 complex Nuraghi, Zedda and Belmonte discovered that the orientation is always toward the south of east, and displays three clear "peaks" (i.e., directions around which most of the monuments' orientations tend to be concentrated), one facing the sunrise at the winter solstice, a second at moonrise at the south major standstill, and a final peak, the most pronounced, even further southeast, in the direction of the rising of the asterism of the Southern Cross–Centaurus. Moreover, the peak moves southward from 43 degrees southeast to 45½ degrees, if one considers first the simple Nuraghi (probably built first), and then the complex ones. This movement matches fairly well the precessional


Centaurus
Antlia
Crux
Norma
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Apus
Chamaeleon
Carina
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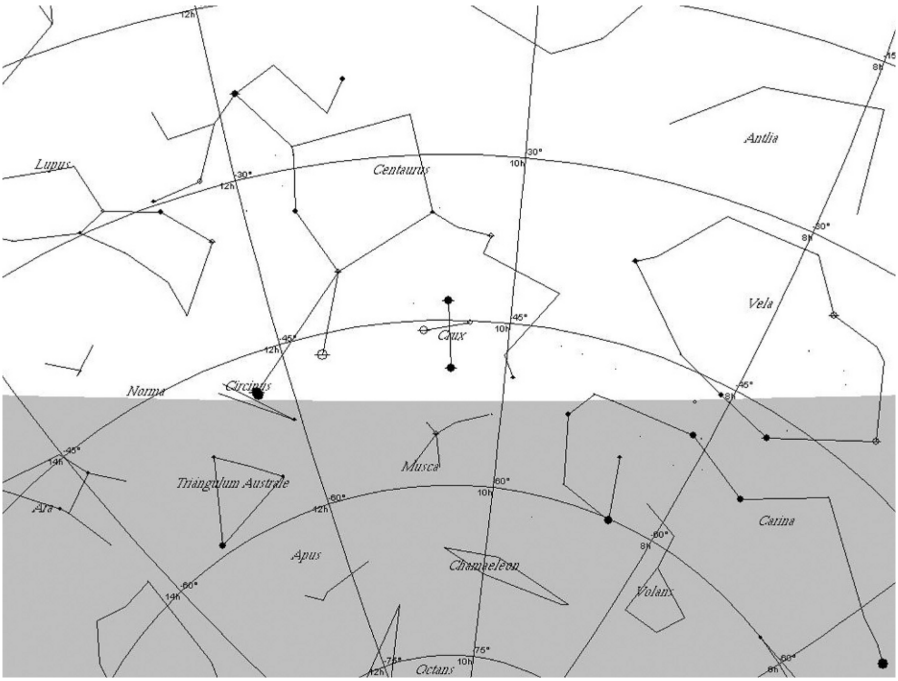
Octans
Pavo
Mensa
Dorado


Antlia
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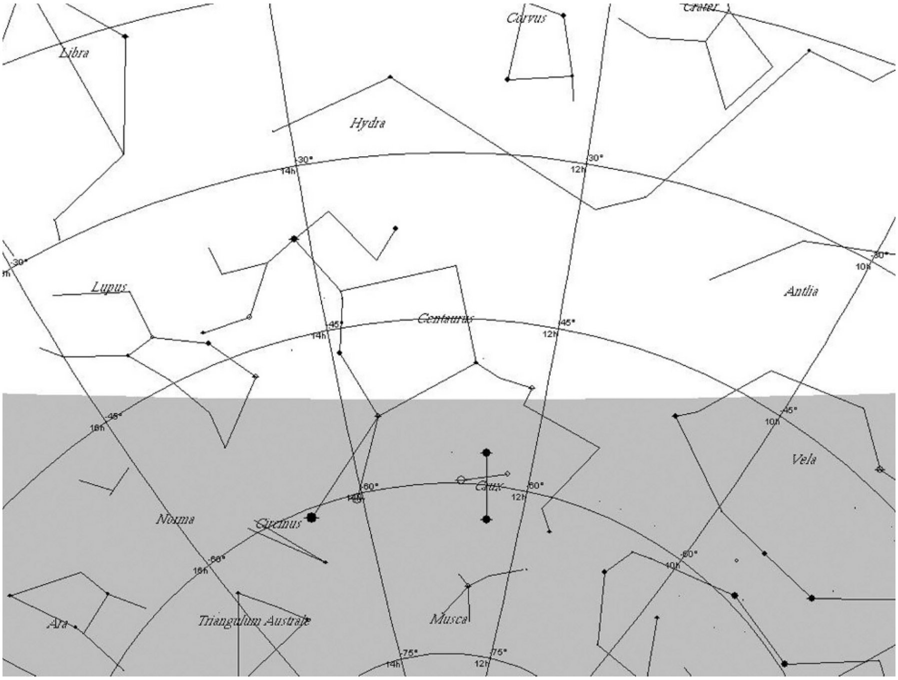


Figure 3.9: The effect of precession on the stars of the southern sky in the Mediterranean area, here taken at Malta latitude. In the first image we see a reconstruction of the sky in 3000 BC, with the Southern Cross culminating relatively high in the sky. In the second image we see the same constellation around 500 BC, still visible but at very low altitude. In the third image, we see the same portion of the sky today: the whole constellation ''culminates below the horizon'' that is, is always invisible. It will come back in the Malta's sky around 12000 AD.

displacement of the rising point of Alpha Centauri in the period 1500 to 1000 BC; actually, due to precession, the whole asterism became invisible from the Mediterranean latitudes during the end of the last millennium BC.

The discoveries by Hoskin in the Balearics and by Zedda and Belmonte in Sardinia show that megalithic builders on these two islands were extremely fascinated by heavenly phenomena. Naturally one suspects that this might also be the case for Malta. As a matter of fact, if one looks at the plan of the Maltese temples, one realizes that they all have their entrances facing southeast, except Tarxien, which faces southwest, and the second temple of Mnajdra, which is directed due east. This obvious tendency toward southeast orientation prompts the immediate thought that the buildings may have been oriented toward sunrise at the winter solstice or at a lunar standstill. But this is not the case. Both the winter solstice and the south major lunar standstill in Malta are too northern in relation to the orientation of the temples' axis. Hoskin therefore suggested that such temples were aligned with the rising of stars of the southern horizon, particularly the Southern Cross. Although the temple era in Malta terminates around 2500 BC, while the first megalithic monuments in the Balearics can be dated around 1800 BC, it is at least tempting to speculate that their orientations are the reflection of the same ideas, a sort of stellar religion connected with the Cross–Centaurus group, which spread across the Mediterranean and, according to recent findings, arrived also in central Italy (Magli 2007a).

The hypothesis of an astronomical orientation of the Maltese temples, which seems eminently reasonable, has been rejected by many archeologists. For example, Donald H. Trump (2002), one of the most eminent scholars on the prehistory of Malta, has this to say:

> The lines are too far south to be linked with the rising or setting of the sun or moon, even at their most southerly. It has been pointed out that the stars of the Southern Cross would have been visible just above the southern horizon at this distant time, but so low, and less brilliant than many others in the heavens, that they are hardly likely to have influenced the temple builders to this extent. This illustrates well the problems of prehistoric religion. Clearly the builders saw some significance in their alignments, though unrelated to the movements of the heavenly bodies. Whatever the reason for their choice, it is quite impossible for us now to discover what that significance was.

Oddly, at least in my view, it is quite the opposite, that is to say, not only were Maltese temples closely correlated with the stars (the objection that the stars of the Cross–Centaurus were "low" does not make sense, since the height of the horizon is accounted for in any serious archaeoastronomical study, while the statement "they were less brilliant than many others in the heavens" is patently wrong), but also we have undeniable proof that these buildings were closely connected to the *solar* cycle (Albrecht 2001).

To understand such links, the ideal starting point is Mnajdra 2, which is directed toward true east, that is, to the equinoxes. Access to Mnajdra 2 is clearly defined; it runs straight across to the opposite wall, where a central altar is to be found. To the left and right there are two identical monolithic slabs, and the upper external corners of the two slabs define two alignments that pass through the access to the temple. One of the two slabs points east of north, the one defined by the slab on the left as you enter, while the other points southeast. The "window" that they span corresponds to the path of the sun on the horizon during the year. Thus, Mnajdra is effectively a *stone calendar*. The sun rising at the winter solstice makes a flag-like (or ax-

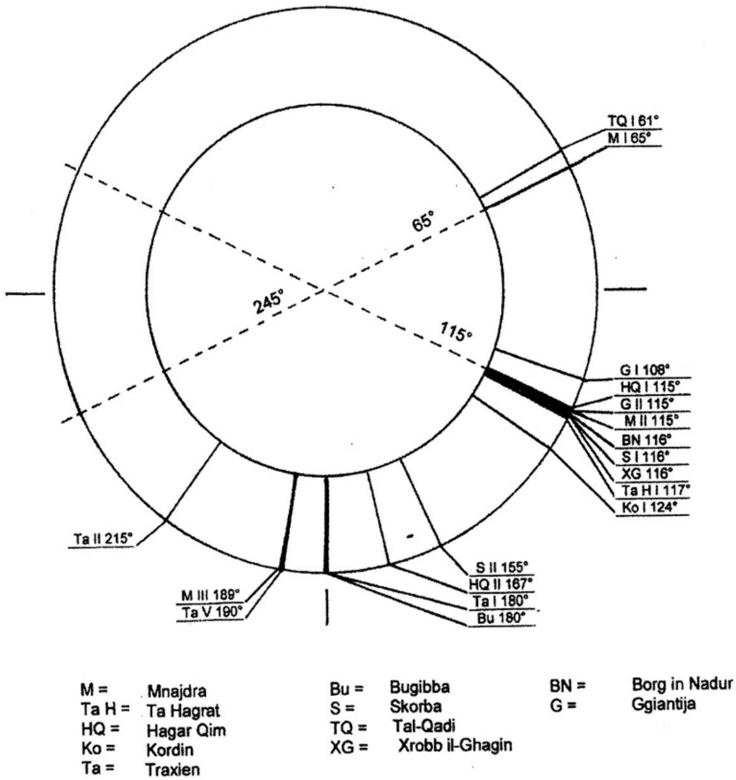


Figure 3.10: Orientation diagram of the left ''altar stone'' in Maltese temples (adapted from Albrecht 2001). Each line reports the azimuth of the front of one such stones; capital numbers refer to various units in the same temple (e.g. Ggantija I and II). Dotted lines refer to the solstices sunrise/sunset.

like) figure on the right slab. In the course of the seasons, one can follow the movement of the sun, which rises on the horizon, observing day by day at which point the light strikes the altar inside the temple. In particular, the equinoctial sun rises in alignment with the axis, while when the ax figure is re-formed on the opposite slab, the sun has reached the midsummer rising point.

The builders of Mnajdra were thus interested in heavenly bodies—very interested indeed. Following the hint from Mnajdra 2, Klaus Albrecht studied the alignments of the altars and discovered that in all the Maltese temples facing southeast, which are the majority, the sun rising at the winter solstice lights up the altar stone set to the left on entry. This allows the direction of the temple's axis itself to be, as we have seen, set further south of the solstice, planning the structure in such a way as to obtain both alignments. It should be noted that Tarxien, which faces southwest, nevertheless obeys the rule perfectly, since the right slab is oriented toward sunset at the winter solstice. The Hypogeum also seems to follow this rule: the facade of the Holy of Holies seems to be oriented in the negative toward the winter solstice.

At Malta there was, then, a bit more than a certain interest in heavenly bodies, especially if we consider that the facade of the Holy of Holies is almost 8 meters below ground and thus cannot be reached by sunlight. We might say that there was the same interest in heavenly bodies as there was in Newgrange, or Maeshowe, or Stonehenge: Maltese temples acted as solstitial indicators exactly as do these other great monuments. Interest in the heavens is also attested to in various other clues, such as a curious carved stone whose significance is difficult to figure out, the *Tal Qadi Stone*, today at the Museum of Valletta (this is a fragment of a slab showing a radial division into five segments, four of which contain stars and the fifth, a lunar crescent), or marks etched onto monolithic slabs in certain temples, for example at Mnajdra, which may refer to observations of stars rising (Foderò Serio et al. 1992). Of course, the problem of the basic reasons behind this interest in celestial cycles in Malta still remains completely open. It would be quite reasonable to refer the astronomer-priest model (see Chapter 2) to Malta as well, and thus assert that the temples were run by an elite of people who somehow founded their power on the celestial cycles (connections between this hypothesis and the "cult of the Goddess," will be discussed in Chapter 15). The other point to understand (though it might seem rather banal) is how the builders contrived to shift and erect such great masses of stones, and with such bewildering ease.

3.5 Cart Ruts

The problem of how huge quantities of rocks were quarried, transported, dressed, and put in place in Malta and elsewhere has never been solved definitively (see Appendix 2). Yet at Ggantija and Tarxien, numerous balls of rock, the size of a football, can be seen. Some of these balls are scattered around, and others are in the foundations at the bases of blocks making up temples, and it is believed that they were used to facilitate the placing of the stones in position. Malta would appear to be replete with clues as to how the transport of blocks was effected. Yet, like everything dating back to the age of the temples on this extraordinary island, even these clues raise more puzzles than they solve.

On the western coast, near Sliema, a road snakes up to the interior and leads to Naxar. If one looks carefully at the escarpment, one realizes that it is scored by ruts, as if a giant had sliced it, with incisions whose only common denominator is that they always run in parallel pairs, the same distance apart, like railways. These cuts clearly seem to be tracks, laid down, however, by a madman, intersecting and forking off without any apparent logic. At one point a "secondary track" branches off, like the service line of a station, and after a few hundred meters rejoins the original track, again for no apparently logical reason. Looking down into these furrows, one realizes that they often vary in depth (not just from pair to pair but also between two ruts of the same parallel pair), from 10 centimeters to as much as 50 or 60 centimeters, and that the hump of rock in the center is not smoothed down. Something similar can be seen only in some other Maltese sites, in particular at Dingli, not far from Mnjandra, in a place nicknamed Clapham Junction, due to its resemblance to the chaotic railway hub in London.

These tracks are called *cart ruts*. They are undoubtedly the work of humans, and extremely old, since tombs dating from the Phoenician period (7th to 6th centuries BC) were cut in the rock, partly destroying many of them. Precise dating is difficult, however; some experts are of the opinion that they date from the Bronze Age, while others would place them at the time of temple builders.

Even though we call them cart ruts, the ruts created by actual wheeled

Figure 3.11: Cart Ruts ''crazy'' crossings at Clapham Junction.

Figure 3.12: Cart Ruts at S. Pawl. Notice the difference in depth between paired lines.

carts passing constantly on stone are quite different from what we have here. There are many examples from Roman times (those in the Via dell'Abbondanza at Pompeii are very famous, for instance), which consist of two parallel ruts, but have roughly the same depth and show signs of wear in the center, significantly less than that caused by wheels transporting a load, but present nevertheless, on account of the passing of draught animals. We can actually also find cart ruts from the Roman Age in Malta, and there is no question about the difference: the Maltese cart ruts, whatever they are, could not have been created this way.

To have an idea of current knowledge regarding cart ruts, one may again consult Trump (2002), who presents an interesting suggestion as to how they were made. One sees indeed an ox dragging along a sledge without wheels. Two cords, each carrying a boulder, hang from the back end of the sledge. The boulders, as they are dragged along, have the sole aim, apart from the obvious one of breaking the ox's back with fatigue, of gouging out the cart ruts.

Even more unreliable are, however, other suggestions and analogies that have been advanced. For instance, an analogy with the so-called Etruscan *Vie Cave* has been sometimes made. The problem is that archaeology has never been able to interpret this phenomenon as well, and so the analogy only confuses matters. Indeed, the *Vie Cave* are spectacular pathways, quite practicable, that amble along with gentle slopes, deeply (*very* deeply, up to 20 meters) etched into tuff, to be found chiefly in the Etruscan areas of Pitigliano and Sovana, in Tuscany. Datable definitely before the 6th century BC (also because of tombs of that period discovered inside them), they are extremely enigmatic constructions, largely overlooked by archaeologists up to now, most likely endowed with some symbolic, apart from functional, significance.

Finally, it has been recently suggested, based essentially on traces of deliberate carving visible in some of the cart rut furrows, that the Maltese ruts were made as water drainage canals, in order to safeguard the scarce land available on the island and to expand agriculture (Sagona 2004); of course, it is in this case rather difficult to understand why they had to carve them in rigorously parallel pairs.

A Civilization Entitled to No Place

4

Egypt has no place in a work on the history of mathematical astronomy.

—O. Neugebauer, *A History of Ancient Mathematical Astronomy,* 1975

4.1 Egypt of the Pharaohs

Any discussion about Egypt seems doomed to begin by quoting an extremely banal sentence of the historian Herodotus, who called Egypt "the gift from the Nile." Actually, the Egypt that we know today is quite different from the swampy land with a tropical climate that was the typical habitat of that part of Africa until circa the year 4000 BC. It was under this climate, so different from the desert climate that will be the typical Egyptian one from the time of the pharaohs to the present, that the largest part of the history of this country, the so-called predynastic era, took place (the term *predynastic* means the time of history prior to the beginning of the pharaoh era, around 3100 BC).

It is important to note that the difference between predynastic and dynastic is basically a formal, political one. It is impossible, indeed, to tell prehistory from history in this way; the findings from the predynastic era include many jewels with pearls and ivory carvings, and at that time the Egyptians were masters in the art of carving stones, from alabaster to the very hard diorite (cf. for example Gardiner 1971). Even much of the religious iconography is present from very ancient times, for instance the cow-goddess with the solar disk between the horns; as we will see, astronomy was already present as well.

The drying of the Saharan zones took place progressively through the whole Neolithic Age, ending during the course of the fourth millennium. In the meanwhile, two states were created, one in Upper Egypt (the south) and the other in Lower Egypt (essentially the Nile's delta). Around the year 3000 BC those two reigns were unified under one ruler, a pharaoh possibly by the name of Narmer, with whom the dynastic history was to begin. The

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_4,

Figure 4.1: Map of Egypt

subdivision of the following pharaohs into 30 dynasties is due to the Greek historian Maneton and is not free of gaps and inaccuracies, and does not always match the genealogical successions. Anyway, it is a scheme that was kept also by the modern historians and it thus has become of common use. Within this scheme the Egyptian history is usually divided in three large periods, the *Old Kingdom*, the *Middle Kingdom,* and the *New Kingdom*, regarding which I will provide some information that will be needed later on.

In the first centuries of the Old Kingdom the structure of the state became very well defined: on top there was the pharaoh, the god-ruler who resides in the capital (Memphis, not far from the modern Cairo) and exerts absolute power, followed by castes of scribes, priests, and warriors. The efficiency of this organization is one of the basic elements that contributed to making the Old Kingdom, and in particular the short period of the fourth dynasty (circa 2600–2400 BC), the period of the human history when humans created the greatest architectonical constructions of all times. There is nothing, indeed, that can be even remotely compared to the pyramids of the fourth dynasty in Dashour and in Giza, which we will visit in detail in later chapters.

With the fifth dynasty, the pyramids became smaller and of lesser quality construction. Nevertheless, for the first time under the pharaoh Unas, the walls of the interior rooms started to be adorned with texts carved on the walls, the so-called *Pyramid Texts*, a collection of formulas meant to aid and accompany the departed during his voyage to the afterworld (they are of extreme importance for us; see Chapter 17). With the following dynasties there was what looks like a slow decay of the centralized power, which culminated in political fragmentation and anarchy (First Intermediate Period). The reasons of the collapse of the Old Kingdom are unclear. The country was again unified around the year 2040 BC by the pharaoh Mentuhotep when, formally, the Middle Kingdom began (circa 2040–1790 BC) with Thebes (today‘s Luxor) as the capital. The Middle Kingdom terminates with the 13th dynasty and the invasion of the country by the Hyksos. The regaining of the sovereignty, started in Thebes, happens with the 18th dynasty and the beginning of the New Kingdom (circa 1550–1150 BC).

During the period of the New Kingdom, Egypt expanded toward the south and, under Tuthmosis I, conquered Nubia. When Tuthmosis II died, his sister (and wife, as it often happened in the royal families) Hatshepsut acceded to the throne and reigned for 22 years. The royal architect Semnut built for the queen the grand funerary temple of Deir el-Bahari. Various pharaohs succeeded Hatshepsut, and Egypt expanded toward Palestine and Phoenicia (Tuthmosis III) and toward Mesopotamia (Tuthmosis IV). Amenophis III founded the Amun Temple in Thebes; his follower

Amenophis IV–Akhenaton reformed the religion into a monotheistic cult of the solar disk Aton and moved the capital to a new city named Tell el-Amarna. Right after that, however, Tutankhamen, the pharaoh who died extremely young and whose tomb was discovered almost untouched in the Valley of the Kings, moved the capital back to Thebes and returned to the old religion.

The following dynasties are marked by the greatness of two pharaohs, Seti I and his son Rameses II. To Seti I we owe the magnificent temple of Abydos, while Rameses II was a prolific builder. During his extremely long reign (which lasted probably 66 years), the temple of Dendera and the two large temples of Thebes—Luxor and Karnak—were refurbished and enlarged. In the western part of Thebes, Rameses II built the grand Ramesseum, and in Abu Simbel (not far from the border between Egypt and Sudan of today, in Nubia) the two temples that were excavated in the rock were both literally sliced and rebuilt on a higher ground when, in the 1960s, the Aswan Dam created Lake Nasser.

Rameses II was also the pharaoh of the war against the Hittites, which ended with the famous battle of Kadesh on the Orontis river. With the death of Rameses II a new phase of decline began. The proper end of the New Kingdom is usually identified as 1070 BC, but the independence of Egypt held quite a bit longer (Third Intermediate Period), until the arrival of the Persians in the year 525 BC.

During thousands of years, Egypt essentially kept many unitarian characteristics that made this civilization the longest lasting one in the history of mankind. Among the causes of this longevity one can include the solid structure of the state, a climate that was relatively constant, and the constant presence of an articulate religion, as witnessed by the many temples.

To understand the structure of the Egyptian religion, it is convenient to divide the complex Egyptian pantheon into different groups (cf. for example Donadoni 1975). A first group includes the divinities associated with the natural phenomena, led by Re (Ra), God of the Sun, sometimes worshiped also by the name of Re-Horakhty (Horus of the Horizon) and intimately connected with the figure of the pharaoh himself, and then Shu (the Air), Nut (the Sky), and Geb (the Earth). In the sky were also Sah and Sopdet (Sothis), respectively represented by the Orion constellation and by the star Sirius, and considered celestial counterparts of Isis and Osiris (see below). A second group included the divinities associated, at least initially, with specific geographic regions, such as the Crocodile God Sobek (Kôm Ombo), the God Montu (then substituted by Ammon [Thebes]), the Cow-Goddess (Dendera), and so forth. From the western Delta of the Nile come instead the falcon Sopdu and Seth. A third group of divinities is associated with the afterworld: Anubis, the god of the mummification procedures; Osiris, the god of afterlife, whose cult was extremely popular and spread all over Egypt; and Ptah, a Creator God of ancestral type associated with the funerary cult during the New Kingdom. Because many divinities covered many similar tasks in different regions of the country, a gradual relocation grouped them either into families, composed by father, mother, and son, or by identification. In this way, for instance, Ammon and Ra became Ammon-Ra, Atum and Ra became Ra-Atum, and so on. It is necessary to add to this scheme the divinities associated with animals, such as the bull Api of Memphis, and the cult of some special objects, such as the Ben-Ben stone, worshiped in Heliopolis.

Finally, the ruler credited himself as a god, *always the same one*, named Horus, reincarnated each time in the new pharaoh. As a living god he was also the supreme priest, the contact point between the human and the divine, and responsible for the order of things, the *cosmic order* or Maat. The pharaoh symbolically renewed his rights of the reign with a celebration called *heb sed*, which ended with a (perhaps symbolic) race with the sacred bull called Api. It appears to have been a long-run celebration, occurring perhaps every thirty years, even if there have been many exceptions to this rule (for instance, Amenhotep III celebrated two festivals shortly after the first one). One thing is certain: the celebration was very ancient and it already existed at the time of the first dynasties; it would be interesting to establish if the origin of the cycle of thirty year had an astronomical reason, something that, as far as I know, no one has yet investigated.

The most complete documentation of the religious aspect of the life in Egypt comes from the cult of the dead. In the Old Kingdom, life in the afterworld is basically reserved for the pharaohs for whom the pyramids were built, rigorously on the west bank of the Nile, where the sun sets. This bank was reserved for the dead, as will be the royal tombs in Thebes in the New Kingdom. As time went by, the need to control the ever larger territories made the local authorities gain more and more power, including the sacerdotal duties. As a consequence, autonomous necropolises appeared together with large templar complexes. Thanks to royal donations, those temples accumulated territories of their own and became places of power that managed both humans and farming fields. This process, which had already started toward the end of the Old Kingdom, will then continue through the whole history of Egypt.

In the Old Kingdom, life in the afterworld was thus reserved for the Pharaohs, and the people of the higher social classes tried to share such a destiny by being buried in tombs, today called *mastabas*, next to the pharaoh's pyramid. During the Middle Kingdom the possibility of a life in the afterworld spread to priests and high state officials, so that texts regarding the rebirth, similar to the Pyramids Texts, were carved on the internal sides of their coffins. Finally, during the New Kingdom, the texts meant to accompany the departed were written on the walls of the tombs and on papyri (Bresciani 2001). Among those texts, the most important one is the *Amduat* (the book of what is in the afterworld), which documents the voyage of the Sun God into the 12 divisions of the Reign of the Dead, corresponding to the 12 hours of the night (see below). Similar to the Amduat are the Book of the Gates, in which the 12 divisions are associated with 12 doors or gates to cross; the Book of the Caves, in which the afterworld is divided in six parts; and the Book of the Earth. The ancient formulas of the Pyramids Texts and of the Coffins Texts, instead, merge in the Book of the Dead.

All these texts were somehow meant to guide the soul in the afterworld. It is, nevertheless, difficult to explain the various types of souls that the ancient Egyptians believed to exist. Indeed, the body (Khat) was just one of many, and not just two, parts of the human being, and the meaning of the remaining spirit-parts is far from having being completely understood. First there was the Ka (the "double"), which was independent from the body and could be "transferred" elsewhere, in a statue for instance. Then there were the Ba, a kind of bird-soul, meant to feed the dead and female partner of Ra on the solar boat; the Khaibit, or shadow-soul; the Akho, or immortal soul, destined to ascend to the heavens; the Sahu, a kind of spiritual incorruptible body that one could obtain by undergoing the judgment of Osiris; the Sekhem, or vital force; the Ab, meaning the heart, destined to be weighed during the judgment of the dead and possibly eaten by the god Ammut if the actions in life were found unworthy; and finally the Ren, the true name, to be kept secret to avoid magic spells.

In this way, the afterlife of those who would have managed to pass the tests of the afterworld and the judgment of Osiris was going to be quite hectic: Khat and Ka in the tomb; Ba with Ra on the solar boat; and Akhu, as we will see later, together with the gods in the region of the northern stars. The necessary condition, though, was the perfect preservation of the body, obtained through mummification, a procedure linked to many ceremonies. Perhaps the most important one was the so-called *Opening of the Mouth*. It seems that this ceremony was initially conceived of as a ritual to allow the statue of the dead to "receive" the Ka as a guest and also the food offerings for it. The statue was situated in the *Serdab*, a special room in the tomb. There is evidence that this ritual already existed in the first dynasties and it is also mentioned in the Pyramids Texts. From the scenes of the tomb of a royal officer, Metjen, and from the texts it appears that the ritual was performed by touching four times the mouth of the deceased, first with the fingers of the officer and then with some special instrument. One instrument was the foreleg of a bull (perhaps made of wood) and another one was a curved ax with the same shape but with an iron blade.

The techniques for iron extraction in Egypt became of use some 1500 years after the Old Kingdom; therefore, at first glance the use of this material looks puzzling. Actually the iron used in the Old Kingdom was meteoritic, meaning that it was not extracted but was directly available in small quantities that fell on Earth in the form of meteorites. The meteorites, being fragments of comets or of very small planets that disintegrate, can indeed be of two kinds: stone meteorites (the vast majority), or iron meteorites (made of iron and nickel). The arrival of these latter objects, in flames and accompanied by a thundering noise, was interpreted as a celestial message, to the point that the iron, called *bija* in the Pyramids Texts, was the material in which the bones of the dead pharaoh were supposed to turn into; it may be that the whole celestial sphere was thought to be made of the same material. The iron meteorites are usually in the shape of a cone, and it is likely that the Ben-Ben stone, worshiped in Heliopolis, which was exactly in this shape, was an iron meteorite.

Another instrument used during the rituals was a kind of knife with two blades, in the shape of a swallow tail, called *psh-kef*, already present in predynastic tombs. Complete sets to perform the Opening of the Mouth ritual have been found, and can be seen in the Cairo National Museum. They are limestone boxes with separate spaces for two iron blades, one *psh-kef*, two small bottles, and four small chalices. The ritual remained in use also during the Middle and New kingdoms, becoming, however, one of the main operations to be performed directly on the mummy of the dead and not on his statue. One of the most famous depictions of the ceremony is that appearing on the fresco of Tutankhamen's tomb in the Valley of the Kings. In the scene, the priest Ay is depicted while he is opening the mouth of the pharaoh's mummy, granting him, in this way, the celestial life and legitimating, *founding*, at the same time his own temporal power as successor.

4.2 A Primitive Mathematics

As we have seen, the civilization of the valley of the Nile was extremely complex, based on a formidable social, economic, and religious structure.

All this would suggest that science was quite rich in content, and, in particular, the construction of so many monumental buildings suggests a deep knowledge of geometry, mathematics, and engineering. Strangely, however, according to the classic works on the history of science, this seems not to be the case. For example, one of the most renowned experts on the science of the ancient times, Otto Neugebauer, has often called the mathematics of ancient Egypt "primitive," and did so especially in his famous book *The Exact Sciences in Antiquity*, considered by many a fundamental reference.

How the primitive Egyptian mathematics worked is something that we will discuss shortly. But first, it would be interesting to know on what documents and evidence Neugebauer—and the science historian Boyer (1991) and many others—based his lapidary assessment of the Egyptian mathematics. He based it on only two pieces of evidence: one papyrus, the *Rhind Papyrus,* and one piece of a papyrus, the *Moscow Papyrus*. The available written documentation ends here. The reason, I believe, is simple, although I cannot prove it. The papyri containing scientific and technical information, such as astronomical observations, mathematics and geometric notions, and building plans, were not usually placed in tombs as an "endowment" for the afterworld, and yet the great majority of the papyri that we have today do come from the tombs. As a result, we have many copies of the Book of the Dead, but only two little pieces of papyrus addressing mathematics. To base our conclusions on just these two fragments, as Neugebauer and other science historians have done, is ludicrous; in this case, we cannot rely on just these brief written sources for our knowledge (I will address this problem in depth in later chapters).

Further, even the interpretation of these sources is quite a delicate issue. The Rhind papyrus, preserved today in the British Museum in London, gets its name from the Egyptologist Henry Rhind, who bought it in Luxor in 1858. It is about 6 meters long and 30 centimeters wide, and was written at the beginning of the New Kingdom or shortly before that by a man named Ahmes, who acknowledges that he is copying from a document that is 200 years older (the Moscow Papyrus belongs more or less to the same period). The Rhind Papyrus addresses 87 problems, the Moscow Papyrus, 25. Some of those problems are of a theoretical nature and deal with the manipulation of fractions or with the solution of simple equations similar to the famous brick riddle ("A brick weighs 1 kilo plus a half of a brick; how much does a brick weigh?") for instance: "A quantity added to a quarter of that quantity gives 15. What is the quantity?" Other problems are of a geometric nature, such as the calculation of the volume of a pyramidal frustum (truncated pyramid). The elementary operations between integer numbers involved are

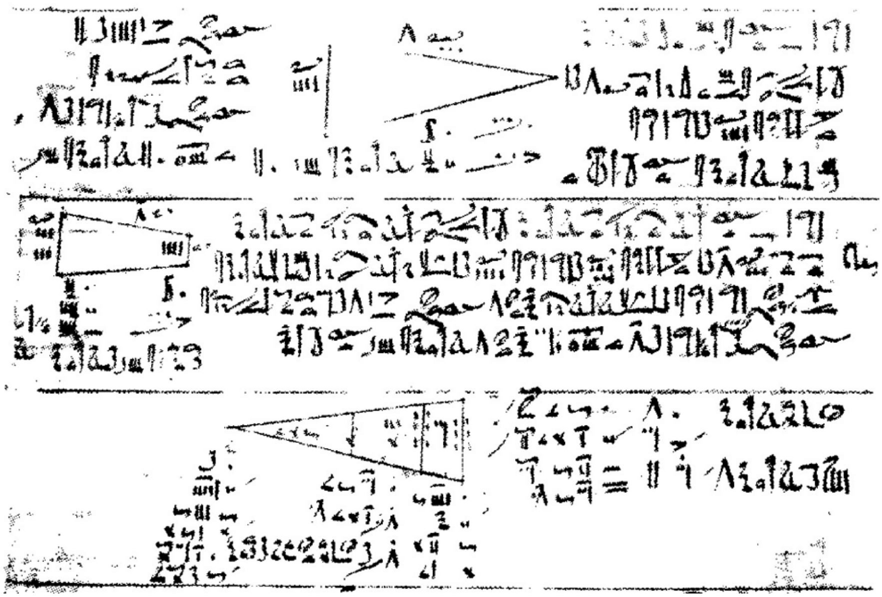


Figure 4.2: Examples of exercises of the Rhind papyrus

performed following a method often vilified and considered primitive in the mathematics literature. It is, however, basically equivalent to the binary system, the one used by computers today. Rational fractions are used as well, but always changing them to the form of unit fractions (for example, 2/5 = 1/15 + 1/3).

All in all, the choice of problems looks quite didactic. It is, therefore, difficult to determine the level of knowledge required to solve the problems contained in the Rhind papyrus.

Thus, the science historians' claim about the poor knowledge of the ancient Egyptians is quite suspicious. Further, we have no document regarding mathematical knowledge in the *Old* Kingdom, and no one can affirm that such knowledge was inferior to that in later times; it is very hard to believe that somebody like Ahmes would have been able to orient within 3 arc-minutes to true north an object 150 meters tall and weighing some seven million tons. However, this has really been done, and it has been done in the Old Kingdom, as we shall see. Perhaps, Neugebauer should have given it a little bit of extra thought.

4.3 A Boring, Delaying Calendar

The foundations for the study of astronomy in the ancient Egypt were laid by Otto Neugebauer together with Richard Parker. The whole body of what they considered to be the known texts of Egyptian astronomy was published in four large volumes (Neugebauer and Parker 1964). These books are difficult to find today, but fortunately a copy belongs to the architecture library of my university, the Politecnico of Milan.

In these volumes, Neugebauer and Parker state:

> The study of all available Egyptian astronomical texts nowhere reveals the existence of such a level of theoretical understanding as was reached in Babylonian and Greek astronomy in the fifth or fourth century BC. This is not surprising since the mathematical tools developed in Egypt were by far too primitive to be of use in astronomical investigations.

Even worse, the work starts with the Middle Kingdom because, according to the authors, the earlier age of the pyramids, one of the most intense and wonderful periods in the history of mankind, did not leave any record of astronomical knowledge. As I discuss in later chapters, this assertion is blatantly incorrect. For the moment, however, let's look at what is certain and universally accepted. The only astronomical concept that is universally accepted as dating from the Old Kingdom is the codification of the Egyptian calendar. Maybe in predynastic times a lunar calendar already existed; nevertheless, very soon, during the first dynasties, a solar civil calendar of 365 days—without a leap year, thus slipping approximately one day every 4 years with respect to the solar cycle—was introduced as well. In Egypt, though, the only significant natural event was the cycle linked to the annual Nile flooding, rather than to the alternation of the seasons. Therefore, the year was divided not into four seasons but into three: *Akhet* (flooding), *Peret* (growing of the crop), and *Shemu* (the dry season). Every season was divided into months of 30 days, and every month into weeks of ten days. Five days (usually called *epagomenal days)* were added to the calendar to reach a total of 365.

The calendar was codified in a period in which the day of the heliacal rising of Sirius (the day in which it becomes visible again just before dawn after a period of invisibility), the brightest celestial object after the Sun, the Moon, and Venus, roughly coincided with the flooding of the Nile (which is a *gradual* event that happens over 30 to 40 days) and with the summer solstice, chosen as New Year's Day. The likely reason behind this choice is linked to a cult of "stellar rebirth"; a trace of this cult is, for instance, the fact that the mummification process was ritually fixed to last 70 days, which is a good approximation of the period of invisibility of Sirius at Memphis (it is impossible to define with high precision the period of invisibility of a star; see Appendix 1). In any case, the duration of the cycle of Sirius, or *sothic cycle,* is of 365.25 days, and as a consequence of that, New Year's Day started wandering with respect to the heliacal rising of Sirius, completing a full cycle after 1461 years, when the heliacal rising of Sirius and the beginning of the year coincided again. Such a long period is known as the *sothic year*; in a way, the existence of this "double geared" count of time is similar to what happened among the Maya, who had two calendars running simultaneously and commensurable through a "long year" lasting 52 solar years, as we shall see in Chapter 7.

From the work of writers from the classic age, we know that in the year 139 AD the heliacal rising of Sirius coincided with the beginning of the new year; therefore, the calendar could have been codified 1461 years before, around 1321 BC, a date that is actually *too late* according to all sources. The consequence is that the calendar must have been adopted not one but *two* sothic years before the year 139 AD, which means around the year 2781 BC, right at the time of the Old Kingdom, just before the age of the pyramids (therefore we can at least be sure that, at that time, heliacal risings of bright stars were observed).

The fact that the Egyptian astronomers recorded the heliacal risings of Sirius for millennia is of extreme importance for Egyptology. Indeed, it is obviously possible to calculate the days in which the heliacal rising of Sirius happened through the centuries. In 1870, the Egyptologist Goerg Ebers bought a papyrus in Thebes where the event is recorded to occur on the ninth day of the third month Shemu during the ninth year of Amenhotep I, and other heliacal risings are recorded by other sources under Sesostri III and Tuthmosis III. It is then possible to link the reigns of such pharaohs to dates on our calendar and therefore identify, for instance, to which Gregorian year the ninth year of Amenhotep I corresponds. Further, thanks to some sources that record the durations of the reigns of the single pharaohs (for example the list of the kings, existing in the temple of Seti I in Abydos), it is thus possible to pinpoint the chronology of the pharaonic dynasties (it is a complicated and risky operation; for instance, if the observation recorded in the Ebers Papyrus happened in Memphis, it would have been in the year 1537 BC, while if it happened in Thebes, it would have been the year 1517 BC). Unfortunately, we did not get any recordings of heliacal rising of Sirius prior to the reign of Sesostri III (circa 1830 BC); therefore, the chronology of the Old and Middle kingdoms is much less accurate than that of the New Kingdom (for a recent and thorough approach to the interesting problems raised by the Egyptian calendar, which are only addressed in brief here, see Belmonte and Edwards 2004).

The "wandering" of the civil calendar generated in some writers the crazy idea that the ancient Egyptians struggled to put up with the continuous problems caused by the progressive shifting of the dates with respect to the seasons, and some even wrote that the Egyptians' stupidity prevented them from reforming the calendar during the three thousand years of their history. Probably, instead, since it was the flooding of the Nile that dictated the yearly cycle of farming rather than the solar cycle, they simply did not feel the necessity of adjusting the calendar. In any case, the Egyptians knew the solar cycle perfectly well. To verify this, all we need to do is to visit one of the most magnificent temples in human history.

4.4 Solar Orientations of Egyptian Temples

Many of the Egyptian temples had a millenary life, and were, through the centuries, modified and extended according to the will of the different pharaohs. The typical structure, made of a *pylon*, which is a large masonry facade, followed by a courtyard, a hall with columns, and at the end a chapel, became longer and longer through the years thanks to an added second pylon, a second hall, and sometimes extra chapels, obelisks, or accessories buildings. Even if many Egyptologists still doubt it, I believe that there is no question regarding the fact that the great majority of the Egyptian temples were astronomically oriented; in any case, at the moment a vast archaeoastronomical campaign is being carried out, and I hope a definitive answer to the question will be found (cf. Belmonte and Shaltout 2005, 2006.)

A pioneer in the studies regarding the astronomical orientation of the Egyptian temples was Norman Lockyer, who addressed the subject in his book, *The Dawn of Astronomy* (1894). The book was published at a time when the chronology of ancient Egypt was still unclear, and was thought to go much further back in time than it actually did. Therefore, the book is now quite dated, and many of Lockyer's statements are wrong because they are linked to incorrect dates. Despite all this, Lockyer had the great merit of having been the first to demonstrate the ancient Egyptians' interest in astronomy and, in particular, in the sun cycle.

The orientation of the temples could be solar, that is, toward the rising or the setting of the sun on some special days, not necessarily the solstices; or stellar, that is, toward the rising of important stars or toward circumpolar stars. A very important example of a temple with solar orientation is the grand temple of Amon-Ra in Karnak, built for the first time during the 12th dynasty (c. 1900 BC). It is a magnificent complex beautifully refurbished in time by the various pharaohs (Plate 7). Contrary to the nearby Luxor Temple

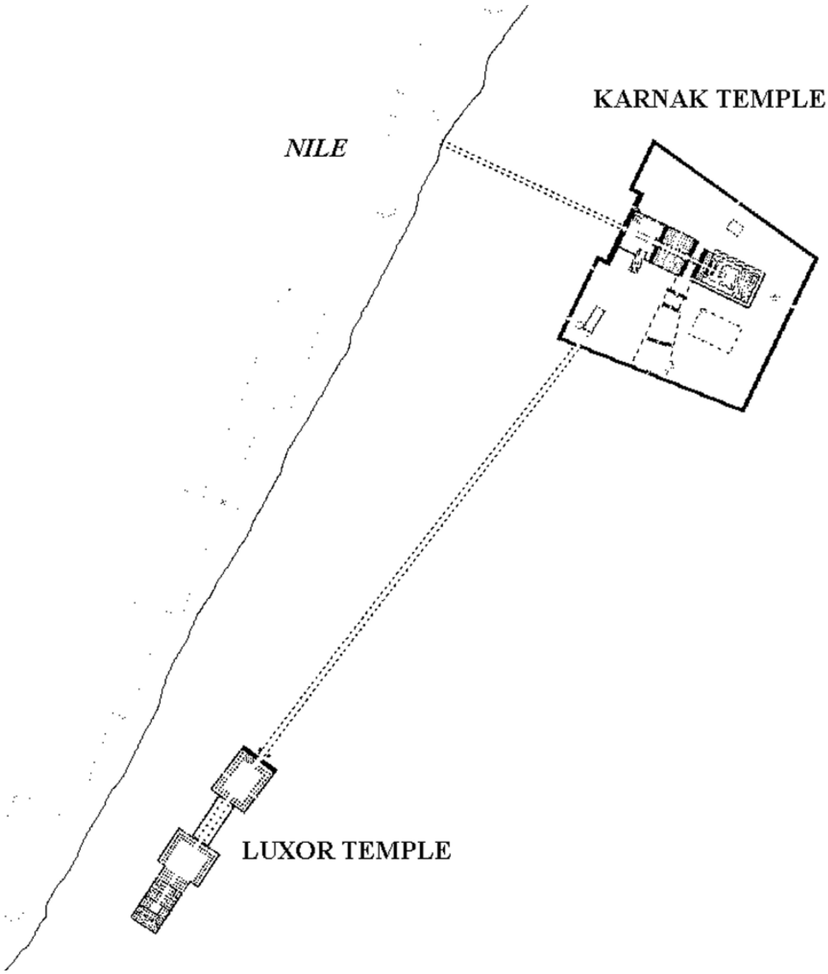


Figure 4.3: Plan of Karnak and Luxor temples (north on top). Notice that the Karnak axis goes perfectly straight, while the Luxor axis bends several times. Both temples have been embellished and elongated in the courses of several centuries.

(Plate 8), the temple clearly shows a main axis to which various homogeneous parts were added by Amenhotep III, Tuthmosis I, Tuthmosis III, Hatschepsut, and Rameses II; this last pharaoh contributed the wonderful hall with columns that are 14 meters tall and 2 meters wide, which became popular worldwide thanks to the film inspired by Agatha Christie's novel *Death on the Nile*. Lockyer showed that the axis of this temple, when one is looking from inside out, is oriented toward the sunset on the day of the summer solstice. He thought, therefore, that the sun rays at sunset would flood the corridors and reach the chapel at the end of the temple, and that the latter was used as an astronomical observatory to keep track of the solar cycle. But this actually could not happen, because the hills on the west act as a barrier that blocks the sun rays just before they align with the corridors. Unfortunately, this “mistake” made by Lockyer (I will explain the quotation marks; see below) was a disastrous one, because the archaeologists became diffident about the astronomical interpretation, and convinced themselves that the orientation of the temples, Karnak in particular, was toward the Nile. Actually, the position of the axis of the Egyptian temples was always decided on by taking into account the position of the Nile, both for religious (for instance, the arrival of the procession via the river) and for practical reasons (the transport of construction materials and of obelisks). The temple in Karnak, in particular, was built with its main facade facing the river. This did not exclude the astronomical orientation at all, however; the solstitial orientation of Karnak is a fact, and it would have been enough, before deciding that Lockyer’s ideas were wrong, to have considered that the sun, on the day of the *winter* solstice, rises in the direction opposite to the one where it sets on the day of the summer solstice.

In the 1960s, the problem was reconsidered by Gerald Hawkins. He noticed a window, in a little chapel built by Tuthmosis III in the east end of the temple, aligned with the sunrise at winter solstice. An inscription in the chapel shows the pharaoh in front of the window, and the texts says: “We applaud your beautiful face, you biggest of all Gods, Amun-Re" (Krupp 1983). The temple was therefore *really* aligned on a solstitial axis, as Lockyer determined, but given the existence of the hills on the western horizon, the observations of the solar cycle took place on the opposite side.

Lockyer found other solstitial alignments, for example that of the axis of the temple of Amenofi III in Luxor. Today we know that solar alignments were also used in Egypt to realize some spectacular events that I will call, borrowing the term used by the religions historian Mircea Eliade (1964), *hierophanies*.

To describe them, let’s think of a building aligned with the sun that rises or sets in a particular direction, and consider it together with the sun itself, in its constant motion, as a single thing, like a mechanism made of different gears. When the gear in motion (the sun) aligns with the given direction, the mechanism operates and something happens (for example, the light penetrates in a dark corridor). If this mechanism has a religious connotation, one can envision the phenomenon as a *divine manifestation*. In a certain way, then, it is as if the objects produced by human effort become alive at the very same moment they become the instruments of such a manifestation (see Chapter 15 for further details). In this book we discuss some extremely impressive hierophanies of rare beauty, and the first one is indeed in Egypt, in

Abu Simbel, where Rameses II (1279–1213 BC) built two temples excavated in the rock. Until the 1960s, the temples stood on the bank of the Nile and for over three thousand years they welcomed, and intimidated, all those who reached Egypt from the south. The construction of the great Aswan Dam, which created the artificial Lake Nasser, would have sunk the temples, so they were dismantled and rebuilt inside an artificial cavity made of armored cement some dozens of meters above the site of the lake.

The facade of the main temple is carved in the rock and houses four gigantic statues, 22 meters tall, of the pharaoh. The temple is oriented toward the east (we shall shortly see how), and on the top of the facade a line of baboons watches the dawn with their paws raised as a sign of adoration. On the left side of the facade, a chapel dedicated to Re-Horakty is oriented toward the raising of the Sun on the summer solstice (Krupp 1988). The interior, originally carved in stone, contains a series of halls aligned one with the other and with frescos telling the heroic life of the king. The last, small hall has, in its rear wall, four statues representing four divinities sitting down next to one another: Ptah, Amun-Ra, Rameses II as a God, and Re-Horakhti (Plate 8).

On February 22 and October 22 of every year, since 3200 years ago, the sun rises in alignment with the axis of the temple. Since the temple was restored and the corridor was cleared of debris in the 19th century, the sun rays, on those two particular days, run again through the galleries, crossing all the halls in a row and reaching the chapel at the very end of the building. The sun carefully avoids Ptah but illuminates Amun-Ra, and then it moves, illuminating Rameses II and, in the end, also Re-Horakhti. The sun, then, manifests and makes tangible the sacredness of the temple through a cyclic phenomenon that occurs twice every year (it is likely that the two dates had calendrical significance and/or coincide with the date of accession of the pharaoh).

4.5 The Stretching of the Cord

The orientation of a temple took place when the foundations were laid. This operation had an important symbolic meaning, and coincided with a precise ceremony described and represented in many temples, such as that of Hatshepsut and that of Dendera, for instance. The ceremony was called *stretching of the cord*, and it is extremely ancient, being quoted for the first time in the *Palermo Stone*, a list of the kings of the first five dynasties (Belmonte 2001).

In a typical depiction of the ceremony, the pharaoh who ordered the

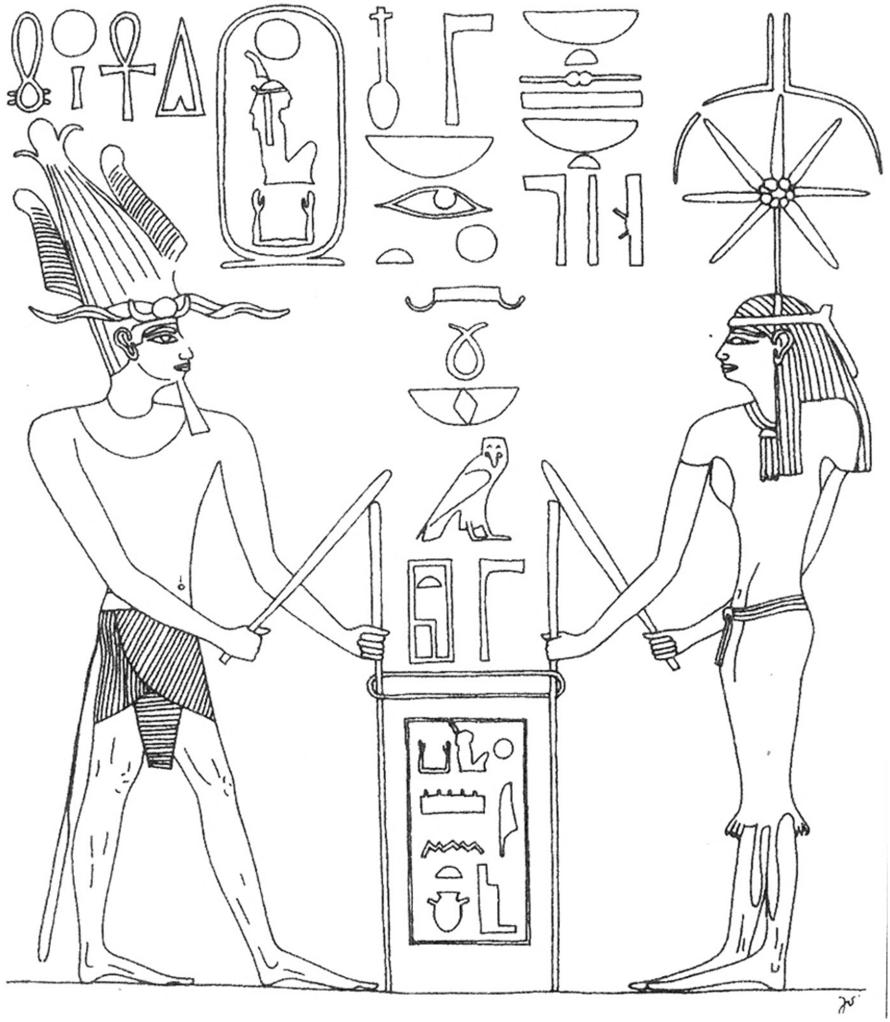


Figure 4.4: The "Stretching of the cord" ceremony from a carving in the Hatshepsut temple

building of the temple is shown together with the goddess *Seshat*. Seshat was associated with wisdom and knowledge, as well as with writing. Interestingly, it seems that she was also associated with the *transmission of knowledge,* since one of her titles was Guardian of the House of the Books.

The pharaoh and the goddess face each other, and both of them have a kind of hammer in one hand and a pole in the other. Between the two poles there is a rope ring being pulled. The texts associated with these depictions include sentences that doubtlessly regard the observation of the northern sky. For example, in Dendera, the texts state, "Watching the sky and at the celestial objects rising movements, once identified the *Ak* of the constellation of the Bull's Foreleg, I calculated the angles of the temple."

The Bull's Foreleg constellation, called *Mesketiu* (*Mes)* by the ancient Egyptians, is our Ursa Major constellation and precisely the brightest part of it is also known as the Big Dipper or Chariot, composed of seven stars and typical of the northern sky. Therefore, the ceremony refers to the orientation of the temple toward the north. The same shape of the Bull's Foreleg recalls the terrestrial geographic north in Egypt; the delta of the Nile was indeed indicated as a Bull's Foreleg. Anyway, it is still not clear how the orientation was carried out (maybe by specialized astronomers, even though we cannot be sure if the pharaohs themselves studied astronomy or not), and it is not clear at all toward which northern direction they were looking when orienting a temple to the stars. Indeed, these temples are *not* oriented toward true north, and therefore the ceremony was not meant to find the celestial North Pole using the movements of suitable stars (as was done for the pyramids, as we shall see in Chapter 18). The main problem is that we do not know what the term *Ak* indicates. It could be a certain position, for instance the maximum distance reached by a circumpolar star east of north, or a particular position of two or more stars together. In any case, the orientation of a temple toward the circumpolar stars had a strong symbolic meaning: these stars were one of the destinations of the soul of the dead pharaoh, and the typical shape of the two constellations Ursa Minor and Ursa Major appears frequently in the ceremony of the opening of the mouth. As we saw, the priest officiating the ceremony used some curved axes, and also a bull's foreleg (Plate 10).

The celestial objects were observed with a simple but effective instrument called *Merkhet* (one of these instruments from the late period is today preserved in Berlin). The Merkhet was basically a palm stem with a slit at the bottom of one side to be used as a viewfinder. Then a level with a plumb line was used to show the directions on the ground. Even if the Merkhet is the only Egyptian astronomical instrument of proven existence, the Spanish astrophysicist and archaeoastronomer Juan Belmonte pointed out that the goddess Seshat, in the depictions of the stretching of the cord, is represented with some kind of hat (which is also her hieroglyphic) in the shape of a seven-petal flower with a long stem, which is included in a bell-shaped symbol. The seven petals could again be the seven stars of the Ursae, and the goddess hieroglyphic could represent a true instrument for observation where, in the middle of the seven-point star, a star was collimated so that the stem would offer the perpendicular to the horizon and therefore the direction sought (Belmonte 2001).

Even if it is likely that the temples oriented in directions close to true north have been intentionally oriented toward circumpolar stars, further research is needed to clarify the specifics of the orientation. For example, let us consider the Hathor temple of Dendera, located close to the city of Qena, some 60 kilometers north of Luxor. The temple dates back to the Middle Kingdom, but its present state is dated around the first century BC. The wall carvings record the ceremony of the stretching of the cord, and indeed the main axis is oriented northerly, in the direction 18.5 degrees east of north. One of the possibilities is that the axis was oriented as to indicate the maximum distance reached on the right side of the pole by the brightest star of the Big Dipper, *Alfa-Ursae o Dubhe*. Interestingly, however, the orientation of the east–west axis, which is 18.5 degrees south of east, points to the rising of Sirius, and a chapel dedicated to Isis is aligned on the same axis.

In the course of his pioneering studies on the temple's orientation, Lockyer was the first to notice the existence of a very interesting circumstance. A stellar alignment of a building remains operative only for a few centuries after construction, because precession drifts, slowly

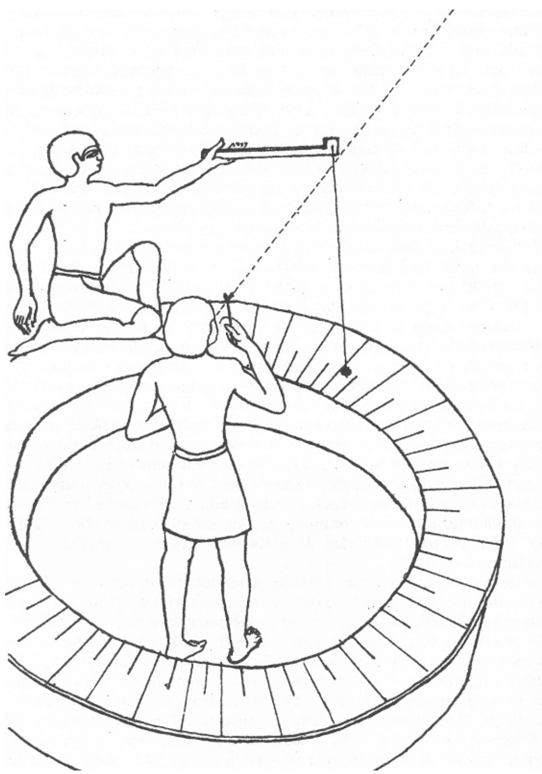


Figure 4.5: The astronomer and his assistant making measures with the Mercket

but regularly, the rising point of all the stars on the eastern horizon. As a consequence, let us suppose we build a temple according to a certain stellar orientation and then, after three or four hundred years, we decide to renovate it by adding, for instance, a new corridor hall. When measuring the orientation, we will find that if we want the corridor to be oriented toward the same astronomical phenomena of the one previously built, the new axis has to be shifted (we have already encountered a similar situation in the temple of Ggantjia in Malta, where a new temple was built that was very similar to the previous one but with a shifted axis).

Puzzling deviations of the axis of the same building or nearby buildings are found in many instances in Egypt; for instance, in Medinet Habu, where Rameses III (1184–1153 BC) had his House of Millions of Years built with an axis that deviated a few degrees from that of a preexisting temple built by Hatschepsut and completed under Tuthmosis III (1490–1436 BC). Even in Dendera, the chapel dedicated to Isis was built on top of a previous building from the Rameses II period (c. 1300 BC), and its plan is rotated of 2½ degrees compared to the previous one, a measurement that seems to correspond to the precessional movement of the rising of Sirius in the time that elapsed between the two constructions. A similar situation can be found in the so-called *Thoth Hill* temple in Thebes, rebuilt during the Middle Kingdom on the foundations of an archaic temple (Wilkinson 2003).

Finally, perhaps the most puzzling example is given by the magnificent temple of Luxor. The axis of this temple, contrary to what happened, as we have seen, to the solstitial axis of nearby Karnak, which was strictly maintained in each subsequent addition, was slightly deviated on the occasion of each of the four New Kingdom renovations that occurred in the course of the centuries.

Judging from the plan, there seems to be no doubt that these subsequent shifts were dictated by the desire to build according to some astronomical phenomenon that was shifting as well; however, no one has been able so far to prove this circumstance.

4.6 Stellar Clocks

As we have seen, there is an almost complete lack of scientific texts belonging to the pharaonic period. Therefore, even though Neugebauer and Parker's book is titled *Egyptian Astronomical Texts,* it is actually a collection of depictions and texts of astronomical content inserted in a religious context, specifically a funerary one: images painted on the inside walls of wooden coffins of the Middle Kingdom, or frescoed on the walls of the tombs during the New Kingdom. In particular, spectacular astronomical ceilings appear in some of the tombs of the Valley of the Kings and in the unfinished tomb of the royal architect of Hatshepsut, Semnut, in Deir el Bahri. These are, therefore, images that the two authors have selected according to a quite subjective criterion, excluding the possibility that astronomical content could be present in the funerary texts of the Old Kingdom as well. As we shall see, this is a major error because such content is indeed there, and transpires clearly in the Pyramid Texts; for the time being, however, we proceed with the Middle Kingdom texts.

The existing material can be classified into three categories of documents with an astronomical content: the *decanal lists*, the *stellar clocks,* and the *astronomical ceilings*. The decans were 36 celestial objects (some were single stars while others were *asterisms,* that is, groups of stars) with heliacal rising occurring in successive weeks. Since the Egyptian week consisted of 10 days, a calendar could be made associating a decan with each week ($36 \times 10 = 360$); the 5 days needed to bring the calendar to 365 days had decans of their own as well. The first decan was Sirius. The following decans were chosen among the celestial objects that have a period of invisibility comparable to that of Sirius, which means about 70 days. Neugebauer and Parker noted that the celestial objects with this characteristic are located in what they called the decanal belt, a region of the sky south of the ecliptic that includes Sirius and many other stars, for instance Orion. The decans are quoted in the texts with peculiar names, so that it is not easy to associate them with specific celestial objects, to the point that Neugebauer and Parker decided that it was impossible to find them. Instead, very good progress has been made on this matter (Belmonte 2001b), even though it is still debated (cf. Conman 2004).

The decans were also used as a sophisticated watch to measure the nocturnal time. This is how the decanal watch worked: On the specific day of the heliacal rising of a decan, the last hour of the night of that day was found through that decan. The following day the rising happened just before dawn, 2 days later even earlier, and so forth. After 10 days (a week), another decan was designated to indicate the last hour of the night, and the previous decan slipped into the hour list, indicating the *previous* hour with its rising, and so forth until the 12 hours of the night were all indicated before ending the calculation. The decanal hours did not all last for the same time. This seems strange to us, but the Egyptians would have regarded as strange our way of measuring the nighttime hours. Indeed, for the Egyptians the night, the period when it is dark, always lasted 12 hours, with the hours of variable length, while for us the hours all last the same fixed time and the night (the

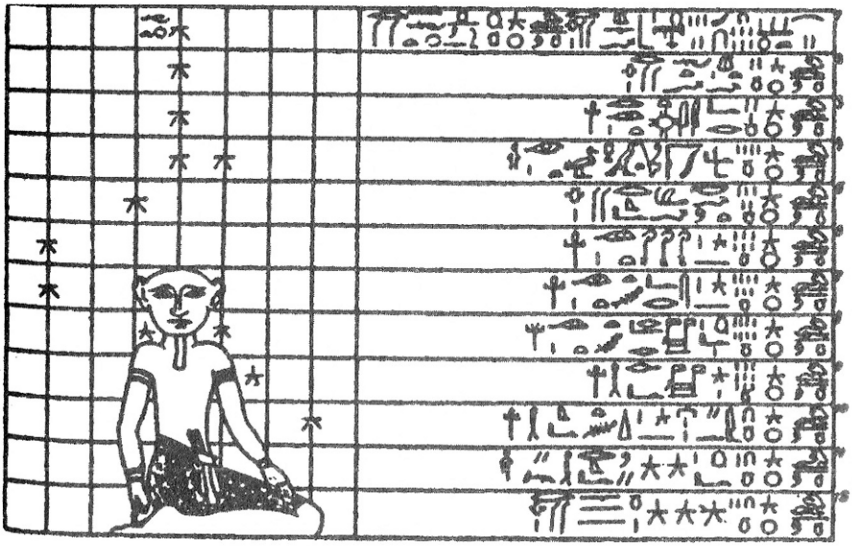


Figure 4.6: An example of a Ramesside star clock.

period when it is dark) lasts a different number of hours according to the different seasons.

In any case, it was the division of the night into 12 hours that was decided in ancient times and that was certainly already in use around the 9th dynasty (2154 BC) to generate the division of the day into 12 hours. Such division is documented in the New Kingdom by the existence of a solar watch (based on measuring the shadow of a Gnomon) of the period of Tuthmosis III (c. 1490 BC). The use of the 24 hours to divide the day was made stable and filtered by Hellenistic astronomy, which mixed it with the sexagesimal division, and with the 7-day week imported from the Babylonians (see Chapter 5) finally originated our very uncomfortable convention of dividing time in 7 days of 24 hours of 60 minutes each. Because every decan indicated, through its rising, the beginning of a certain hour of a certain week, and the following week it would move on to the next hour, the first time that a decan entered the calculation of the night hours was at its heliacal rising, and the last one was after indicating the 11th decanal hour, which means after 120 days. The *decanal lists* depicted in many coffins from the Middle Kingdom are then lists of decans organized so as to make it possible to read, from left to right, the subdivision of the night hours. They are, basically, tables that can be schematized in the following way: on the lines are the hours (12 lines) and there are the decan columns (36 columns) with one special column added for the epagomenal days. In any box of the table there is the name of a decan written diagonally. In the central part of the table there is a vertical belt where the Goddess of the Sky Nut, Mes-Bull's Foreleg, Orion, and Sothis-Sirius are depicted, and one horizontal belt with an inscription invoking the intercession of these divinities for the deceased, together with those of the Sun-God King and of other decans.

In the New Kingdom, the decanal lists were substituted by *stellar clocks*, called *ramessides* because they were known thanks to the frescos on the walls of the tombs of the pharaohs Rameses VI, VII, and IX. They are depictions of a sitting, somewhat unhappy man (probably because he had to remain perfectly still) and a table with nine columns and 13 lines. The first line represents the beginning of the night, and the others the 12 hours of the night. The seven vertical lines are associated with seven parts of the human body, and the grid was therefore used as reference system, with the central line representing the meridian. A different star is indicated for every single hour, together with the position of the star with respect to the man of reference (presumably the assistant to the astronomer, or a statue). The scheme is repeated using different stars 24 times, one for each of 15 days of the year.

Neugebauer and Parker (1964) criticize the presence of errors and imprecisions both in the decanal lists and in the stellar clocks. I find these criticisms ridiculous; it is obvious that both the decanal lists and the stellar clocks are based, in the funerary context, on developed astronomical knowledge. The astronomical data were inscribed in the tombs for a ritual purpose, to accompany, as it is sometimes said, the journey of the deceased through the night, but they were based on astronomical studies. The artists frescoing the tombs in the Valley of the Kings (even though not at all illiterate, as the excavations in the workers quarters of the Deir el Medina tombs prove) were not astronomers, and it is logical to expect them to have committed some mistakes. It is thus the lack of other sources that forces us to examine depictions copied from preexisting texts, and the one who compiled the originals was an astronomer, possessing precise observations collected through the centuries. Indeed, it is easy to understand that the Egyptian astronomers should have accurately mapped the sky and measured the heliacal rising and the meridian transit of many stars, to be able to choose 36 of them to subdivide the hours of the night. Moreover, it is hard to believe that such an extremely complicated method like the one of the stellar clocks was used in practice to count the hours of the night, and indeed the use of water clocks—containers full of water with a hole allowing the fluid to exit and a series of lines indicating the level reached by the water, from which it was possible to determine the time that passed during the night—is well documented for that period. So the stellar clocks were a method to record astronomical data, rather than a method to count the hours of the night, except, maybe, on some special ritual occasions.

4.7 The Egyptian Constellations

Considering the way that the Egyptian astronomers have been treated by the academic world until recently, it is not surprising that the problem of the Egyptian constellations is still far from being solved.

Two historical figures who are often the subject of disputable speculations are the female pharaoh Hatschepsut and her architect Semnut. Many historians believe that they had a romantic affair, but more importantly their names are linked for eternity because we owe to them one of the most impressive masterpieces of architecture of all time: the temple of Deir el Barhi, on the west bank of the Nile at Luxor.

Next to the temple, Semnut had a tomb built for himself on the side of the mountain. The tomb remained unfinished for unknown reasons, but the fresco of the funerary chamber was already drawn, although not fully colored, at the time of the abandonment. This fresco (c. 1473 BC) can be considered a compendium of astronomy of the New Kingdom, and is both the oldest and the most complete compendium known to us.

The fresco, 3 × 3.6 meters large, was made by tracing a grid of red and blue lines, partially still visible today, and then painting the hieroglyphics in black. Touch-ups in red and blue appear on some of the figures. The picture is divided into two parts by a double belt of stars with a central inscription. The top square shows a list of decans similar to a stellar clock. Under the name of each decan are depicted the stars representing it. The list starts, on the left side, with Sirius followed by Orion represented turned toward Sirius, and then by the Iades, the stars that form the basis of the Taurus constellation, in the typical shape of a V. On top of them there is a group of four stars, three of which are aligned with one another, and the central one is circled by three ellipses, possibly representing the Pleiades (Juan Belmonte, personal communication). Four of the five visible planets are also represented—Jupiter, Saturn, Mercury, and Venus—while Mars is missing, as in many other later astronomical representations probably copied from the same source. The bottom square shows what is probably a 12-month calendar. In the center and below are some figures of constellations of stars. These figures were named by Neugebauer and Parker with terms that only served create more confusion; for example, they used the term *northern constellations*, even though they specified that they are *not* all circumpolar constellations. On the left and right sides of the “northern constellations” there is a line of standing figures representing "partner" divinities, like Isis and Horus’s sons (the northern constellations, following a similar scheme where the figures would sometimes change, were represented in many other tombs, for example in the astronomical ceilings of the Ramessides tombs).

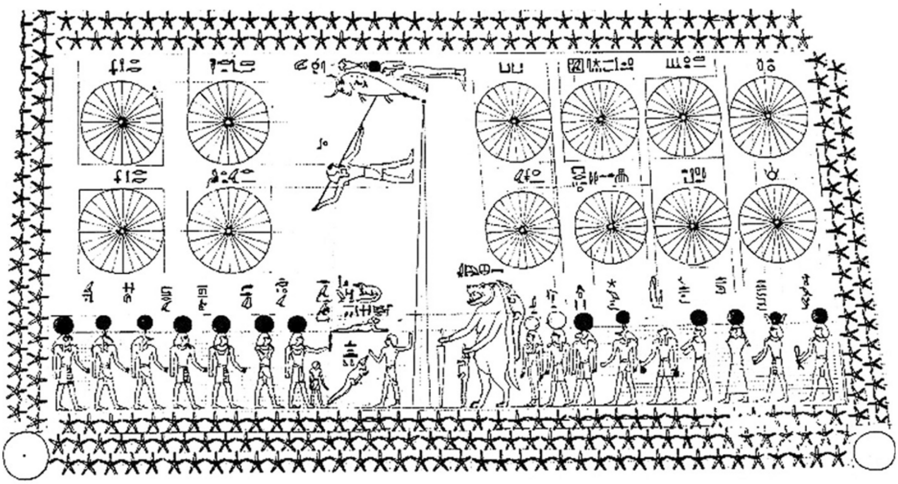


Figure 4.7: Senmut astronomical ceiling, the "northern constellations".

Endless discussions and debates have addressed the problem of the identification of these starry figures with the constellations, but most such debates are uninteresting. For instance, for a long time there has been a discussion regarding the question of whether the Egyptians had elaborated a zodiac of their own (meaning a division of the stars of the ecliptic into constellations; cf. Appendix 1) before the introduction of the zodiac of Babylonian origin, and there has been more than one attempt to use the lack of knowledge regarding the zodiac as proof of the lack of astronomical knowledge, which makes no sense. What really matters is to try to understand the logic behind the representation of the various constellations, zodiacal or not. It is quite obvious that the identification of ancient constellations, not only in Egypt, is complicated by the fact that there is no reason why different people should connect the stars in the sky to form the same figures (even worse the same animals, if they live in completely different parts of the planet), and therefore the constellations can be very different from ours (for example, many civilizations kept Orion and Sirius separate; nevertheless, during the Minoic period in Crete, Sirius and Orion were part of the same constellation, a double ax, with the handle formed by a segment linking Sirius to Orion's belt, see Blomberg and Henriksson 2007). As a consequence, when looking for the first time at the Egyptian constellations, one cannot avoid being fascinated by them. It is indeed the representation, right in front of us, of how an Egyptian read the sky some 3500 years ago. While we inherited our main constellations from the Babylonians and, therefore, did not invent their figures by ourselves, the images depicted in the tombs of the New Kingdom represent a projection into the sky of the imagination and of the religious thought of the Egyptians of that time. Even the way in which the images are represented in the sky is different from our own; it looks like someone had stretched and flattened the celestial vault, according to a different sense of perspective than the one we are used to now, which is nevertheless perfectly logical and organized.

Despite all these problems, we can at least attempt to identify the figures (Belmonte 2001a, Belmonte and Lull 2006). We will use the terms (a bit complicated, but of common use) chosen by Neugebauer and Parker:

1. *Mes:* a bull's foreleg, which we have met before (in the Semnut ceiling as an oval bull, and in other depictions, like the one on the ceiling of the tomb of Seti I, a real bull).
2. *Hippo:* a female hippopotamus, standing on two legs, with a crocodile on its shoulders. The hippopotamus is leaning against a pillar and another crocodile.
3. *An:* a falcon-god pointing a spear toward Mes.
4. *Serket:* a goddess with a disk on her head, parallel to Mes.
5. *Lion:* a lion, in some pictures, like the ones in Semnut, has a crocodile tail.
6. *Sak* and *Croc:* crocodiles; Sak with a bent tail, on top of Lion, and Croc with a straight tail, under Lion.
7. *Man:* a standing man facing Croc.
8. *Pole:* a pillar or pier, set between Hippo and Mes.

The key to unraveling their counterparts in the sky is clearly Mes, which certainly represents the Big Dipper. The Bull seems to rotate around the pommel of the instrument hold by Hippo (in the Seti ceiling there is a Bull tied with a rope to such a point); therefore, the Hippo's paw identifies the celestial North Pole. Because at the time, due to precession, the pole was near the constellation Draco, Hippo must be identified with our Draco, while the pillar leaning against it is in a position corresponding to the Little Dipper. The identification, however, of all the other constellations is much more delicate. One possibility is to read them like a spiral in the sky and, at the same time, move from right to left in the picture; in that case An, the falcon killing the bull with a spear, could perhaps be identified, at keast in my opinion, with a constellation in the Cygnus and Hercules region; not all experts agree, however (see Belmonte and Lull 2006). *Serket*, the goddess with the disk on her head, is our Virgo, and Lion is our Leo (but its tail perhaps should be identified with the Cancer). Under Lion we find Croc, maybe to be identified with Hidra. The other crocodile above Lion is then in the Gemini region. Lastly, the falcon, present only in some of these pictures, should be identified with Perseus.

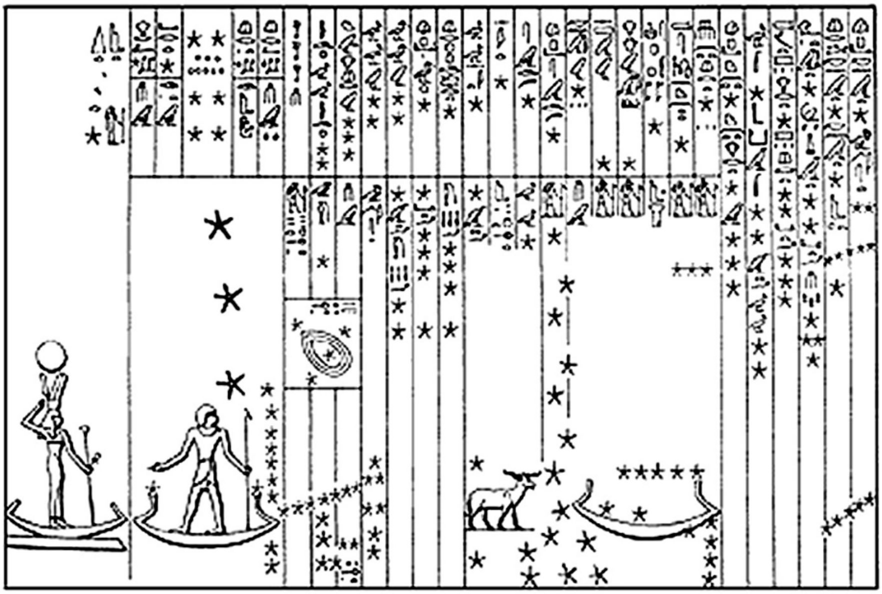


Figure 4.8: Senmut astronomical ceiling, the ''southern constellations''. In particular, from the left, Sirius, Orion, and Taurus are clearly visible.

Incidentally, it is interesting to note that the scene staged around the celestial North Pole is very similar to the completely unrelated one we discussed in Lascaux (see Chapter 1), painted about 14,000 years earlier. There as well a one-legged being, the baton-bird, indicates the pole, and there is also a bird-man, basically identifiable with the Cygnus constellation, the constellation that, due to precession, hosted the celestial North Pole at that time (Rappenglueck 1999).

Beside these northern constellations, it is probable that the Egyptians identified the stars of the Milky Way with a celestial river, a kind of cosmic counterpart of the Nile. They also had, as we have already seen, at least two more constellations ("of the south"), corresponding to Orion-Osiris and to Sirius (our Canis Major). Sirius is represented as a star between the horns of a cow, while Orion-Osiris (*Sah*) is represented as a man holding a baton. In the Semnut ceiling, Orion turns to his left and holds the baton with his left arm; however, in many other depictions, for example in the one on the Pyramidon (the stone in the shape of a pyramid forming the cuspid of the pyramid) of the pharaoh Amhenemat III (c. 1800 BC), a shining star is sitting on the hand of Orion. It is Aldebaran, the beautiful star at the bottom of the group of the Iades, in our Taurus (the Bull) constellation. The region of these southern constellations formed by Sirius, Orion, and by the Iades, was identified in Egypt, already in very ancient times, with the *Duat*, or Kingdom of the Dead. It is not clear, though, if this afterworld was also, in some way, *underground*, and, conversely, it is not clear where the stars of the Duat were supposed to go during their invisibility period.

As we have seen the exceptional interest (and complexity) of the astronomical ceilings is due to the fact that they depict an imaginary view of the sky according to the thought and the feelings of the ancient Egyptians much before the arrival of the astronomical ideas of the Babylonians, which percolated through into Egypt in Hellenistic times together with the zodiacal constellations as we know them.

A merging occurred then between the autochthonous constellations (the Bull's Foreleg and the Hippo, for instance) and the imported zodiacal constellations; the reflexes of this syncretistic vision of the sky can be seen in various depictions (incorrectly called zodiacs), the oldest one dating to the 2nd century BC. The most famous of such zodiacs is certainly the one from the temple of Hathor in Dendera, today preserved in the Louvre. It is a bas-relief carved in heavy sandstone, found on the ceiling of a chapel on the roof of the temple. The relief contains a map of the sky within a circle held by four human couples with falcon heads, and by four divinities associated with the cardinal points. On the external belt run the 36 decans, the first one of them corresponding to Sirius, represented by a cow on a boat. On the inside we find the zodiacal constellations depicted together with the Egyptian traditional figures like Hippo and Mes (Aubourg 1995).

4.8 Temporary Conclusions on Egypt

This chapter discussed, in brief, what we know about Egyptian astronomy during the Middle and New kingdoms. Our knowledge is inadequate, as it is based on second-hand material drawn in coffins or painted in tombs. But I think that if one considers seriously even just the few sources that we have, and puts them together with a series of objective data on the astronomical orientation of the temples, there is enough material to conclude that, at least starting from the Middle Kingdom, astronomical knowledge in Egypt was absolutely complete and comparable to that of any other great civilization, if not superior to it, as testified to by famous Greek writers (curiously enough, these conclusions can also be drawn from Neugebauer's works even though he takes every opportunity to affirm his lack of esteem for the Egyptian scientists).

As for the problem of determining how old the knowledge of astronomy is, since the Old Kingdom unfortunately did not leave us any astronomical coffin or astronomical ceiling whatsoever, but only the greatest and most complex buildings ever built in human history, we will address this issue in the final part of the book.

When the Method Is Lacking

5

> The philosophers from Sumer lacked that primary instrument of knowledge which is our scientific method based on definition and generalization.
>
> —S.N. Kramer, *The Sumerians,* 1963

5.1 Babylonian Astronomy

This chapter discusses four Asian civilizations corresponding to four geographical areas: Mesopotamia, the Indo-Sarasvati valley, China, and Japan. The reason for giving such a brief account is that, In contrast to the history of astronomy studies based on written documents, field archaeoastronomy in Asia is less developed. For instance, various treaties of Babylonian astronomy were written on tablets and have been carefully studied, but a systematic study of the astronomical orientations of the Ziggurats, the big Babylonian pyramids built in raw bricks, is lacking. On the other hand, because of written sources, we know a lot about the development of astronomy from ancient times not only in Mesopotamia but also in India and China, and therefore it would have been impossible not to mention these countries in this book.

Mesopotamia, in the modern Iraq, is the flooding bed of the Tigris and Euphrates rivers. It is therefore very fertile even though, in contrast to the Nile, the floods of these two rivers are very irregular. As is well known, a consolidated tradition considers Mesopotamia the cradle of all civilizations because of the development of the Sumerian cities, which started in the fifth millennium BC. It is, however, hard to say how true this dogma is in reality. In Jericho, in Palestine, people already lived in a fortified city with 7-meter-tall walls many millennia earlier, and the first settlements in Anatolia and in the Indo-Sarasvati valley occurred approximately around that time as well (after all, even the term *civilization* is an extremely subtle one to define). The first dating of Mesopotamia itself is complicated by unclear stratigraphy and, moreover, by the fact that we do not know the real size of the Persian Gulf in

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_5,

ancient times. In any case, the Sumerians were among the first people to leave written evidence of their activities, including navigation; hydraulic structures; huge urbanization (archaeologists believe that their cities could have had up to one hundred thousand inhabitants); monumental architecture, with the building of the gigantic Ziggurat; and literature and the arts. The written evidence that the Sumerians left is quite complete, and, in addition to literary, scientific, and educational texts, we have religious rituals, lists of kings, royal decrees, and court sentences (Kramer 1963).

The Sumerian civilization, with its first traces left in Eridu around the year 5000 BC, ends in about 2300 BC, with the reign of Sargon the Great, soon to be substituted by the Assyrian domination in the north, and by the Hammurabi's kingdom around the year 1700 BC.

Differently from the Assyrian state, which will last over a thousand year, the Babylonian state is not strong enough and will suffer many dominations: by the Amorites, the Cassites, and the Caldeis. To this group belongs Nebuchadnezzar, the last great Babylonian king who reigned for 43 years during the seventh century BC; in 539 BC, Babylon was finally conquered by the Persians.

I use the term *Babylonian* to refer to the whole culture of the Mesopotamia area, as is usually done. Because of the many findings of texts written on clay tablets belonging to royal archives and libraries, we know Babylonian astronomy much better than the astronomical lore of the many people for whom we have only traces, such as for the Megalithic people, as we have seen, who probably did not have a written culture, or the Egyptians, of whom we do not have papyri of explicit astronomical content. It is therefore hard to decide, as Neugebauer (1975) tried to do—influencing in a negative way, at least in my view, the whole discipline of the history of ancient science—if Babylonian astronomy was really so more advanced than the other astronomies. In any case, Babylonian astronomy, as with many other ancient astronomies, was linked to astrology and divination, meaning the prediction of future events through a series of different operations (such as *hepatoscopy*, examining the liver of sheep; see Pettinato 1998). There was, therefore, no distinction between astronomy and astrology, a distinction that is unnecessary for us to understand in the historical context, while today it is fundamental because "modern astrology" does not have anything to do with the observation of the celestial bodies.

Babylonian astronomy was impressively complete and accurate; its development was connected with that of mathematics as well. The Babylonian number system was based on 60. It is a base that does not have an obvious interpretation (base 10 entails counting using the fingers; base 20 entails using the fingers and toes; and so forth). Teon in the fourth

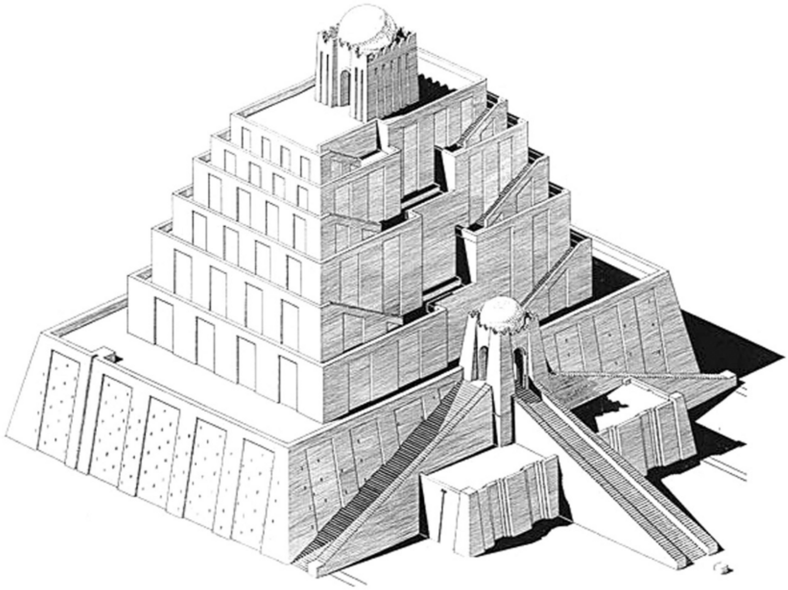


Figure 5.1: A reconstruction of the Ur Ziggurat as it may have appeared in the 6 century BC

century AD supposed that the system with base 60 could come from choosing a minimum common multiple of 1, 2, 3, 4, and 5. Then, however, it would be necessary to explain why such a multiple was chosen, and this invalidates Teon's explanation. Neugebauer, in turn, suggested that a system that was originally based on 10 was later modified in order to divide weighs and measurements into thirds. But it would be necessary to explain why this division into thirds was necessary, and Neugebauer's explanation is inadequate. Some further theories have been based on astronomy, but they are not proved either. Thus, we do not know why a numerical system based on 60 was used, but it was a system that worked just like any other one. Interestingly, as a consequence of this choice the Babylonians invented the measure of angles that we still use today: the full circle is divided in 360 units (the degrees), probably because 360 is the multiple of 60 closest to the number of days in a year. The degree is further divided in 60 primes (or arc minutes), and in an arc minute there are 60 arc seconds. I insist that this is an arbitrary choice (to divide an angle in 360 units is as natural as dividing it into, say, 127 units), and for us who inherited it from the Greeks and the Romans it is anything but an easy division, because our number system is decimal and therefore it forces us to repeated, unnatural mind calculations (as the introduction of the Euro currency in Europe a few years ago demonstrated, mind-computing often leads to mistakes).

The astronomical measurements of the Babylonians were extremely precise. Some of the measurements found in the Babylonians lists are indeed accurate to one arc minute. This is a noteworthy achievement. Think how small to the naked eye is an angle of *1 degree*. And now divide it by 60. This would seem to be a level of precision that the unaided human eye could not achieve, also if the visual abilities of humans in the past were better than ours. Astronomers used a surveyor's cross, an instrument that helps make triangulations, and an artificial horizon (a wall with a perfectly straight top), which facilitates making astronomical observations. However, with these methods, the maximum observable accuracy is in the order of two arc minutes. It is therefore probable that the Babylonians invented an instrument to improve vision, a telescope (usually this word is preceded by the adjective *rudimental,* but I wonder why it should). There are indeed ancient tablets that mention astronomers' lenses supported by a golden tube to enlarge the pupil, and in Nineveh a rock crystal lens was found (Pettinato 1998). Maybe one day a new archaeological excavation will find a Babylonian telescope for the first time.

The oldest known Babylonian astronomical treatise is the *Mul-apin*, of which several copies on clay tablets are available. The earliest example is dated 687 BC, but there is no question that the astronomical data it reported were compiled at a much earlier date. Many dates (as early as 2300 BC) have been proposed, but a recent complete analysis has shown that the date were most likely compiled around 1370 BC at a latitude of around 35 degrees. It belongs, therefore, to the Assyrian period and geographical area (Schaefer 2007). The content of the text is divided as follows:

1. A list of celestial objects divided in three paths, or "belts," called Enlil, Anu, and Ea. The list contains 71 objects, some of which are planets, others of which are single stars and constellations. Enlil, for instance, contains the Crab (Cancer) and the Lion (Leo); Anu contains the Pleiades, Taurus, Sirius, and Orion; and Ea contains Aquarius and Scorpio.
2. A list of the heliacal rising of various stars.
3. A list of the simultaneous rising and setting of some couples of stars.
4. A list of the time passing between the risings of the same couples.
5. A list of the simultaneous culminations and risings of some other stars.

Tablets of the same period contain lists of the months of the year, and, related to them, three constellations, one for each path, with the coordinates of the brightest star in each constellation. The idea of gathering together stars and constellations, then, is documented in Babylonian astronomy around the second half of the second millennium BC (Schaefer 2002).

Actually, the division of the ecliptic into 12 constellations and the creation of the zodiac that we use today were ideas of the Babylonian astronomers. It is important to keep in mind that, although the concept of 12 zodiacal signs is so commonly accepted, there is *no physical reason whatsoever* to divide the star belt of the ecliptic into exactly 12 groups. Rather, it is a *cultural* consequence of desire of associating a constellation with each month of a 12-month year; other cultures may represent the constellations of the ecliptic in a complete different way (as we shall see, for instance, the Mayas probably had 13 zodiacal constellations, while the Indu had 27), or even measure the motion of the sun during the year by means of completely different celestial objects of reference.

More information regarding the deep interest of the Babylonians in the configuration of the celestial bodies, Jupiter in particular, associated with the main Babylonian god Marduk, and Venus, associated with the goddess Ishtar, can be found in the *kudurru,* large stones used to mark off land that was acquired or donated, that date from the second half of the second millennium BC. It is indeed very likely that the representation of planets, constellations, and belts existing in the kudurru was used to indicate the dates of the contracts for land or of land donations in terms of astral configurations, and therefore represent the sky on specific days, a possibility that needs further investigation (Iwaniszewski 2004).

As I mentioned before, divination had a very important place in the life of the Babylonians, and the astronomers, acting as astrologers, used specific handbooks for this purpose. Famous among them is *Enuma Anu Enlil,* a series of astrological tables, of which two different versions exist. The text comprises associations between celestial events, such as the eclipses and the appearance and disappearance of Venus, and various prophecies, for example, "If there will be an eclipse on the sixteenth day of the month, the king will die, the country will become a desert, and the enemy will ruin the agriculture fields." The suggestion provoked by negative omens could be so intense as to force the king to exchange places on the day in question with a royal substitute, a poor man (initially chosen within the aristocracy and, in a later period, chosen from the people) who would rule the country on the day that was considered unsafe for the king, and then would be killed.

The observations of the Babylonian astronomers were probably made observing the sky from the *Ziggurats*. The construction or reconstruction of these buildings went on for thousands of years, from the Sumerians until the sixth century BC. They were large pyramidal terraced buildings, with a rectangular or square base, built with raw bricks and covered with tiles or baked bricks. On top of these buildings there was a temple that could be reached by ascending suitable ramps. The Ziggurats could be large (more

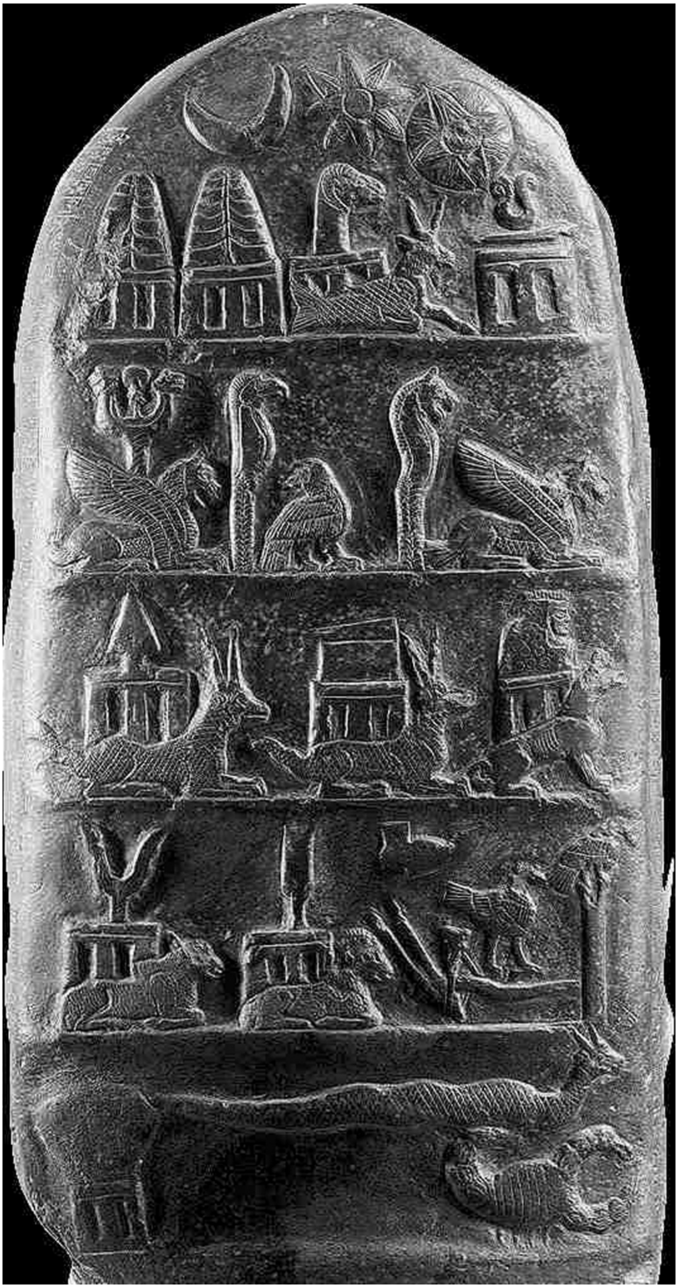


Figure 5.2: An example of Kudurru (12 century BC circa) from Susa, today in the Louvre Museum in Paris. Among the many symbols representing divinities, the Moon, Venus and the Sun are immediately distinguishable on the top, and Hydra and Scorpio at the bottom. The upper band contains the symbols of Anu, Enlil and Ea.

than 50 meters wide and 60 meters tall), but those that remain today are unfortunately in terrible condition or underwent heavy restorations (for example, the Ur Ziggurat in Iraq). The most famous Ziggurat is certainly the one quoted in the Bible as the Babel Tower, the Babylonia Ziggurat, refurbished for the last time by Nebuchadnezzar. Even if the tower was destroyed by Persian fury, we miraculously inherited the *plan* of the building, inscribed on a tablet (now at the British Museum). Judging from the plan, it was a tower with a square base 90 meters wide and of equal height. It developed into seven squared towers of equal width and length, one on top of the other. The seven floors were probably associated with the five planets plus the sun and the moon and on its top there was a temple of Marduk.

The links between the Ziggurat and the sky were therefore very strong, but they are not yet completely understood, and to my knowledge there has been no reliable archaeoastronomical study of them. As a sample test, I have made some calculations using an archaeological map of Ur, where there is one of the largest Babylonian Ziggurats, first built around the year 2100 BC. This type of analysis is in danger of errors, first because it is impossible to know if north as indicated on the map is the true north, determined with a transit, or the magnetic north found with a compass, depending therefore on the magnetic declination of the day on which the map was drawn and thus not reliable for astronomical purposes; and second, because it cannot take into account the height of the visible horizon. With this caveat, the orientation of the building, according to the map, is clearly pointing to sunrise on the day of the summer solstice, indicated by the central access ramp on the front part of the building.

5.2 People Who Never Existed, and Rivers that No Longer Exist

Mesopotamia was not at all an island from where civilization radiated, as was believed before the scientific revolution brought by radiocarbon dating washed away the “diffusionism” (see Chapter 2). Actually, both in the west and the east of Mesopotamia other cultures bloomed together with the Mesopotamia civilizations, some almost completely unknown today, as was proved by the recent discoveries made in the Iranian site called Ajantep.

As far back as the 1920s, archaeological discoveries started to show that there had been a civilization in the Indian subcontinent that was as old as the Mesopotamian civilization. It was indeed at that time that the excavations in the two cities of the Indo Valley, Harappa and Mohenjo-Daro, began. This civilization owes its name to these two cities, even though we know that it actually bloomed much further east than that, in the flooding bed of a river that does not exist anymore, the Sarasvati.

Around the year 2500 BC, the Indo-Sarasvati civilization, just like the Mesopotamian one, had cities accurately planned, with hundreds of buildings, pensive gardens, and a public sewage system.

Unfortunately, scholars are not yet able to decipher the many inscriptions found, especially on document seals. The lack of literary documents themselves was, until recently, perfectly coherent with the idea that Sanskrit, the language of the main sacred Indu texts, the *Veda*, was not native to the area but had been imported to the Indian subcontinent by a people coming from the west, the Aryans, around the end of the second millennium BC.

Based essentially on arbitrary interpretations of the Veda themselves, the

Figure 5.3: The area of the Indo-savrastati civilisation (from Feuerstein, Kak and Frawley 1995, under kind permission)

idea of an Aryan invasion (even believed to be the absolute bringer of civilization before the discovery of the archaeological sites in the Indo Valley) was promulgated by Childe and by Wheller, and was accepted until recent years. But now we know that there is no real evidence of such an invasion; beside, the drying up of the Sarasvati river and its tributaries, mentioned in the Veda, happened progressively during the centuries around the year 2000 BC, and therefore long before the first supposed invasion, which probably never happened (Feuerstein et al. 1995).

The Veda (meaning "knowledge") were therefore written during the Indo-Sarasvati period. Its four main books were orally passed on from a very early period. Until about a thousand years ago, no one had ever inscribed them in writing, so they were transmitted by memory (a typical Veda contains about ten thousand verses). There is no doubt, however, that the Brahmins memorized the Veda (as they still do today), being careful not to change a single syllable of the texts, which are considered sacred. Therefore, we can be sure that the texts of the four books, which contain hymns (Rigveda), sacrificial formulas (Yajurveda), melodies (Samaveda), and magic formulas (Atharvaveda), are today very close to the texts as they were conceived at least 3000 years ago. The interesting thing is that many of the verses of the last three books are copied by those of the Rigveda, as if the author wanted to put together a certain amount of verses (see below).

The backdating of the Veda brought with it a radical revision of their interpretation—a revision that is ongoing today. In particular, a part of this revision includes the analysis of the astronomical content of the texts, a point that was never considered before. Today, although much of the astronomical code is yet to be deciphered, we are at least sure that the Veda contain astronomy and show mutual influences with Babylonian astronomy (Kak 1994, 2000).

The main idea at the heart of the Veda is that of a tripartite division and connection: connection between the three levels of the cosmos (earth, earth surface, and sky) and connection between the three levels of souls (spirits, humans, and celestial divinities). The level of humans had its center in Mount Meru, a true belly button of the world for the Indus, while the celestial level was located in the polar region of the sky, viewed as a cosmic counterpart of the mountain itself. In Vedic astronomy, just as in the Babylonian astronomy, the sun, the moon, and the planets played a crucial role and were identified with the seven main gods of the Hindu religion. The planets' motions, and those of the sun and the moon, were accurately followed through the *naksatras*, 27 celestial divinities (stars or constellations) that were used to divide the ecliptic into equal parts (the sun would then spend about 13 1/3 days in each *naksatra* every year). We have many

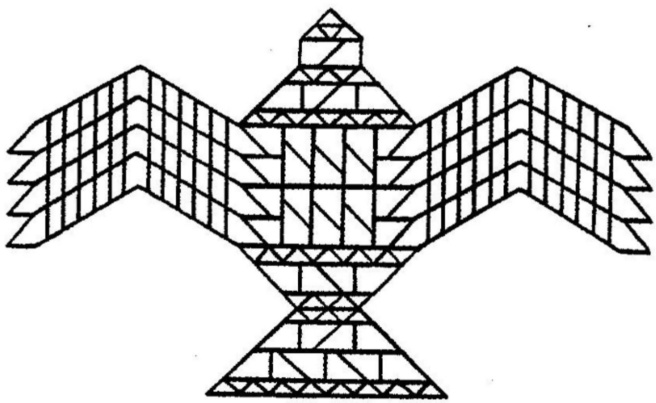


Figure 5.4: Vedic altar shaped as a falcon (from Kak 2000, under kind permission)

lists of naksatras compiled in different centuries; the lists contain the same celestial objects, but start at different points; the reason for these differences is that each list started with the naksatra with the sun rising on its background during the spring equinox and, due to precession, this background very slowly varies with the passing of time. There seems to be no doubt that the Indian astronomers knew that the sun was "changing the naksatra" with a slow but constant velocity every thousand years or so (25,776 years of the precessional cycle divided by 27 naksatras).

The tripartite nature of the cosmos was replicated on the fire altars that played an important role in Vedic life and religion. Study of Vedic ritual has shown that these brick altars were used to represent the connections among the astronomical, the physical, and the spiritual levels. The altars therefore embodied Vedic astronomical knowledge. In particular, an important ritual comprised the construction of three brick altars: one round, representing the earth; one half-moon shaped; and one square, representing the universe as a whole and consisting of five layers (three levels with two interconnections). Another important altar was connected with the concept of time-flowing and was shaped as a falcon, oriented toward the east. Astronomy ruled in a systematic way every aspect of the construction of these altars, including, for instance, the number of bricks used to build each layer, and the area of every extension of the altar itself, determined according to analogical criteria. For example, since there were three different calendars—one linked to the naksatras; a second, lunar, of 354 days; and a third, solar, of 365 days—the ratios between the areas of preexisting altars and restored altars had to be equal to the ratio between the numbers of the days of the three calendars, the total number of bricks used had to equal that of the hours in a year, and so forth (Kak 1993).

Finally, it seems that this strict principle of analogy is the key to understanding the very same structure of the Veda. Indeed, it looks like the Veda themselves were conceived as a brick altar, meaning that the number of syllables, the number of verses, the number of hymns, and the number of books have all been determined according to astrological-astronomical criteria.

5.3 The Celestial Empire

The first traces of geographically stable cultures in today's China are located on the banks of the Yellow River and can be dated from about the year 2800 BC. The first imperial period, however, is that of the Xia (c. 2100–1600 BC) and Shang (c. 1600–1000 BC) dynasties, whose capitals were in the Valley of Henan. To this period belongs also the first evidence of a Chinese astronomy, such as, for example, the first recording ever of a solar eclipse. This information was discovered in a strange way. In 1899 an army officer, Wang Yirong, intrigued by a medicine called "dragon bones," which was suggested by a healer from the Henan province, discovered that the bones were very ancient turtle shells, with carved inscriptions, found in digging excavations near Xiaotun, home of the Shang capital during the second millennium BC.

These shells were used for divinations; a question was written on them and then the inner part was punctured and placed over a heat source. According to the cracks produced on the outer part of the shell, the diviner made his predictions, which were later recorded on the same shell, together with the date. Often, the success or failure of the prediction was also recorded, together with important celestial events that happened in the meanwhile, such as eclipses.

The Shang were followed by the Zhou (1000–221 BC). Under the Zhou dynasty the imperial domain expanded toward the north, beyond the Yangtze River, and the celestial foundation of the emperor‘s power acquired its definitive form. The emperor, the "son of the sky," was considered responsible for the cosmic order, while the temporal power was in the hands of a feudal bureaucratic structure, and the effective control of the territory was ceded to local families. Due to fragmentation and internal fights, however, the imperial power steadily decreased, and between the fourth and the second century BC, China fell into a constant state of war between small states, each one trying to affirm his hegemony. Finally, in the year 221 BC, the king Qin managed to unify the country and to proclaim himself emperor.

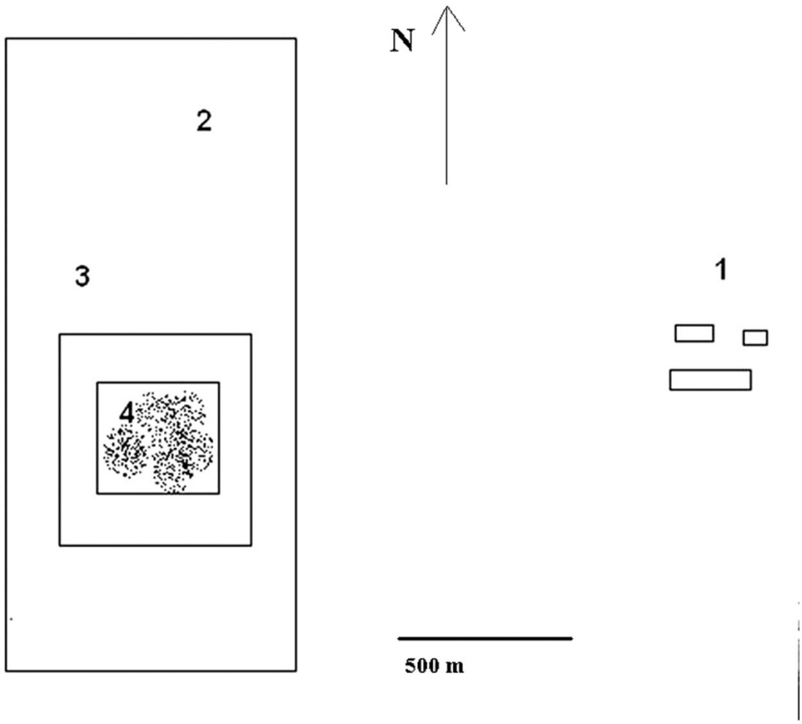


Figure 5.5: The mausoleum of Qin: 1—The three Warrior's pits discovered so far 2—external wall 3—internal wall 4—tumulus

Under Qin, China established firm borders, and Qin himself accelerated the construction of one of the greatest and most visionary structures in the history of mankind: the Great Wall, which is over 5000 kilometers long. When Qin died in 210 BC, the empire was taken over by the Han dynasty (206 BC to 220 AD); during its reign, Confucianism, which was previously opposed, became the state religion, and Chinese written history began with the work of a historian named Sima Qian.

Emperor Qin was one of the key figures in Chinese history, and his name is indissolubly linked to one of the most fascinating discoveries in the history of archaeology. In Lintong, 35 kilometers east of Xian, in a spectacular position between the Wei River and Mount Lishan, there is a hill that is 76 meters tall. According to ancient tradition, the landscape of the area, when seen from above, recalls the profile of a dragon, with the hill as the eye. It has been known for ages that the eye of the dragon is not a natural hill but rather the funerary tumulus, as well as the ideal center, of the gigantic funerary complex of Emperor Qin. The tumulus, with a square base almost 500 meters wide, is one of the largest ever built on our planet, and it was once probably much higher than it is now. Even though archaeologists knew that this was a funerary complex, no one ever wanted to or was able to excavate its interior, and legend states that it is guarded by gigantic stone animals. Sima Qian described the interior as a true palace buried in the hill, full of traps and pitfalls. According to him, in the central chamber there is a lake of mercury upon which the bronze coffin of the emperor floats. Sima Qian also stated that a ceiling studded with precious stones reproduces the starry sky, and this assertion is reasonable because we have many wonderful ceilings frescoed with a starry sky in tombs of the Han and of the following dynasties.

But what is really hidden inside the structure is a mystery. Anyway, Sima Qian chose not to mention another spectacular element of the Qin complex—something that, on the day of its discovery in the spring of 1974, made reality so much greater than any fantasy regarding the content of the tomb.

The area of the Qin tumulus is not isolated: the whole Xian Valley is a gigantic sepulcher in which emperors and nobles were buried, often inside huge mounds that are scattered in the fields and are visible today. As a consequence, farmers are used to finding here and there pieces of ancient pottery or of stone sculptures. So on that spring day in 1974, when a farmer came upon the terra cotta head of a statue, he was not surprised. And after the first statue a second one appeared. And then another, and another (Plate 11).

The statues were arranged in a tunnel (today called pit 1) that was 210 meters long, 60 meters large, and made of nine parallel corridors 3 meters wide (later two more of these pits were discovered). The term *pit* is imprecise, as the floor was tiled and the ceiling was made of pine logs and waterproof plastered, and the whole thing was carefully buried about 1½ meters deep. The corridors of pit 1 contain about eight thousand heavy terra cotta statues in life-size scale (actually slightly larger than life size) representing the imperial army's privates, archers, officers, carts, and horses (or it may be more appropriate to say *all* the privates, *all* the archers, etc.). The pits discovered later contain statues as well: in pit 2 there are 2999 soldiers, two officers, 116 horses, and 89 carts, while in pit 3 there are 69 soldiers and a cart, probably that of the main officer (Portal 2007).

The statues show a variety of expressions and clothes; their heads could be exchanged and were sculptured and baked separately, to be then inserted in a special cavity in the neck. The terra cotta Qin army figures look dressed for combat, except that they have no weapons. But large quantities of bronze weapons, especially arrows, have been found in the eastern corner of pit 1. The corridors look as if they were previously explored, and maybe on that occasion the weapons were removed, possibly during a rebellion that occurred in 206 BC (there were signs of vandalism everywhere when the warriors were first discovered), and so we cannot be sure if the army was originally "armed" or not.

To accomplish such a gigantic project of burying an entire replica of his army together with him, Qin would have needed to mobilize several thousand trained workers. The statues are very heavy (some weighing hundreds of kilos each) and were backed in special workshops using a delicate and long process (that took 5 days), which the archaeology experimenters of today have found hard to reproduce. These workshops were outside the funerary complex, so each statue had to be packed, carried down into the tunnel, and placed in its final location based on the actual layout of the army in the field.

The discoveries in the mausoleum area show the close links of the tomb with the celestial order. For instance, the funerary complex, which might be more appropriately called a funerary city, since its external perimeter was 12 kilometers long, was made of three citadels, one inside the other; the innermost one, with a square base, hosts the tumulus, which was built on three levels. The inspiring principle of all this is the idea of cosmic order among Earth, humans, and the sky, with in its center being Qin, who proclaimed himself as the keeper of such an order. Thus the whole complex was strictly oriented to the cardinal points, the tunnels with the terra cotta army being no exception. For some unknown reason, however, the tunnels of the army are not in front of the complex, which seems to be on the northern side, and do not surround it as a whole; the pits are indeed located on the eastern side of the mausoleum. This fact suggests that maybe the east was reserved for the soldiers (and maybe also for the terra cotta material), and that the other jobs of the emperor's entourage as well as other materials could be associated with the other cardinal points. The idea, therefore, is that Qin wanted with him more than just a replica of his army. On the west side of the mausoleum a sample excavation discovered a pit containing two bronze sculpture groups. One represents a warrior driving a four-horsed chariot, while the other is a kind of carriage or wagon driven by a sitting postilion and pulled by four horses (it could be the representation of the transport of the king's coffin, but the wagon is empty). Being only a small trial excavation, it gives us an idea of what a future study of the mausoleum could reveal.

Qin's successors, the emperors of the Han dynasty, had themselves buried in large funerary barrows, most of them still to be excavated. It is certain that many emperors after Qin, such as Jing Di (141 BC) for instance, tried to follow his path and were buried with terra cotta armies, not of life-size scale but rather composed by miniatures, about 50 centimeters high. The archaeoastronomical study of the funerary complexes of the Hans is just beginning but already is proving to be very interesting and complex. For instance, the funerary barrow of the emperor Wen (154 BC), which is of rectangular shape, is reported to be aligned so that the diagonals point toward the minor north and south lunar standstills (Tiede 1979).

The history of Chinese astronomy in ancient times, from the Han dynasty on, is very interesting. For instance, it contains the only written document regarding the explosion of a supernova in 1054 AD, a spectacular phenomenon that created what is today known as the Crab Nebula (see Chapter 7). However, to investigate the history of Chinese astronomy any further is beyond the scope of this book. Instead, we move further east.

5.4 Following the Gods' Paths

Usually, when Westerners consider Japanese history, they most likely think of the era of the Samurai, which coincides with the Middle Ages and the Renaissance. However, there is a millenary earlier history of Japan that can be roughly divided into three periods: Jomon (c. 13,000–300 BC), Yayoi (c. 300 BC to 300 AD), and Kofun (up to c. 650 AD).

The Yayoi period is one of migrations (if not real invasions) by people of Chinese and Korean origin, bringers of the Chinese culture of the Han, who end up mixing with the autochthonous Jomon. The Yayoi introduced iron and bronze to Japan, as well as systemic rice farming. As a consequence, the extremely long previous period, which covers the traditional ages of Western history (the Neolithic, Copper, Bronze, and Iron ages), has been often underestimated by historians who regarded it as a very long primitive age of hunter-gatherers. Luckily, today, this foolish idea is being reconsidered. We know, for instance, that the Jomon were among the first humans to invent pottery, which they produced as early as around 15,000 BC; we know that they lived in large camps, some of which were made of dozens of oval-shaped huts, arranged in a horseshoe shape around the main square (some archaeologists even call them "proto-villages"), and that they grew wheat and chestnut trees. Further, Jomon art is extremely refined, and can be divided into six periods, based on the different styles; these findings clearly show the existence of commonly used objects as well as purely artistic creations, such as, for example, the renowned *Dogu*, which are intriguing, stylized human figures that were created over thousands of years of Japanese history (Kidder 1993).

Another ever-existing characteristic of Japanese art and thought is the quest for harmony between the man-made landscape and the intrinsic beauty of nature, a quest with its roots in the Shintoist religion. Shintoism—

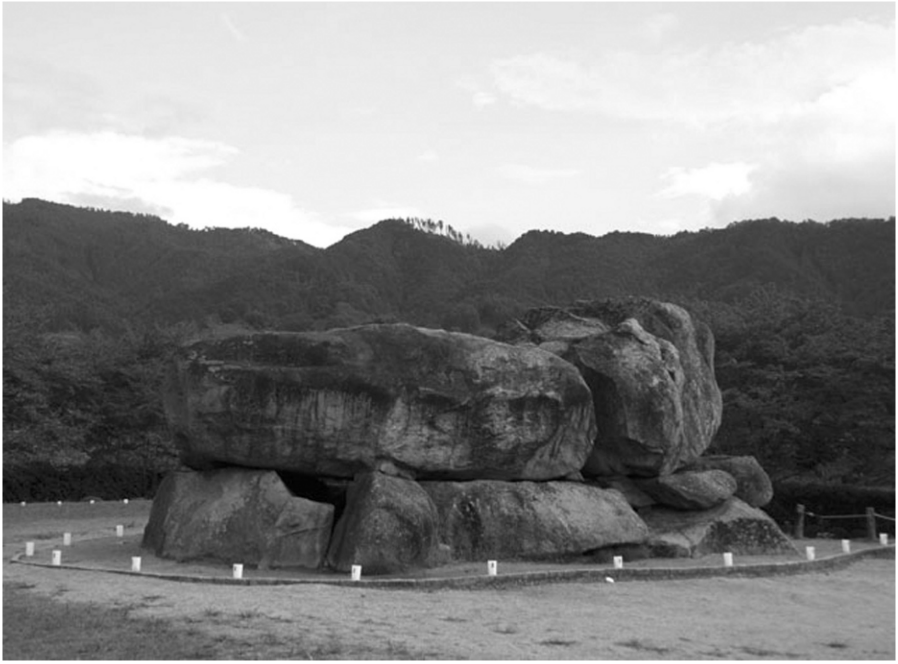


Figure 5.6: The Ishibutai Kofun

from *Shinto*, path of the gods—is an animistic-naturalistic religion of very ancient origins, with Amaterasu, the Sun Goddess, as the main divinity. There are numerous other gods—so many, in fact, that the religion is characterized as the "anxiety of the divine" because of the impossibility of counting them all. The gods populate the universe, which today is living in the "time of man"; nature—rocks, trees, mountains, grass—does not "speak" anymore but is vigilant, synchronized with the celestial level, to the point that even today the temples are built near springs, mountains, and other places considered sacred.

A central role in this quest for harmony with the divine is played by the relationship with the sky, so that many temples are also "temples of the sky" dedicated to Amaterasu or to stellar divinities such as, for instance, the three divinities "who generated the whole," identified with the three stars in the Orion Belt.

Traces of this continuous quest for attunement with the celestial level are clearly visible in the Jomon period. For example, there are many stone ovals from this period on the island of Okkaido, the most famous one being in Oshoro. They are not made by particularly large stones; nevertheless, the natural stones and the megaliths shaped by humans often look melted together. The result is that the human work is hard to distinguish from that of nature, as occurs still today in the fascinating Japanese art of the gardens, where the sacred stone, or *Iwakura,* is a crucial element. A spectacular case is that of the megalithic site known as Kanayama, composed of three groups of monoliths. They are huge rocks, probably left on the side of the mountain by natural events many years ago, but then adapted, polished, and placed by humans in a V configuration. The "windows" created between the pointed corners of the stones enable observing the sun rising and setting on some special days of the year (interestingly, similar megaliths adapted by humans in a style that looks similar to the Jomon one, have been recently found in Italy, in Nardodipace, Calabria).

As previously mentioned, the Jomon culture was replaced around the year 250 BC by populations coming from the Chino-Korean area. In the same period, Japan is for the first time cited (under the name of *Wo*) in the Chinese historians' chronicles of the Han dynasty. At the end of the second century AD, a complex process of unification occurred that brought Japan to independence under the guide of the *Tenno* or "emperor of the sky" (the political mechanisms behind the unification and the contemporary detachment from the Chinese vassalage are not clear yet). The first period following the independence (between the third and sixth century AD) is called *Kofun* (funerary tumulus). Indeed the first Japanese rulers, the Yamato dynasty, had themselves buried in stone chambers engraved beneath large earth mounds. Some of these works are comparable to the more renowned monuments built in Europe by the megalithic culture, such as the chamber tombs in the Carnac region, or Newgrange and Knowth in Ireland. The construction technique of the Kofuns itself was very similar to that used in Europe 2500 years before; the funerary chamber and its corridor were built first using huge stone blocks covered by heavy lintels, and then the structure was covered by an artificial hill, sometimes over 30 meters tall. The construction technique of the inner chamber is clearly visible, for instance, in the spectacular monument called *Ishibutai Kofun,* which was not covered with an artificial hill; I am fairly sure that the Britannic Megalithics engineers would have been happy to exchange ideas with their Japanese colleagues of 2500 years later, since Ishibutai Kofun, with its huge covering slabs weighing over one hundred tons each, would not pale next to the Carnac Grand Menhir.

The majority of the artificial hills covering the chambers have a round shape. However, some have a shape similar to a keyhole, composed by a rectangular ramp granting access to a circular structure. The biggest artificial hill ever made in Japan (and one of the biggest artificial hills in the world) belongs to this last category. It is the *Daisen Kofun*, in the city of Sakai, south of Osaka (Plate 12). This Kofun is 500 meters long; the ramp is

286 meters long and the circular hill is 40 meters tall, for a total of one and a half million cubic meters of volume. The structure is surrounded by an artificial lake with a perimeter of almost 3 kilometers. The tumulus was never excavated, but in 1872 a typhoon revealed the existence of a small chamber, where small terra cotta statues of men and animals (typical of the Kofun period) were found, together with a gold armor and an iron sword. Even though we do not know who is buried in that hill, tradition dictates that it was built under the 16th emperor, Nintoku. The tomb is surrounded by many others of circular shape, and not far away from it there is another Kofun of nearly the same size, the *Misanzai Kofun*.

Most of the numerous tumuli of the Kofun period, just like the Daisen Kofun, is still sealed in respect for the dead. But some of them were looted in ancient times, and we have a little information regarding some other ones that was gained through noninvasive explorations performed using video cameras. In the tumuli studied so far, the *Takamatsu Zuka Kofun* and in the *Kitora Kofun*, both in the Asuka area, the inner part of the funerary chamber contains an accurate representation of the universe. This is a tradition coming from China, where there are many wonderful tomb ceilings frescoed with a starry sky, belonging to the Han and following dynasties (e.g., the starry ceiling of the tomb of the princess Yung, not far from Xian). However, in the Kofun case, the representation of the sky has some peculiar and enigmatic characteristics.

The funerary chamber, which is very small (1 meter high, 1.3 meters wide, and 2.2 meters long), is aligned toward true north. The chamber was thus conceived for the celestial purpose of putting the deceased in the center of the cosmos. The four cardinal points were represented inside by images, painted on the walls, of four animals, symbolizing also the four seasons: the Azure Dragon of the east (spring), the Red Bird of the south (summer), the White Tiger of the west (fall), and the Black Turtle (actually a kind of snake with shell) of the north (winter). It is interesting to note that such a division of the cosmos in four parts, which is extremely natural, belongs to many different cultures, such as the Aztecs, the Incas, the Babylonians, and the Etruscans (see Chapter 15 for more detail). Curiously, it appears also in the novel by Frank Baum, *The Wizard of Oz*, where the four cardinal points are symbolized by four witches.

Once the funerary chamber was cosmized by orienting it according to the cardinal points, it was ready to be a true replica of the cosmos and, as a consequence, a map of the starry sky (a planetarium, as we would call it today) was painted on its ceiling. In the painting, the sun is represented, using gold foil, on the eastern wall, while the moon, as a silver plaque, finds its place on the western wall. The stars are represented by gold disks with a diameter of about 1 centimeter. The representation is centered around the celestial North Pole, which, due to precession, moves with respect to the stars. The Pole star during the third and second millennia BC belonged to the Draco constellation, but at the time of the Kofun construction, the North Pole did not coincide with any star, and the closest constellation to it was Ursa Minor (to which our polar star Alpha-Umi belongs). This constellation therefore had a key place in the astronomy of that time (in China it was called the "Emperor's Palace"). Also Ursa Major (or better the Big Dipper), represented as a paddle, was considered very important; it was indeed used as a clock to measure the passing of the seasons (looking north every night at the same time, it is in fact possible to see the handle of the paddle rotating, day after day, in an counterclockwise manner, and it is therefore possible to use its position to divide the course of the year). The sky was subdivided into 28 *shuku* or "positions" corresponding to regions crossing the ecliptic. In the ceilings, the stars belonging to each shuku are linked by red lines, even though only the main star of each group is represented in the right position; further divisions are present as well.

Such complex frameworks were evidently copied from sources compiled by astronomers to study the sky and for astrological purposes as well. Interestingly, the sky represented in the Kitora Kofun is extremely detailed; the region of the circumpolar stars is indicated by a circle, and the celestial equator, the ecliptic, and the horizon of the observer are represented as well. Despite the obvious decorative and symbolic function of the paintings, it quite clear that what it is depicted is not a *generic* representation of what is visible in the sky, but rather an accurate map of a particular sky configuration. Many of these sky maps are indeed known, drawn both in China and in Japan, but all of them belong to a much later period than the one presumed for the construction of the Kitora Kofun. Therefore, the map represented in the Kofun could be the oldest example of one of these maps (or, to be more precise, the reproduction on the tomb walls made by an artist, of one of these maps).

Studying the configuration of the sky recorded in the map, it is possible to identify the corresponding (approximate) date and latitude of the drawing (Miyajima 1999, Yoke 1985). The latitude where the astronomer who designed the map was located happens to be between 38 and 39 degrees north. The Japanese region of Nara, where the tumulus is located, is much further south than that (around 34 degrees north), and the only sensible possibility is that the map was drawn in the ancient Korean capital of Kokuryo (close to where Pyongyang is today), and therefore not in Japan. Also the date is puzzling, since the sky on display in the map seems to refer to years around the first century BC. This date, however, is much earlier than the construction of the tomb, which should have been built around the sixth to seventh century AD. The fact that an emperor, or some other important member of the royal family, wanted in his tomb such an old map is perhaps due to a simple coincidence (for instance, that the artist merely copied a map that was available to him). However, it may be that the map of the Kitora Kofun was specifically chosen because it refers to the period when, due to precession, the equinoctial point was slowly moving from Aries to Pisces, and a zodiacal era was ending. This would add the Kofun drawing to those examples that testify to the fact that the precession of the equinoxes, once observed, was associated with a very strong celestial “power" (the most important example is that of the Mitra cult; see Chapter 14).

Wheels, Octagons, and Golf Courses

6

The Hopewellian earthworks are fairly simple geometric structures. . . . Any moderately intelligent and mathematically untutored individual can do this.
—Olaf M. Prufer, Core and Periphery: The Final Chapter on Ohio Hopewell, in *A View from the Core: A Synthesis of Ohio Hopewell Archaeology*, 1996

6.1 A Land Full of Surprises

The United States is a land of high interest and unexpected surprises for those who are interested in the past. Indeed, there is still a lot to discover about the native North American people before the conquest. Many archaeological sites have not been adequately studied, and others, unfortunately, have been lost forever. However, what was saved is enough, as we shall see, to show that North America was the cradle of a civilization that built some of the most amazing monuments of human history, in both their dimensions and their sophisticated construction.

6.2 Poverty Point

One of the few true historic paradigms is that rivers can be ideal places for the development of great civilizations, and this is certainly true in the case of the Mississippi. The first part of the history of Mississippi River civilization can be referred to as Poverty Point, which is the name of a site in Louisiana, in the lower Mississippi River near the Bayon Macon River. The first traces of Poverty Point culture date from the year 5000 BC, but it reached its highest level of development between the years 1700 and 1350 BC, and traces of this culture can be found scattered all the way to Tennessee and, on the coast, to Florida. These traces include objects made with various, often imported, materials, such as copper, magnetite, and galena, as well as "microlites,"

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_6,

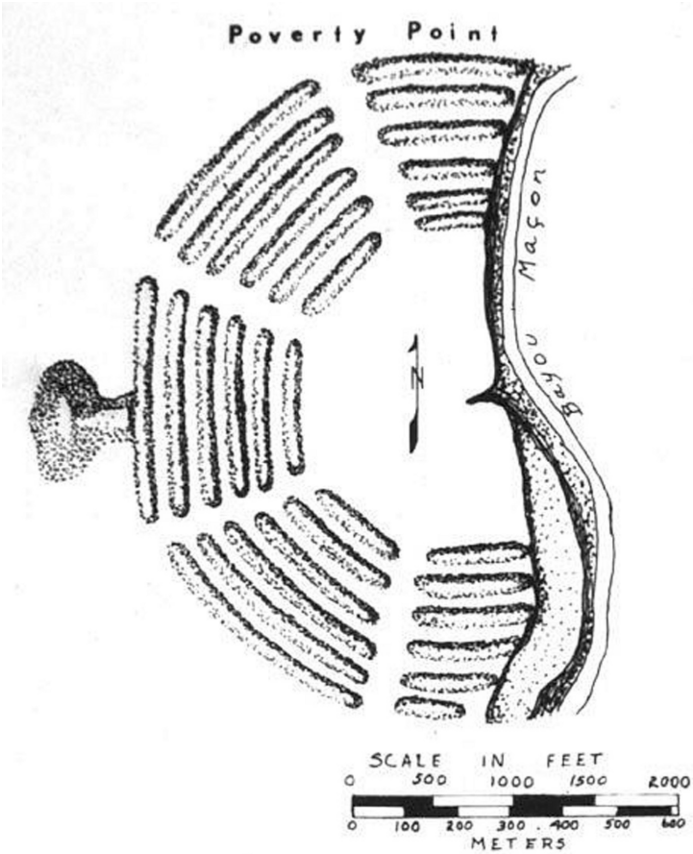


Figure 6.1: Map of Poverty Point

which are small geometric objects made of stone, of unknown use. Poverty Points architects built huge earthworks and artificial hills, or *mounds,* as did succeeding populations. In most cases the scope these mounds is not clear, as we shall see, although some of them, especially those having the form of barrows, were certainly used as tombs.

The tradition of construction of huge earthworks is found throughout the history of Native Americans: in Ohio, in the Mississippi Valley, during the Poverty Point era, and, with smooth transitions, into the Adena (800 BC to 100 AD) and Hopewell (100 to 500 AD) eras. In the Hopewell era, this monumental architecture develops even further, and a wide demographic expansion takes place, based on agriculture, in particular in the fertile plan created by the confluence of the Mississippi, Missouri, and Illinois rivers. Hopewell artists worked with many kinds of imported materials, such as shells coming from the Gulf of Mexico, mica from the Appalachians, and obsidian from the Rocky Mountains. Hopewell astronomers, as we will see, dedicated themselves to a carefully study of the solar and lunar cycles and projected the construction of great geometrical structures.

The Poverty Point site lies on the Bayon Macon River and was first studied in 1873. But it was only in 1950 that archaeologists, through the use of aerial photography, discovered that Poverty Point is a huge artificial terraced structure, shelving toward the river, and that it must have been conceived in a grand plan. This structure is in the shape of six concentric semicircles, each one composed of an artificial terrace (earthwork) a few meters high and over 60 meters wide. The terraces, separated by corridors 10 to 50 meters wide, form an amphitheater that overlooks the river. The corridors do not converge at a single point and do not divide the structure in equal sectors; the southwest section is crossed by another corridor, 91 meters long, that continues out of the complex. In the center of the semicircles is a square with a two-level platform on its far eastern side, which was probably the base of a wooden building; another square was on the western side, where large holes for posts were found. Various mounds are spread around in the surroundings, and the biggest one, Mound A, 21 meters tall, is directly linked to the terraces. The dimensions on the site are as follows: the diameter of the external terrace is over 1200 meters long; the external perimeter, all of which has been found to be complete, is 2½ kilometers long; the diameter of the internal square is of 594 meters, almost double the maximum size of the St. Peter's Square ellipse in Rome, which is 320 meters long.

The river crosses the structure, but apparently the original shape was octagonal, and initially it was thought the river may have changed its course, destroying the two missing terraces. But now many archaeologists think that the course of the river never changed, and that the structure was conceived as an amphitheater facing the river. I disagree, not because I think that such a grand building overlooking the river bank—and therefore subject to erosion—was beyond the builders' skills (it is apparent that the builders of Poverty Point knew how to build gigantic earthworks), but rather because of the structure's symmetry. Indeed the octagon, as a key geometric shape, was used during the Hopewell phase in other places in North America, as we will see later. Why, then, should the builders of Poverty Point have allowed the river to break the structure's symmetry?

We have very little information on how the builders of this amazing monument lived and thought. No houses or tombs have been found, and it is not even clear whether the site was residential or ceremonial, although the only findings—hundreds of microlites, stone pipes, pregnant female figurines, plus some deposits of intentionally broken pieces—seem to indicate that the monument was ceremonial. Many objects were imported from the Ohio and Tennessee River valleys, and perhaps also from the Olmec areas of central Mexico. In any case, it is certain that the site is a very clear example of the fact that a stable farming economy, which Poverty Point shows no sign of, is not a necessary prerequisite for the construction of monumental works.

How can we determine the intended purpose of these mounds? The monument is laid out quite accurately along a north–south axis, on the west bank of the river; therefore, the amphitheater is the ideal place to watch the sun rise. Further, it is possible to identify the four azimuths corresponding to the four corridors, although the high level of erosion of the structure makes it difficult to measure them precisely. These azimuths measure 191, 241, 299, and 344 degrees. The 241- and 299-degree azimuths approximate the sunset of the winter and summer solstices; the other two approximately point to the setting of the stars Canopus and Gamma-Draconis (the latter of which is not particularly bright) (Brecher and Haag 1980). Obviously, due to precession, these last two associations may be flawed since they depend crucially on the construction date.

Poverty Point thus might have been connected with astronomical cycles, although this idea has been strongly criticized (see, for example, Purrington 1983, Purrington and Child 1989), especially on the basis of the poor state of the monument, which is far too eroded to take accurate measurements of the alignments. But I believe that the two alignments to the solstices, at least, are quite convincing, and are the only explanation for the intriguing geometrical layout of Poverty Point, which certainly was not casual. Further investigations into the possible alignments of the mounds are essential.

6.3 Effigy Mounds

Mound A at Poverty Point has the shape of a bird with spread wings. In addition, another bird is seen in Motely Mound, which lies some kilometers north of Mound A, although it was probably left unfinished because the tail is just sketched. This kind of earthwork is called an effigy mound because it represents a living creature. It was planned and built with the aim of *replicating on the ground*, on a gigantic scale, a living being. It is difficult, although possible, to identify the figure when standing on the mound, for a clearer image the mound must be viewed from above, in an observation tower or airplane, or in an aerial photograph. Many of these mounds were destroyed by farming, but some survived, including the Serpent Mound and the Alligator Mound, both in Ohio, which were first studied by E. Squier and E. Davis in 1847.

Serpent Mound is a unique object in the world (according to some sources, another existed in Morrow, Ohio, but unfortunately it was destroyed). Basically it is a winding earthwork that resembles a serpent, partially curled up in a spiral and partially stretched to form seven winding parts; the jaws are stretched in order to swallow a huge “egg” earthwork that stands behind them. The mound is on a peculiar site: a geological formation that was probably the result of a meteorite crash. On ground level, the mound looks inconsequential, but when viewed from above, such as from a specially built platform, its grandeur and size, almost 400 meters long, are impressive (Plate 13).

Dating the mound is difficult. Until recently, it seemed certain that it was built by the Adena or the Hopewell and that it was, therefore, at least some 2000 years old. Samples of wood found on the site and recently analyzed have dated from about 1000 AD, during the so-called Fort Ancient period. For now these datings are only an *ante quem* term, however, and I agree with Romain (2000) that the monument is most likely Hopewell. In order to accurately date Serpent Mound it would be necessary to follow the same procedure used in dating Stonehenge, which requires finding materials that were used in the first stage of construction.

How can we determine the intended purpose of Serpent Mound? Let’s look at the alignments defined by the serpent shape. A winding object such as Serpent Mound involves many different "privileged directions”; therefore, studying the alignments entails the data selection problem that we mentioned in Chapter 3: if there are many apparently significant directions and only some of them are astronomically related, reporting just the latter

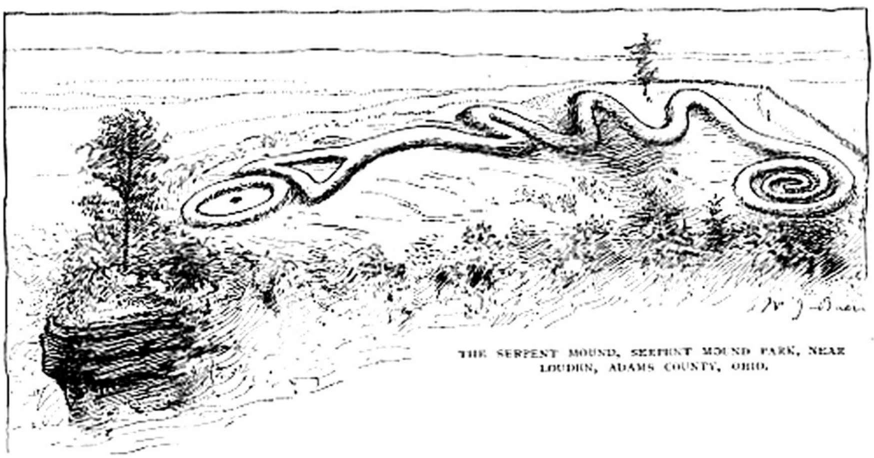


Figure 6.2: Serpent Mound in a 19 century depiction

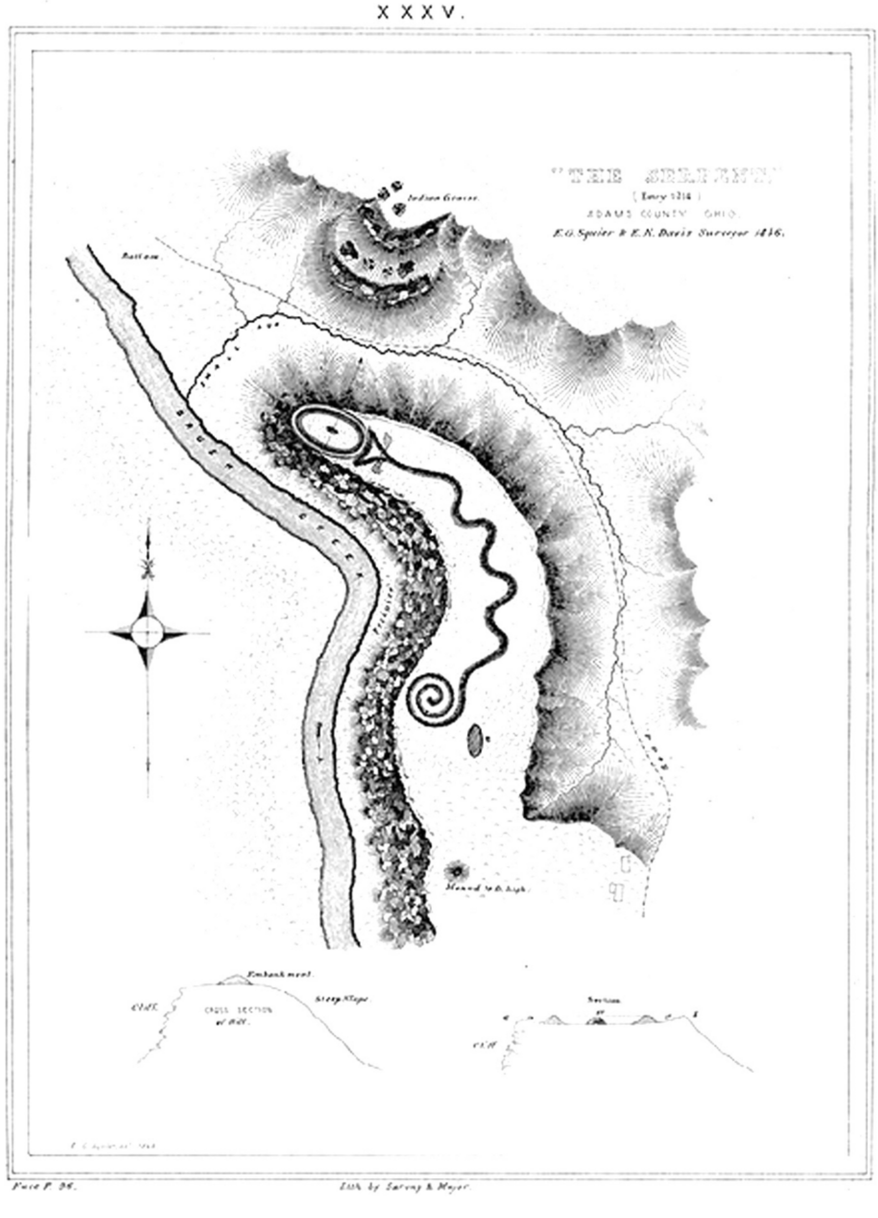


Figure 6.3: Map of Serpent Mound by Squier and Davis

type could attribute to the mound a significance it does not merit. However, there is no doubt that the north–south axis runs from the tip of the serpent tail to the central apex of the head, and that the oval embankment points to the summer solstice sunset (Romain 2000). Further, alignments to the four standstill positions of the moon extend through the convolutions of the serpent's body, and can be individuated by measuring the symmetry axes of the U-shaped winding of the body itself. It is unlikely that these astronomical directions are the result of a casual orientation of the site, but this does not mean that Serpent Mound was an observatory; rather, it was conceived and built as a huge calendar to keep track of the cycles of the sun and moon.

But why a serpent? It may be that the serpent was linked to celestial occurrences, and the work could be a representation, a replica on Earth, of the constellation Draco. However, it is difficult to demonstrate that this was the intention of the builders, unless we find some independent evidence: it may be sufficient to note that the shape of the Big Dipper, another northern constellation, can be easily superimposed on the serpent as well. To find replicas of constellations on the ground is anyway fascinating, as we shall see in the course of this book and especially in Chapter 11, which discusses a place where some tenacious people (including myself) hope to solve one of the most interesting problems in pre-Columbian archaeology.

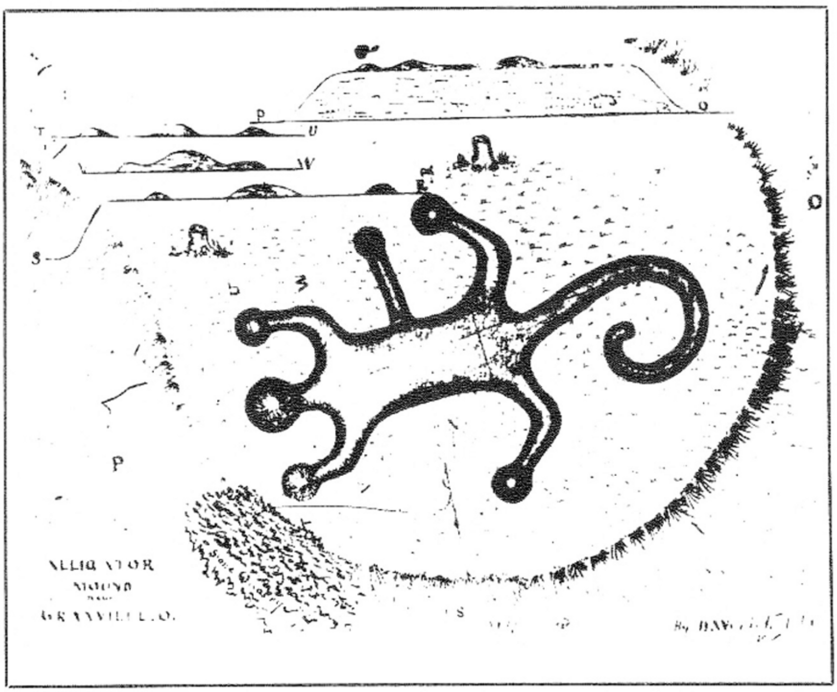


Figure 6.4: Alligator Mound

Alligator Mound, near Granville, Ohio, is not far from the Newark, Ohio, earthworks, which we will discuss shortly, and probably belongs to the same Hopewell period (but keep in mind that, as in the case of Alligator Mound, a more recent date of construction is suspected).

When looking at its layout, and despite its traditional name, Alligator Mound does not look like an alligator. It does resemble a four-legged animal, about 70 meters long, that seems to be crouched on a southwest-facing hill. The tail is curled up in a spiral, and something protrudes from the right side, possibly a fifth leg. Thus the first problem is determining what type of animal this is. Many authors have suggested a puma, basing this idea mostly on the figure's similarity to many Hopewell puma statues of the same period. Others have suggested a possum, a lizard, or a salamander; I believe the latter is the most reasonable interpretation. But once again we are unable to determine why the mound was built. The azimuths defined by the figure, including the main, southeast-oriented axis, have not yet been studied. Anyway, Alligator Mound was a perfect place to observe the sky, and nearby residents of Newark were very interested in doing that.

6.4 Newark

The Newark earthworks are the largest known group of artificial hills of geometrical shape existing on our planet. Built by the Hopewell between the first century BC and the fourth century AD, the earthworks are spread over a vast area of many square kilometers. Today there are only three well-preserved structures: the great circle, with a diameter of 321.3 meters; the octagon, with diagonals longer than 500 meters; and the earthwork known as Wright's, which originally was one of the sides of a large square.

The Newark site, unfortunately, is in the middle of a golf course (obviously called Mound Builders Golf Club), but visiting the site is worth the risk of getting hit by a ball. The structure is conceived as follows: On the edges of the main axis of the great circle there is a small mound called Observatory Mound (for a reason; see below) and a passage that provides access to a small, linear path that leads to the octagon. Inside the octagon are eight other small mounds. Various other elements complete the sacred landscape in Newark, including another large circle surrounding an elevated structure some 60 meters long in the shape of a bird, and another structure in the shape of a moon crescent.

We know very little about the people who built Newark, but they did so with great precision. For instance, they used the diameter of the great circle, 321.3 meters, as a unit of measure. Multiples of this unit can be found when

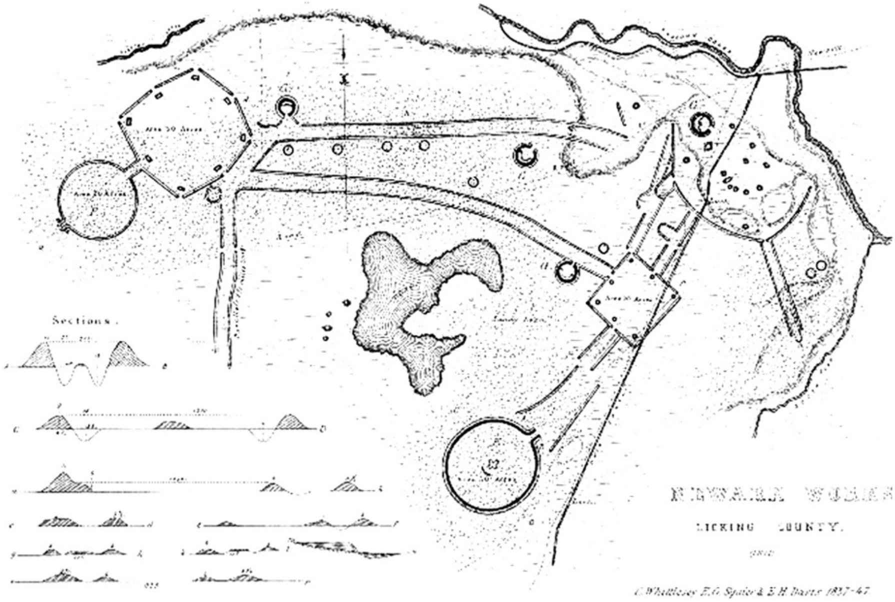


Figure 6.5: Newark earthworks

measuring the relative distances between the geometric centers of the various figures, and the octagon was built as a simple but refined geometrical structure based on this unit. A square was drawn with a side equal to the diameter of the great circle, and the four arches were drawn with a diagonal as a radius and with the center in the four vertices. The octagon was constructed by using the four initial vertices and the four intersections of the axes. The precision in building this structure was such that the diagonals of the square are perpendicular to each other within less than a few arc-minutes.

The Newark earthworks are the relatively simple geometrical figures that "any moderately intelligent and mathematically untutored individual" could have built, as one renewed expert on the Hopewell culture stated once... But why were they built? The complex formed by the great circle and the octagon is a large, very precise, astronomical instrument that facilitates following the cycle of the lunar stations. Specifically, the octagon–circle axis is oriented toward the major northern lunar standstill, while the sight lines defined by two sides of the octagon and by one corner-to-corner line point toward the other three lunar stations (Hively and Horn 1982, 1984; Mickelson and Lepper 2007).

There is a copy, a replica, of the Newark observatory in High Bank, which is in Chillicothe, Ohio, almost 100 kilometers from Newark. It is another group of earthworks, now in poor condition, that included a great circle—

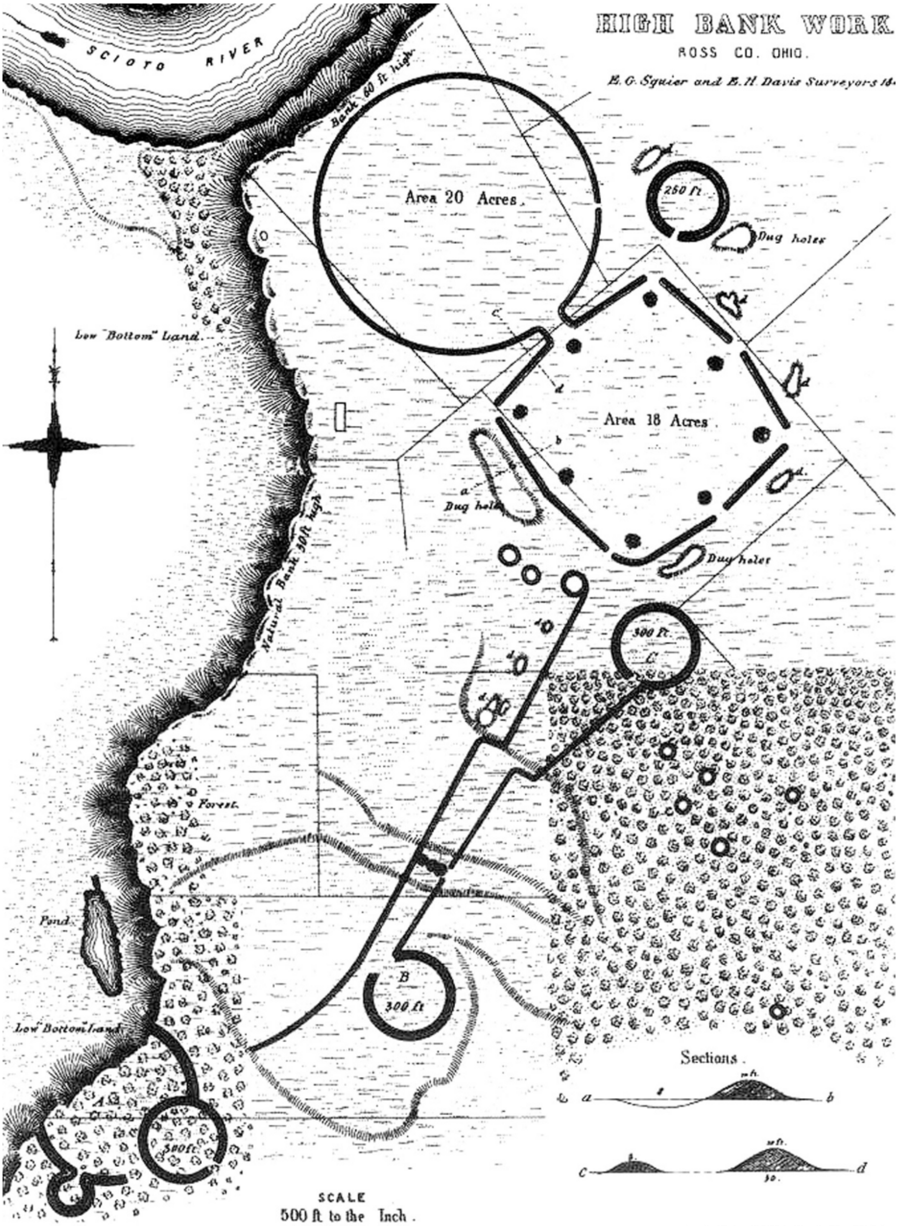


Figure 6.6: High bank earthworks

identical in dimensions to the one in Newark—connected to an octagon that is smaller than the one in Newark. The axis of the High Bank monument is rotated 90 degrees compared to one in Newark. The two structures seem to be complementary parts of a global project conceived by builders who were interested in celestial cycles. Since the lunar maximum amplitude with respect to due east at this latitude is less than 45 degrees, the main axis at High Bank is oriented not to the southern maximum standstill of the moon, but rather further south (the main axis does not exhibit any recognizable astronomical alignment). However, there can be little doubt that this structure was also planned on the basis of astronomical alignments; in particular, the alignment that is symmetrical with respect to the east–west line to the Newark main axis is realized by the direction between the east corner of the octagon and the point were the main axis crosses the circle. Thus a likely explanation for why the High Bank octagon is smaller than Newark's is that the builders had to respect three rules: (1) lunar alignments specular to Newark's, (2) 90-degree rotation of the structure, and (3) identical geometry. The solution to this is to re-scale the dimensions of the octagon (see Hively and Horn 2006 for a statistical approach to this and related issues). Therefore, we can be relatively sure that the 90-degree skew was a main rule governing the construction of the site, for unknown reasons; no recognizable feature of the site can justify the different orientation for practical reasons.

To further support the idea that the two complexes were part of a global project, there have been rumors since the 19th century of a road, made of two parallels earthen banks, connecting the two complexes. In 1862, Charles and James Salisbury followed its traces for a few kilometers until reaching Ramp Creek. Then the road was forgotten until 1934, when an aviation captain, Dache M. Reeves, discovered it again. Recently, with the help of aerial photography, the archaeologist Brad Lepper was able to verify the existence of various parts of this Great Hopewell Road that runs virtually straight, delimited by two earthworks 60 meters apart, for at least 30 kilometers starting from Ramp Creek and going toward Chillicothe, running along azimuth $31^\circ 25'$ northeast (Lepper 1996). It is likely that further investigations will demonstrate that the road reached Chillicothe, connected the two observatories, and ran straight for over 90 kilometers.

The great Hopewell Road was certainly built for ceremonial purposes, and it was likely a pilgrimage route. Interestingly enough, the same rule that led to the 90-degree skew of the High Bank observatory seems to have governed the alignment of the Great Road (Magli 2007d). Indeed, inspecting the direction of the road (and thus the azimuth $31^\circ 25'$ from High Bank to Newark and $211^\circ 25'$ from Newark to High Bank) it turns out that the

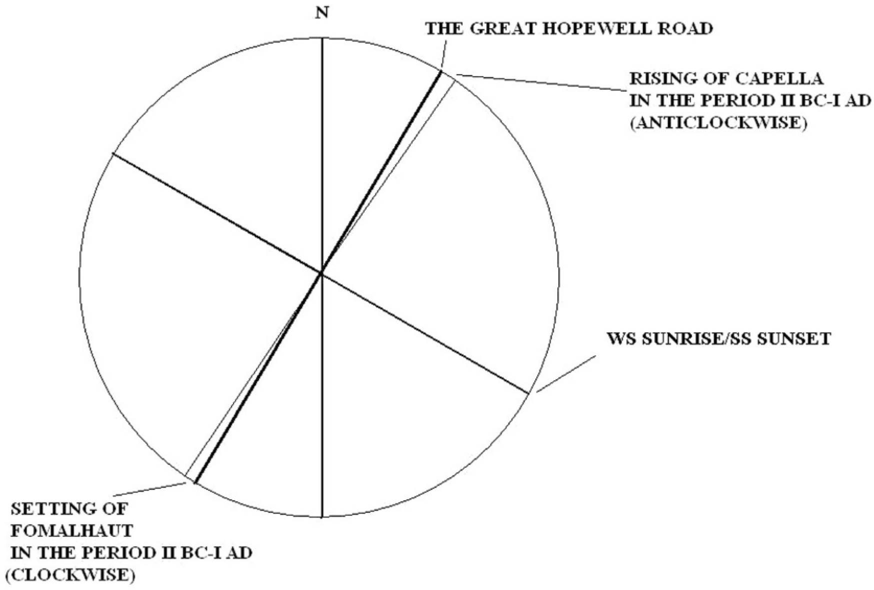


Figure 6.7: The possible astronomical alignment of the Great Hopewell Road

direction orthogonal to the road aligns with impressive precision with the direction of the setting sun at the summer solstice (or, in the opposite direction, with the rising sun at winter solstice). In fact, assuming a flat horizon, in 100 AD the setting azimuth of the sun at midsummer was 301°30′. How can such an alignment, which is measurable for only a few days during each year, be carried on with precision during the construction of the road? A possible solution is the use of the rising or setting positions of bright stars. Due to precession, such positions vary year by year (indeed, day by day), but the variation is very small. Given the azimuth of the road, it is therefore possible to research the period during which the road was constructed (we consider a broad period of 250 BC to 200 AD; but see below) and determine if there were stars rising or setting in alignment with the road. At azimuth 211°25′, an observer looking southwest toward a flat horizon would have seen the bright star Fomalhaut, of the constellation Piscis Austrinus, setting in alignment with the road. The alignment is optimal around 250 BC. Conversely, at azimuth 31°25′, an observer looking northeast would have seen the bright star Capella, of the constellation Auriga, rising in alignment with the road. The latter alignment is optimal at a date around AD 100, a date of construction that seems to be favored based on the archaeological data.

Interest in the motion of bright stars is documented in other Hopewell sites, for instance in the Anderson Mound in Indiana (Cochran and McCord 2001) and, as we shall see shortly, in the alignments of the so-called Medicine Wheels.

Thus we can reasonably conclude that the grand complex formed by the two huge circle and octagon observatories of Newark and High Bank and by the straight 90-kilometer-long, 60-meter-wide road connecting them was conceived as a single project.

Of course, by moderately intelligent, mathematically untutored builders.

6.5 Cahokia

The Great Hopewell Road is many centuries older than another, more famous, great road: the Great North Road built by the Anasazi in Chaco Canyon, which we discuss in Chapter 7. Before leaving the Hopewell cultures, we must discuss Cahokia, Illinois, the capital of Mississippi during 800 to 1300 AD (with at least 20,000 residents). Cahokia was built according to specific urban planning regulations. The city plan is in the shape of a diamond with one diagonal laid on the north–south axis. This axis is also a scenographic direction along which the two main mounds of the city—Pottery Mound and Monks' Mound—are laid; there are a total of 120 mounds. Pottery Mound, oriented toward the winter solstice, was built for funerary purposes. It is basically a 63-meter-long platform where, when excavated, many objects and the remains of hundreds of people, probably sacrificed to honor the two main personages, perhaps chiefs, were found buried. In contrast, Monks' Mound (the name refers to a convent of Trappist monks who lived in the area in 1800) is a huge artificial hill, 30 meters tall, 316 meters long, and 241 meters high. Given the volume of the material that was moved—700,000 cubic meters, which is about a third of the volume of the Great Pyramid—it is the largest structure ever built in the United States (including all modern buildings), and one of the largest in the Western Hemisphere. The purpose of this building is still unknown. On its top there was a large wooden building, possibly a temple. We can assume that building this huge structure took many decades or even centuries, and was done in various stages. What is certain is that, just like Silbury Hill, Monks' Mound is not a simple bank of amassed earth, which would not have survived erosion so well. According to Woods et al. (1998), who studied the various building stages, the hill was built using techniques that allowed draining the water through various layers of clay and by using buttresses to improve stability. Moreover, some years ago, stone foundations were found in Monks' Mound,

Figure 6.8: Monk's Mound at Cahokia

and we still do not know their size. The discovery is surprising because in that area stone is not an available building material and it must have come from far away.

Another intriguing discovery in Cahokia was made by archaeologist Warren Wittry in 1960. His group was investigating the site to make sure that building a road some 900 meters away from Monks' Mound would not result in a loss of archaeological layers. At a certain point, they noticed many large holes dug in the stone and laid out in circular arches. Such holes were obviously a support for some large wooden poles, and therefore the analogy with Woodhenge became inevitable (Wittry 1964). "America's Woodhenge" is composed of four circles of holes drilled in the period between 800 and 1100 AD, and it has been claimed that the holes, especially those of the circle No. 2, were used to measure the motion of the rising sun at the eastern horizon. However, the evidence of an astronomical use is not conclusive. What is certain is that the view from the site at the equinox would have been extremely impressive, with the sun rising behind the huge mass of Monks' Mound.

6.6 Medicine Wheels

Whether the alignments of America‘s Woodhenge would turn out to be casual or not, the best way to trace astronomical alignments is exactly to draw a circle and indicate the alignments using the radii of the circle. This technique was well known in North America, where there are many ancient stone circles. They are often ruins of Native-American camp huts, but some of them have a complex structure, with a large ring made of stones with a central hub and rows radiating from it. Inside these circles there are often piles of stones laid out on the external perimeter in a precise way. The most famous of these structures is found in Big Horn, near Medicine Mountain, Wyoming, which is why it is called Medicine Wheel.

The purpose of Medicine Wheels remained obscure until the beginning of the 1970s, when the physicist John Eddy noticed that the line that can be drawn between the center of the Big Horn wheel and a pile of stones near the complex indicates sunrise at summer solstice. Intrigued by this fact, he studied all the other alignments defined by the lines between the center and other stone piles distributed around the circle, finding three stellar ones (out of four possible ones), referring to the heliacal rising of the bright stars Aldebaran, Rigel, and Sirius (Eddy 1974, 1977).

As we have noted, stellar alignments are strictly linked to precession and are therefore valid only for a couple of centuries. The Big Horn alignments calculated by Eddy are valid for only the last 300 years, and the carbon-14 dating of some wooden fragments found in Big Horn established that the site is about 250 years old, confirming the archaeoastronomical hypothesis. It was nevertheless necessary to extend the investigations to the other sites, which was difficult for Eddy because, as a physicist, he had no way to finance his astronomical interests. But with the help of *National Geographic* magazine, he and two archaeologists, Tom and Alice Kehoe, organized an expedition to study other medicine wheels. The group concentrated its efforts on the Moose Mountain wheel, in Alberta, Canada, and the results were unmistakable: the wheel showed a solstitial alignment and three stellar alignments toward Aldebaran, Rigel, and Sirius, exactly the same alignments of the Big Horn wheel.

But there was one problem: due to precession, the stellar alignments were valid only in the period between the second century BC and the first century AD. Thus, the archaeological investigations would have shown either that Moose Wheel was at least 2000 years old, and in this case Eddy's studies would have proved that the builders had great interest in the same celestial objects for a very long period of time, or that his theories were blatantly wrong.

Tom Kehoe and his team dug a part of the central hub of Moose Mountain and found a stone floor and under it a burned ground on top of a sterile ground. The burned ground was linked to the first stage of the construction of the structure, and therefore the wooden samples taken from it could be used to date it quite accurately. The carbon-14 dating left no doubt: it was from 2600 years ago, plus or minus a few centuries, and therefore compatible with the archaeoastronomical dating.

But this was not the end of the surprises. Both in Medicine Mountain and in Moose Mountain there is a pile of stones (labeled D) that Eddy was not able to explain with any known alignment. In 1979 the astronomer Jack Robinson suggested that the D alignment indicated the rising of the star Fomalhaut. Fomalhaut had heliacal rising and could be seen looking in that direction in Big Horn some 30 days before solstice, between 1050 and 1450, and in Moose Mountain 7 or 8 days before solstice, in a period some centuries later than that indicated for the other alignments. This fact can be explained by noticing that the radius corresponding to the D alignment clearly has been bent. It might therefore be that the external pile was moved according to precession, and that at the beginning it lay more easterly than that, since Fomalhaut rising occurred more easterly during the centuries before and after the first century BC; the stones indicating the Sirius alignment also showed signs of bending).

Thanks to Eddy's pioneering research, we now know that the wheels were used for a very long time. Nevertheless, our concept of a very long time may

Figure 6.9: The Big Horn Medicine Wheel

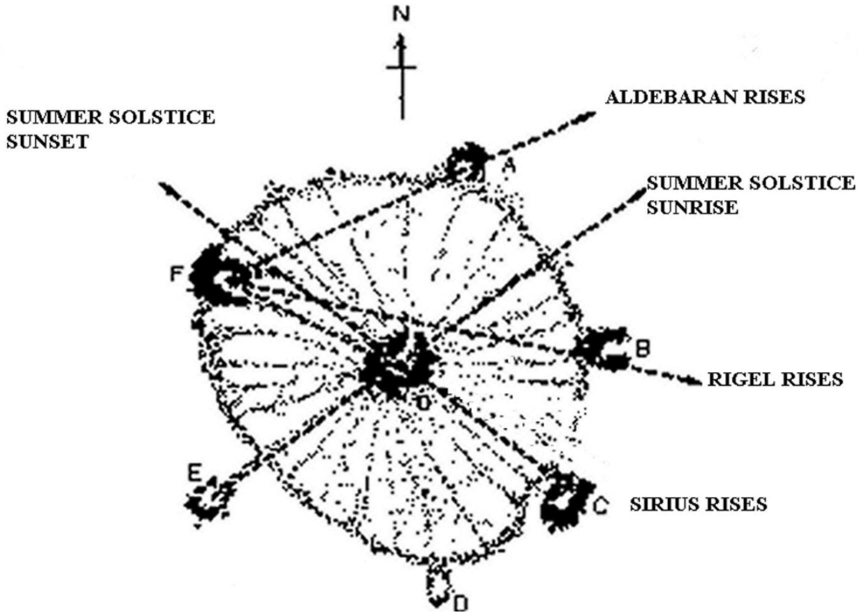


Figure 6.10: The possible alignments of the Big Horn Medicine Wheel

not be adequate to describe the tenacity of the wheels builders. Moose Mountain, with its 2600 years of age, is still young. The Majorville Wheel, in Alberta, is basically a large pile with a diameter of 9 meters, with 28 rays made of stone running toward an external circle made of stones. The structure itself does not show signs of specific astronomical alignments. Majorville, however, is the center of a landscape of many square kilometers where, on the horizon, piles of stones indicate the direction of sunrise at solstice and at equinox. Since the alignments are a few kilometers long, the level of precision reached in Majorville was excellent. When the main Majorville pile was excavated, a rich stratigraphy was found, which allowed dating it with great accuracy. It turned out that Majorville is 4500 years old, which means it is as old as Stonehenge. The wheel was used regularly between the years 2500 and 1000 BC, and was then abandoned for about a thousand years and then used again for many centuries.

After Eddy's early studies, investigations regarding the medicine wheels multiplied, and the criticism of their astronomical links increased as well, based on the fact that most of the wheels' alignments are not precise, being obtained using only piles of stones positioned close to each other and it would have been much easier to perform such a task using poles and ropes (see Vogt 1993; other criticisms by the same author show, in my view, serious methodological failures). Eddy responded, calculating that the probability of a fortuitous alignment with astronomically significant events was low. As far as the accuracy of the measurements is concerned, it is likely that the solution would be similar to the one we mentioned regarding the megalithic observers, namely that the builders intentionally connected the monuments with the astronomical cycles, and that at least some of the monuments were created with the purpose of obtaining accurate measurements, such as the Majorville Wheel.

A problem remains to be solved: Who built the monuments? There is no trace of civilization in these areas, and many of the wheels are placed on mountains, at a high altitude, and can be reached only during a few months of the year—those bridging the summer solstice, of course.

7 Straight Roads, Circular Buildings, and a Supernova

The Great North Road embodies many nonutilitarian aspects and has no clear practical destination. It displays a level of effort in its engineering and construction that is far out of proportion to any material benefits that could be realized from it.

—A. Sofaer, M.P. Marshall, and R.M. Sinclair, The Great North Road: A Cosmographic Expression of the Chaco Culture of New Mexico, in *World Archaeoastronomy*, 1989

7.1 The Anasazi

Anasazi is the name given to the ancestors of the present-day Hopi and Zuni tribes that live along the Rio Grande in New Mexico and Arizona. The Anasazi civilization flourished in the centuries around 1000 AD in the region that corresponds to the border area joining Utah, Colorado, Arizona, and New Mexico. This is not a particularly fertile area, but the Anasazi succeeded nevertheless in building a thriving economy based on hunting and efficient farming (Brody 1990). The Anasazi dwelt in villages that often boasted monumental architecture. Around 1250 AD, however, their life changed drastically: many villages were abandoned, and new settlements were built in out-of-the way, almost inaccessible, places. Abandonment of sites is a phenomenon common also to other civilizations of the Americas, but the Anasazi version was extremely striking and difficult to account for. For example, the Anasazi constructed an enormous 420-room building at Sand Canyon, which was created, inhabited, and abandoned, all in the space of 50 years around 1200 AD.

We have little information about the life and society of the Anasazi. As far as we know, they did not have writing, and until recently they were thought to be (along with the Mayas) a sort of "sons of the flowers." This view, however, now has been modified considerably. For instance, at the so-called Castle Rock site, in Colorado, also inhabited for an extremely short period between 1256 and 1274, there is no doubt that the occupation ended in a

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_7,

massacre. The human remains discovered there show unmistakable signs of cannibalism and scalping. It is thus clear that isolation in inaccessible villages was due to the need for defense. And yet this question of abandonment is far from being fully explained, although there is evidence of repeated droughts, invasions, and social and demographic tension (Nelson and Scachner 2002). It is also possible, as we shall see, that the Anasazi social customs, religion, and way of thinking played a role in this large-scale desertion, and to further explore these issues it is essential to trace their astronomical ideas, as the study of celestial cycles was undoubtedly one of the basic constituent of their very existence.

The place where this is most evident is Chaco Canyon, New Mexico. The Anasazi site there is made up of various two-story buildings, called *pueblos*, which are often enormous. Each pueblo contained dozens, even hundreds, of rooms as well as numerous spaces known as *kivas*. Kivas are circular rooms or buildings dug into the ground and elaborately fitted out inside; some, such as Casa Rinconada, which we shall discuss, are enormous. Access to the kivas was normally from above, and inside were to be found alcoves on the walls and an opening in the floor, set on the north–south axis. A fireplace with ventilating shaft completed the fittings. Archaeologists attribute a symbolic interpretation to the kivas, based on analogous structures (albeit rectangular) still in use today among the Pueblo Indians. It is difficult to

Figure 7.1: One of the Anasazi great Kivas: Chetro Ketl

obtain information from the Pueblo about the ceremonies held in these structures, but it would seem likely that they are closely tied to a cosmological myth, according to which the first creatures lived in the depths of the earth and then emerged by passing from one subterranean realm to another until coming out into the open. The kiva with the recess on the floor must therefore be a representation of the final stage, the "incubator" of men prior to their exit into the world.

The construction of the pueblo of Chaco necessitated the moving of great quantities of stones and timber, over dozens or perhaps hundreds of kilometers. The largest building in the complex is Pueblo Bonito, which contains about 600 rooms and 36 kivas. It is semicircular in shape, with a straight 150-meter-long front. Inside, a wall runs perpendicular to the diameter and an enormous 17-meter kiva is set tangentially to the wall. The building design of this and other pueblos shows clear signs of meticulous planning, and the arrangement of the buildings in relation to one another makes it clear that the complex was conceived in a uniform manner—a hypothesis that is also confirmed by dendrochronology dating (and by the fact that the entire layout is astronomically "anchored," as we shall see shortly).

The position of Chaco Canyon does not appear to have been blessed by any particular environmental benefits, although the natural environment was certainly less desolate than it is today. In any case archaeological investigation has shown that the resident population was numerically disproportionate in relation to the scale of the site and we also have archaeological documentation of deliberately broken pottery, which would suggest the performance of rituals (Lekson 1991, Sebastian 1991). It is thus reasonable to surmise that Chaco was not so much an urban settlement as a place of pilgrimage, visited by people at fixed occasions and dwelt in exclusively by an "elite." But what was this elite involved in?

7.2 The Chacoan's Main Hobby

The first archaeoastronomical investigations in Chaco Canyon took place in the 1970s (Williamson et al. 1975 1977) with the analysis of the large kiva (20 meters in diameter) known as Casa Rinconada. It is a building constructed with meticulous care; for example, it has an axis of symmetry, defined by two opposing T-shaped accesses, directed precisely northward. Little windows have been carved into the inside wall; their arrangement is so regular that a line joining two opposite windows passes through the center of the circle with a maximum error of 10 centimeters. Four holes in the wall,

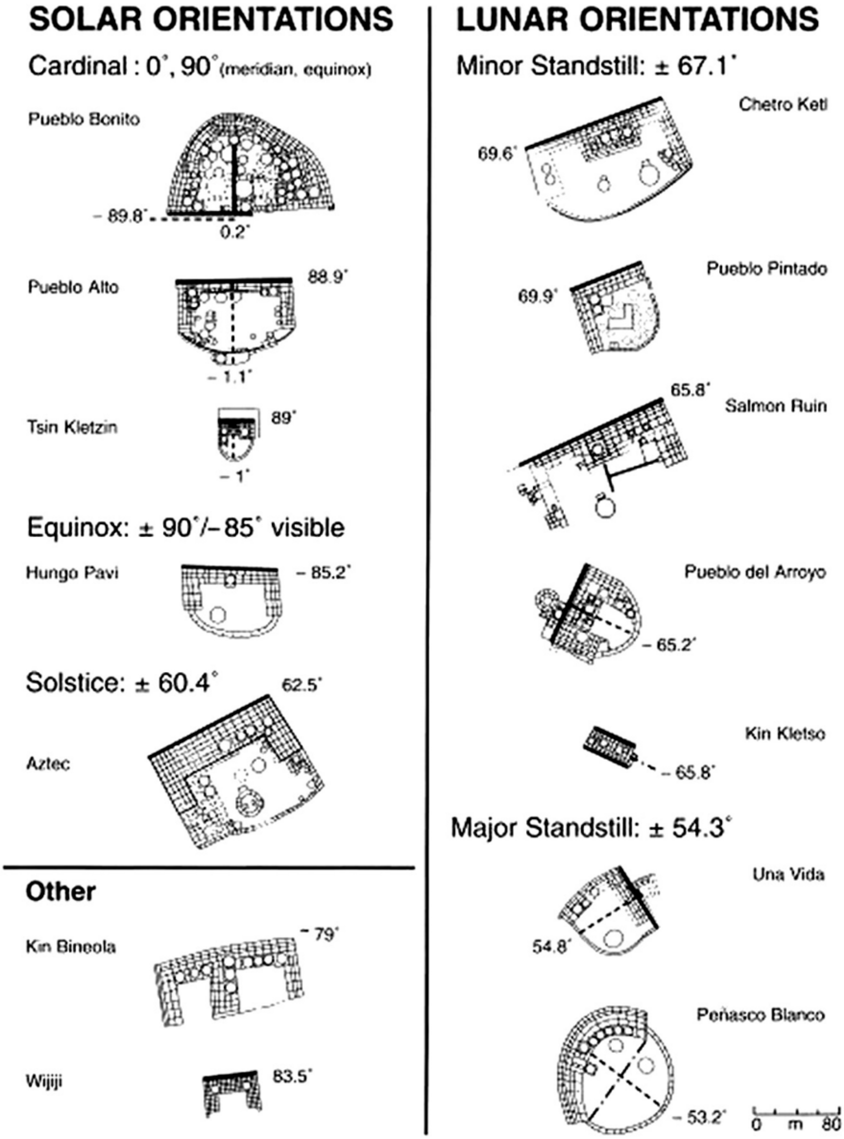


Figure 7.2: Possible astronomical orientations of buildings in Chaco canyon (adapted from Sofaer 1997, under kind permission)

possibly for posts supporting the roof, form a perfectly centered square, but oriented 30 degrees north of east. During the summer solstice the sun's first rays strike the windows and then move along the walls until they light up a specially placed niche. The deliberateness of such an alignment has been contested by some scholars on the grounds that the northwest post would have cast a shadow over the niche. I would argue that we do not know what the post looked like (or if it actually existed), but it is not that important. To have more incontrovertible proof of Anasazi astronomy, we simply need to look at a different building (Sofaer 1997).

There are 14 buildings at Chaco, of which 12 appear to be astronomically oriented: Three are oriented on the cardinal points (Pueblo Bonito, Pueblo Alto, and Tsin Kletzin), of which Pueblo Bonito, the largest building, is oriented with great accuracy; the wall that divides the half-circle is oriented within 15′ of true north, and the western half of the south wall runs straight on the east–west line within 8′ (Malville and Putnam 1993) (Plate 14). A fourth building is oriented toward the summer solstice (Aztec Ruin). Five buildings are oriented toward the north minor lunar standstill (Chetro Ketl, Kin Kletso, Pueblo del Arroyo, Pueblo Pintado, and Salmon Ruin), and two buildings are oriented to the north minor lunar standstill (Penasco Blanco and Una Vida).

Evidence of the Chacoans' interest in lunar and solar cycles is further seen throughout Fajada Butte, a 135-meter-high rocky peak 7 kilometers southwest of Pueblo Bonito. There are numerous *petroglyphs*, that is, drawings carved onto rocks. One is a few meters from the top; it is a semicircle crossed by a radial line perpendicular to the diameter of the base, with a circle placed to the left of the line itself. Thus it is a stylized plan of the Pueblo Bonito complex, which has a large kiva set to the left of the dividing wall. An arrow is drawn outside the figure of the semicircle. We do not know what the carver of the petroglyph had in mind, but the figure links the Pueblo Bonito building with a symbolism relating to the Sun.

Apart from symbolic petroglyphs, on Fajada Butte there are also carvings used as lunar-solar calendars (Sofaer et al. 1979, 1982, 1989). The most interesting, although controversial, example is the so-called petroglyph of three slabs, placed in the vicinity of the summit. This is a drawing made up of two spiral figures; three great slabs of stone are propped on the same rock, over 2 meters high and weighing about a ton each. They cast a shadow over the whole surface on which the drawing is traced. The light can illuminate the figures only through the two openings between the three slabs; the passing of the "blades" of light thus created will vary day by day. At the summer solstice the blade of light crosses the center of the largest spiral. On subsequent days the "arrow" shifts to the right and a second "arrow" appears to its left. At the equinox this second blade of light reaches the center of the smallest spiral. The movement of both proceeds to the right to the point of illuminating tangentially the largest spiral at the winter solstice. By

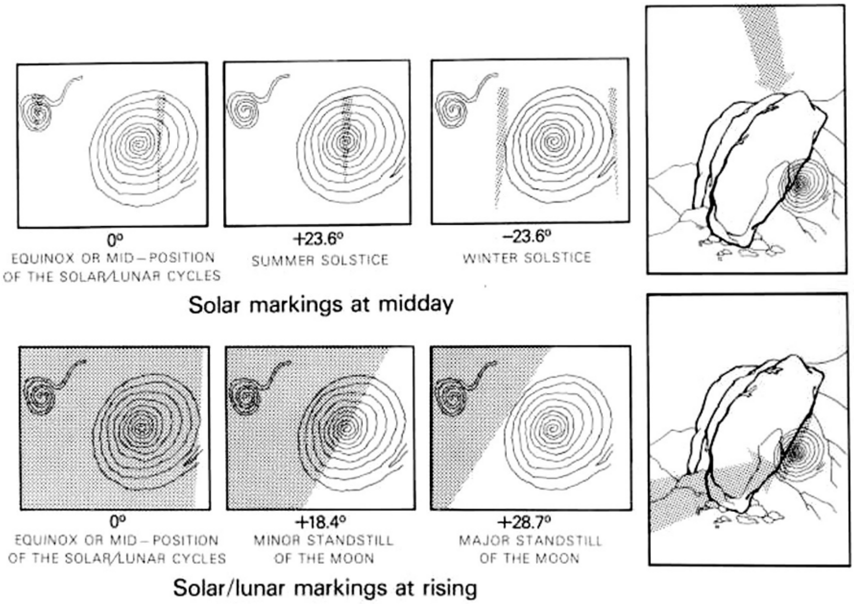


Figure 7.3: Solar and lunar markings on the 3-slabs petroglipys (adapted from Sofaer and Sinclair 1982, under kind permission)

continuing to observe the effects of light and shadow throughout the year, researchers realized that when the sun had, at dawn, an azimuth close to that of the moon as it reaches the north minor standstill, the large spiral was half lit. In other words, when the sun *simulates* the north minor lunar standstill, the petroglyph is illuminated in a special way. This observation encouraged researchers to simulate with artificial light the major lunar standstill as well (which, as we know, cannot be reached by the sun, and is reached by the moon only once every 18.6 years; see Appendix 1). Perhaps it will come as no surprise then to learn that in this case the light leaves the spiral figure in the dark, just grazing it, that is, passing tangentially.

It is difficult to believe that such light and shadow effects could occur by chance (although the risk of "data selection" is always present in these studies). The three-slab petroglyph appears therefore to be a clever lunar-solar calendar; the most puzzling thing about this site is the sheer tenacity of the astronomers who built it, who were forced to make meticulous observations of the sun and moon for many years, climbing up and down the peak of Fajada Butte, if not every day then certainly frequently.

Petroglyphs are not unique to Fajada Butte, but can be found to some extent all over the canyon. One of the most famous drawings is on a rocky outcrop northeast of Penasco Blanco. It shows a lunar crescent, a shining star, and a hand. To understand its possible significance, let's take a trip to the China of the eleventh century.

On July 4, 1054 AD, Yang Wei-te, royal astronomer to the Chinese Court, was engaged in his habitual observations when he suddenly realized that there was a new star (a "guest" star, to use his words) in the sky, in the constellation of Taurus. The star shone so brightly (from four to ten times more brilliantly than Venus, according to modern calculations) that it was visible during the daylight for 23 days; nighttime visibility lasted for about 2 years. Observations of this object are reported also in other Chinese and Japanese sources, although curiously there is no evidence that the phenomenon was ever recorded by Europeans or Arabs. Physically, this was a case of the explosion of a supernova—a star that has exhausted its nuclear fuel and undergoes a violent contraction process, culminating in an explosion. What is left is an object that is extremely dense and invisible to the naked eye, typically what we call a neutron star, surrounded by a nebula (in the case of the phenomenon observed in 1054 AD, we are talking about the formation of what today is called Crab Nebula).

On July 4, 1054 AD, in Chaco Canyon, the moon was entering its final quarter and at dawn it was located less than three degrees from the supernova, facing the same position as indicated by the petroglyph, so that it is tempting to interpret it as a depiction of this phenomenon. Unfortunately, it is impossible to date petroglyphs, so we shall never be sure whether the drawing was made on that particular day, with the aim of representing the appearance of what might be interpreted as a second sun (of course, it may be that the petroglyph simply represented a combination of the moon and Venus). Nevertheless, there exist ceramics originating in New Mexico, definitively dated at 1050 to 1070 AD, on which very similar depictions appear (Brandt et al. 1977).

Orientations of single buildings and petroglyphs show clearly the meticulous interest of the Chacoans in the celestial cycles, and we are therefore tempted to interpret Chaco as another of those places where an *elite* of priests-astronomers exerted their power. A further hint in this direction comes from the suggestion that the ceremonial center of Chaco might have been constructed according to a global plan. Indeed, if one looks at the layout of the buildings in Chaco Canyon, one wonders why they have been constructed so far apart from each other. There do not seem to be any geological—the type of terrain, for example—or agricultural reasons, nor any considerations relating to water sources. (It is not even clear why so many buildings were erected there.) Thus it is likely that the layout of the complex was conceived in terms of an overall scheme. The first to propose the existence of such a master plan was Fritz (1978), who noticed that Pueblo

Alto and Tsin Kletzin, in a north–south direction, and Pueblo Bonito and Chetro Ketl, in an east–west direction, form a cross; that is, the ideal line joining the first two cuts in half perpendicularly the line joining the other two. It was later proposed that most of the Chaco buildings are astronomically related to each other; for instance, the two moon-oriented buildings that lie many kilometers from the Canyon, Pueblo Pintado (27 km) and Kin Bineola (18 km), are correlated with moon-oriented bearings with buildings in the center of the Canyon (Chetro Ketl, Pueblo del Arroyo, and Kin Kletso).

7.3 The Great North Road

Perhaps some of the above-mentioned astronomical correlations are just casual. However, there is overwhelming evidence that the *sacred landscape* of Chaco was deeply connected with the celestial cycles, and that these connections were established across great distances (Sofaer 1997, Sofaer and Sinclair 1986b). Clearly, it is extremely difficult to be accurate when working on such distances, but accuracy of alignments certainly presented no problem to the Chacoans.

To be further convinced, one only needs to look at the roads. Indeed, the careful observation of solar and lunar cycles was only one of two hobbies at Chaco Canyon. The other was building roads. Between circa 1050 and 1125 AD, the Chacoans were engaged in a frenetic program of road construction. The Anasazi roads were built by digging up the surface of the ground and, when necessary, integrating the roadways with masonry work or slicing through rocks.

It is easy to spot Anasazi roads from aerial photographs because the roads are straight. The Anasazi did not like bends or curves. What is today called the Great North Road, for instance, begins at the northern rim of Chaco. From here it runs (in a straight line) in a direction 13 degrees east of north for 3 kilometers. It then proceeds (straight) in the direction of true north for 16 kilometers as far as a site known as Pierre's Complex, which is made up of a collection of small buildings. It then heads (straight) in the direction two degrees north of east for 31 kilometers as far as the peak of Kutz Canyon (most of the road consists of two—on some stretches, even four—lanes, with a breadth that exceeds modern two-lane highways). There are no forks, no bends, no intersection, and no intervening villages—nothing. The closest Anasazi complexes, apart from Chaco where the road starts, are Salmon Ruin and Aztec Ruin, which are scores of kilometers away. The importance of the road, however, is evident in Chaco itself, as numerous secondary roads

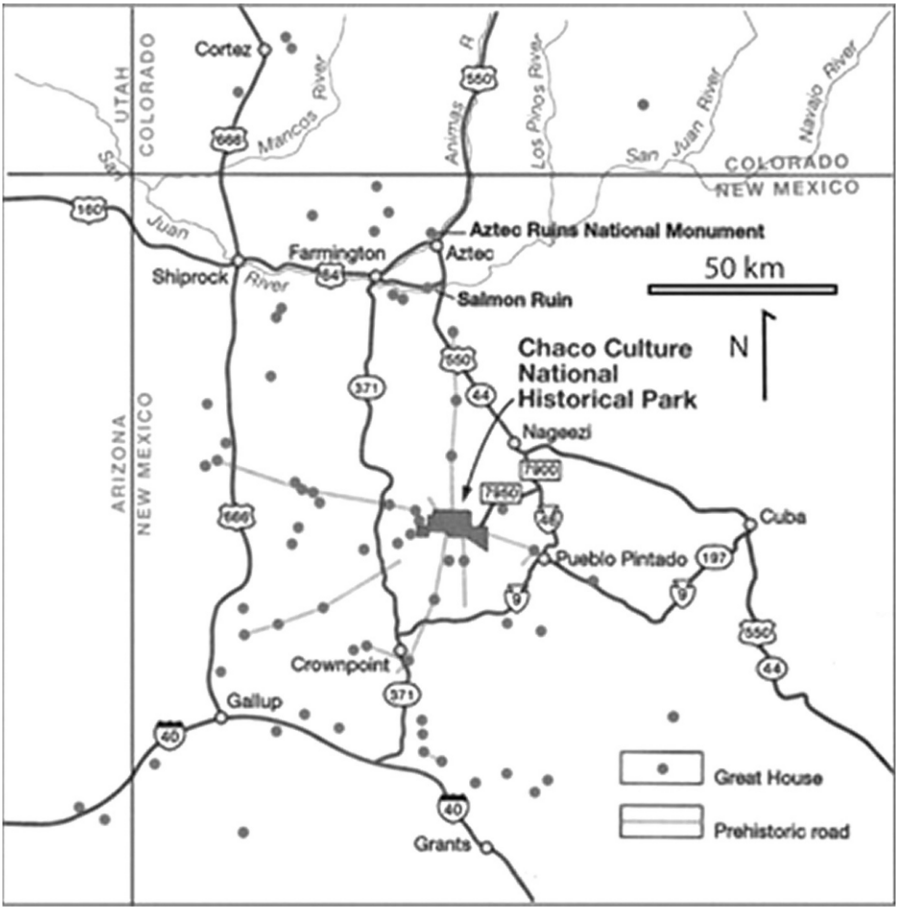


Figure 7.4: A map of the Chaco National Park, showing ancient buildings and the network of ancient roads. The Great North Road is easily recognizable.

and stairways carved into the rocks converge onto it from Pueblo Bonito and from other buildings up to the beginning of the road at Pueblo Alto.

The building of the road was no mean feat and entailed the shifting of great masses of earth and vegetation. When the road had to pass through rocky outcrops, the rocks were duly hewn and modeled so that a straight path might be hewn through them. Everything is grossly out of scale for any mere utilitarian purposes. Archaeological study has found no signs of wear on the road due to traffic, and a considerable amount of pottery has been found, perhaps deliberately broken, both along the way and at its end, as well as on the flights of stairs carved into the rocks on the peak of Kutz Canyon. Thus, even though many in the past argued that the Anasazi roads were trade or communication routes, it is clear today that they had no commercial purpose (Sofaer et al. 1989, Stein and Levine 1983). We can only conclude that the Great North Road, for example, was built for the simple reason that the builders wanted it to be built—however unsatisfactory and frustrating such an explanation might appear (the same might be said of various other stretches of road built by the Chacoans).

From the technical point of view, the question raised by the Anasazi roads is, How did the builders manage to mark out such *straight* paths? Imagine yourself in a desolate canyon, having to solve the problem that the Anasazi faced when they created the stretch of the Great Road leading to Pierre's Complex: moving 16 kilometers in the direction of true north with maximum error of a quarter of a degree. Today such good precision can be easily obtained with a theodolite or a GPS system (not a compass, however, since even the best magnetic compass, after having corrected its reading by taking into account magnetic declination and possible anomalies, is unlikely to give you an accuracy better than a half of a degree). For the Anasazi, the only possibility was to use the sun during the day or the stars at night.

The sun may be used to find the cardinal directions by employing a method sometimes called *Indian circle*. A post (gnomon) is placed in the center of a circle and then, during the day, the two points where the shadow of the post passes over the circumference, in the morning and in the afternoon, are marked: the east–west line can then be found connecting the two points. Yet it is impossible (at least in the view of many, myself included) to obtain an accuracy greater than half a degree or so in this way, since there are too many geometric operations to be carried out with ropes and poles.

The stars can be used to determine north in a very precise way by two methods. The first method makes use of the stars which rise and set. The astronomer constructs an "artificial horizon," that is, a circular wall whose top is perfectly smooth and leveled, and then stands immobile at the center of the circle, signaling to his assistant—who marks them on the wall—the rising and setting point of the chosen star. Bisecting the angle formed by the two ideal lines joining the two points on the horizon with the position of the astronomer indicates north. The other possibility is to identify, using a reference instrument able to measure angles (for example a cross-staff), the upper and lower culmination, that is, the maximum and minimum heights reached, or the maximum east–west elongation, of a circumpolar star, and then looking for the mean point. It is important to remember that the method of finding the celestial north pole with the pole star is only approximate, and it can be used only in the periods in which precession brings the pole close to a sufficiently bright star; the celestial south pole always lies in a zone in which bright stars are not present.

In using one of these two stellar methods, very good accuracy (say 10′ or even less) is undoubtedly attainable (as we shall see during the age of the pyramids in Egypt, accuracy of a few arc minutes was also attained with a method based on two circumpolar stars). The mystery, if any, lies in the depth and seriousness of the commitment that drove the astronomers to operate at such a high level of accuracy. Indeed, we have to imagine the Anasazi astronomers determining north by night, and then their engineers building the road, bit by bit, on the basis of their observations, sending ahead runners armed with fire signals and marking for them the position on the horizon until they were in alignment with the meridian, kilometer after kilometer, night after night.

Even more difficult is to align long straight roads that are skewed with respect to true north, as for example the path leading to Kutz Canyon. It is difficult to avoid making curves, but this avoidance seems to have been of vital (life-giving, literally) importance for the Anasazi. Possibly the directions to follow were associated with astronomical phenomena (rising or setting points of stars), so that the builders could "recalibrate" on the stars each night. The Polynesians navigated far out in the ocean this way, as we shall see in Chapter 12, and maybe the same procedure was adopted by Hopewell when they marked out the Great Road linking Newark and Chillicothe, as we saw in Chapter 6.

7.4 Casas Grandes

Apart from marking out straight roads, the Anasazi were also fanatical about *going* in a straight line. Chaco indeed has a last surprise in store for us.

Solve the following problem: go to a godforsaken canyon, proceed 100 kilometers north, and if while moving you have deviated from the meridian (compared to the one you started on), then relocate yourself on the original one within an error, say, of one degree or less.

This problem is equivalent to determining one's longitude after moving in a fixed direction, and was indeed the agonizing dilemma that sailors were faced with up to the end of the 17th century. In fact, while it is possible to determine the parallel (and hence the latitude) with solar observations or, at night, by working out the height of the celestial pole, it is necessary to know the *local time* in relation to the time of a known meridian (for example, that of Greenwich, which is conventionally designated meridian zero) to ascertain the longitude. We have been able to measure longitude with sufficient accuracy (at least sufficient to avoid maritime disasters) only since John Harrison, in the mid-18th century, succeeded in constructing a clock that was accurate enough to be carried aboard ships for reference. Thus, without a clock showing a reference time (or a GPS—namely a position finder based on satellites), there is only one way to solve the problem: not to make any mistakes right from the start, verifying meticulously one's position compared to the previous one on the horizon, exactly as if we had to mark out a road like the Great North Road, but this time for up to 100 kilometers.

Well, the Anasazi did just that. They moved almost exactly along the meridian for 88 kilometers northward, subsequently settling the villages known today as Salmon and Aztec Ruins. Then, they moved far southward, again along the meridian (Lekson 1999)—very, very far. Eventually, 624 kilometers from Chaco, we come across the southernmost settlement probably influenced by the Anasazi, Casas Grandes (also called Paquime), which today is across the Mexican border.

As we have seen, the phenomenon of the abandonment of Anasazi villages has not yet been fully understood. I believe it possible that one of the reasons was not practical, but a question of symbolism: in some instances, in fact, the Anasazi moved to places not because there was more water, or more food, or fewer enemies. They moved just because there was *more south*, whatever that might have meant to them.

The Land Where the Gods Were Born

8

Who could conquer Tenochitlán? Who could shake the foundation of heaven?

—Anonymous Aztec poet

8.1 A Place that Should Not Exist

The date on which the Americas were first populated by humans is still the subject of heated debate. Once it was not put any earlier than 12000 BC, but today the date is increasingly being pushed back in time. Whatever the truth, agriculture seems to have been firmly established in the valley of central Mexico around 5000 BC, and the production of pottery may be dated to around 2000 BC. Immediately afterward, around 1500 BC, civilization "exploded" with the Olmec culture (c. 1500–200 BC).

The appearance of the Olmecs has often been considered something of an embarrassment, an "undoubtedly gradual process of which some details are missing," as one author stated. Their very existence was, for some authors, including the famous Maya scholar Eric Thompson (this name will be cropping up a great deal later), quite unthinkable, an idea to be rejected until such time as we have overwhelming evidence in its favor. In fact, however, as I have already said, it is extremely doubtful whether human history always (or indeed *ever*) evolves in a slow, uniform, systematic way. Besides, as far as we know, the Olmecs were a sudden, one-off phenomenon, without any formative antecedents (Soustelle 1996).

The main known Olmec sites—La Venta, Tres Zapotes, and San Lorenzo—are to be found in the modern state of Veracruz. These sites, like the megalithic sites in Europe, are "silent." Indeed, though the introduction of writing into Mesoamerica can undoubtedly be attributed to the Olmecs, or at least to the period of transition that linked the Olmecs with the central Mexican civilization of the final centuries before Christ, evidence of Olmec script is extremely limited and it has remained

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_8,

Figure 8.1: The Olmec heartland

indecipherable to this day. In any case, unlike what happened in the east, where it would appear that economics and the need to record merchants' transactions led to the creation of the written word, all known inscriptions in Mesoamerica are definitely of the ceremonial kind.

The symbolic world of the Olmecs was also incredibly rich and abundant, and their cities are dotted with what for us are veritable riddles, such as the "heads"—enormous sculptures carved in blocks weighing as much as several tons, depicting heads of sad expressions, possibly dead—and the "offerings"— sculptures buried in great holes; we do not know what function they served, why they were made, and whether they were really "offerings" to anyone. For example, at La Venta, a hole of 17 by 20 meters, 8 meters deep, was dug out. Then it was filled carefully with tons and tons of slabs of serpentine (a precious material from the Oaxaca Valley, hundreds of miles away), forming quite a refined pattern, and finally covered with a layer of clay and one of sand. The most famous "offering" is *offering 4* in La Venta, made up of 16 little statues, two of which are in jade, 13 in serpentine, and one in sandstone. They all depict static personages with typical Asiatic faces and without sexual characteristics. The figurines show signs of wear and were thus clearly used for other purposes before becoming "offerings". The scene shows four figures who parade in front of the sandstone personage, while the others look on. Behind this central figure stand six jade rods, which may represent stelae. Offering 4 was carefully placed at a depth of about 60 centimeters, with the statuettes in position, and then covered with neat layers of clay of different colors and sand. One day, someone must have gone to check that everything was in place (we know this because the inspection hole has mixed layers of clay around it).

Finally, the Olmec enigmas include items traditionally known as "altars"—huge monoliths, in the center of which a carved figure sits, perhaps on the threshold of the afterworld. This figure holds a child (or maybe a dwarf) with partly human and partly feline features; possibly some of the "heads" were created by re-sculpting altars, or vice versa.

The heads and the altars have been discovered especially in the great sites of La Venta and San Lorenzo, in the modern Mexican state of Veracruz. La Venta was built on a large island in the middle of swampland, and was planned along a main axis oriented 8 degrees west of north. At the end of the avenue we find a large pyramid, unique in the world for its "volcanic" form (conical, but with rounded sides). Some archaeologists think that this is not its original shape; rather, the effect is due to erosion. This is difficult to

Figure 8.2: Giant Olmec head carved in stone

credit, however, and indeed its curious resemblance to a volcano might have been inspired by the volcanoes of Los Tuxtlas. Although these volcanoes are situated over 100 kilometers from La Venta, their importance for the inhabitants of the city is shown by the fact that it was from these very mountains that the basalt needed for the creation of heads and altars was excavated. The pyramid may thus be seen as a monumental replica of the landscape, whose significance, however, escapes us, as does the reason for which the pyramid itself was created, since there are no traces of constructions on it or evidence of burials inside it (Benson 1967).

La Venta is located right in the middle of a highly commercialized petroleum-bearing area. For this reason, in the 1950s, the scholar Carlos Pellicier, concerned about the safety of the artworks, arranged for their transport and display in a natural archaeological park (La Venta Park) in the town of Villahermosa. Unfortunately, however, the sculptures are displayed out of context; the heads, altars, and other extraordinary works of art, already so remote and alien in themselves, are now just some things scattered in a jungle.

Another place where re-creating the past today requires considerable effort, but which might have been utterly splendid, is San Lorenzo. The town

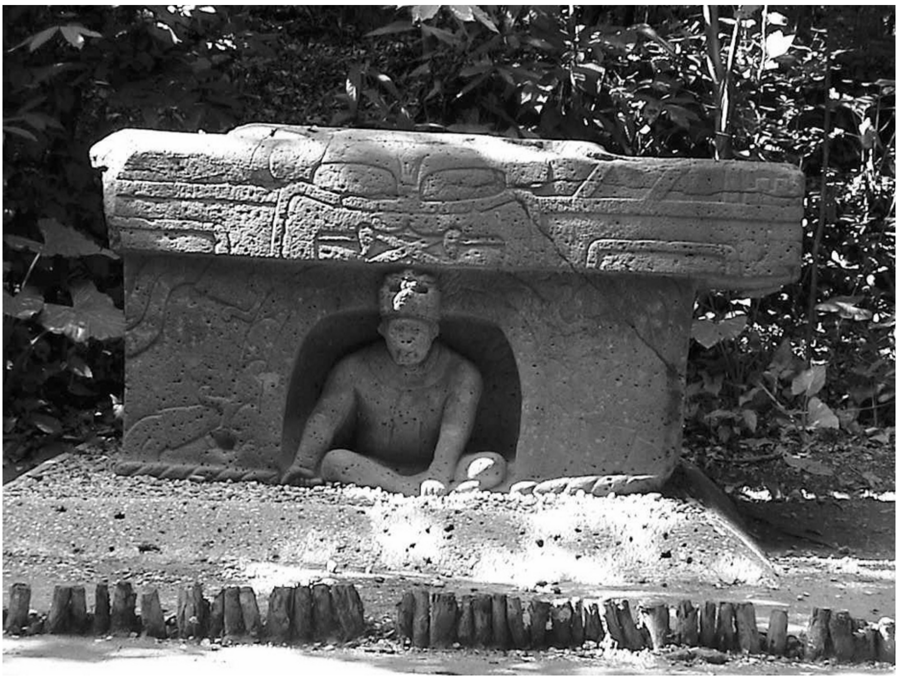


Figure 8.3: One of the La Venta "altars"

(abandoned, probably quite traumatically, around 900 BC) would appear to be built on a natural earth platform, with lagoon pools inside it, but this is not the case. The entire site was literally *created*, made to rise from the marshy terrain by the construction of massive artificial terracing, on the surface of which “pools” (lagunas) were deliberately made, fed by extensive underwater canals. Alas, however, as at La Venta, any attempt now to penetrate the inscrutable Olmec mind is doomed to failure. There is perhaps only one place in Mexico where the sacred landscape of the Olmecs has remained intact, and that can be seen as it was almost three thousand years ago: Chalcatzingo, 120 kilometers from Mexico City.

I showed some friends a photo of Chalcatzingo, and they were all convinced it was a painting depicting a fantastic, magical place conceived by an artist’s imagination. Even today, then, one cannot avoid thinking of Chalcatzingo as a sacred place, and it is perhaps interesting to note that for us today, a landscape is considered sacred when it is hard to believe that such a beautiful place could really exist.

The site stood in the vicinity of two large natural hills, and was occupied uninterruptedly for considerable time, although the peak of its activity was reached between 700 and 500 BC. At that time large areas of territory were terraced for agricultural purposes and irrigation canals were built, as well as long communication roads and settlements on artificial mounds. The whole area was a sacred domain, and today one has to rely on rock carvings at the base of the hills to get a sense of direction within it. These carvings are of two types: some relate to agricultural subjects, particularly the rain, while others seem to be portrayals of the elite—deified chiefs. One of the most important is El Rey (Krupp 1997). The figure seems to be emerging from the jaws of a monster; he is surrounded by representations of what appear to be clouds and rainfall, and holds a scepter in his hand, which has an “S” symbol inscribed on it. This symbol appears in various other places and also seems to be related to rain; maybe it is a flash of lightning.

Not far from the Rain King we find the depiction of a caiman, perhaps rather surprisingly since this is an animal whose natural habitat is in the tropics and who does not figure in the fauna of the Mexican plateau. To understand its significance we have to note that the caiman was associated with Earth and was in a sense an image of Earth itself; it is therefore likely that the whole Chalcatzingo region was identified and chosen to be a sacred ground, whose purpose was to represent or replicate this cosmic caiman. According to this theory, the two peaks of Cerro Chalcatzingo were depictions of the two horns located over the animal’s eyes, while two mounds symbolized the body. Finally, the caiman’s jaws, the same as those from which the Rain King emerges in the rock carvings, were sculpted on a stone slab, which was subsequently rediscovered and can be seen today in the National Museum in Mexico City.

I believe it is extremely likely that the Olmecs' cosmic caiman was also linked to their observation of the sky (for example, maybe they had a caiman constellation). Unfortunately, we know virtually nothing about Olmec astronomy. And yet the civilizations that immediately succeeded them, in central Mexico and the Yucatan, proved to possess a knowledge of astronomy that is extremely detailed and rooted in a vision of human existence and the landscape of man. The Mayas belonged to these civilizations (we shall discuss them in Chapter 9), as did the great city-states of central Mexico. One of these, in particular, has always exercised a particular fascination for the visitor because, with its still, silent, far-off monumental qualities, it is inextricably linked with the most intriguing and enigmatic sacred landscape in the whole of Mesoamerica.

8.2 The Place Where Time Was Born

Crossing the outskirts of Mexico City by car on the way to Teotihuacan, the outlines of the mountains can soon be made out on the horizon, especially that of Cerro Gordo. Looking at the pyramids, it is as though some giant had wished to make a faithful copy of those rounded silhouettes, one thinks, and built what for him would be mere mounds of earth. For the Aztecs, Teotihuacan was the place where time had its birth, where the gods decided on the contents and the order of the world. Indeed during the Aztec era, around the 14th century AD, the city had already lain abandoned for many centuries, its past splendor lost in the mists of mythology. It strikes us how difficult it is today to understand the mentality of men who wished to *replicate the mountains.*

The earliest archaeological evidence from Teotihuacan dates from the first century BC. Immediately after this the city grew enormously, and rapidly became one of the largest cities on the planet at that time, with a population of some 125,000 (Millon 1973, 1992). The splendor of Teotihuacan was to last for a few centuries—traces of Teotihuacan art and customs are to be found all over Mesoamerica—until the city vanished from history along with its inhabitants in the 6th century AD. We know very little about them, and nothing about their language, provenance, or end; we have no written remains.

Only the splendid objects they made, which have been found in numerous burial grounds, speak to us, as well as their wonderful architectural achievements, if we are prepared to listen to them.

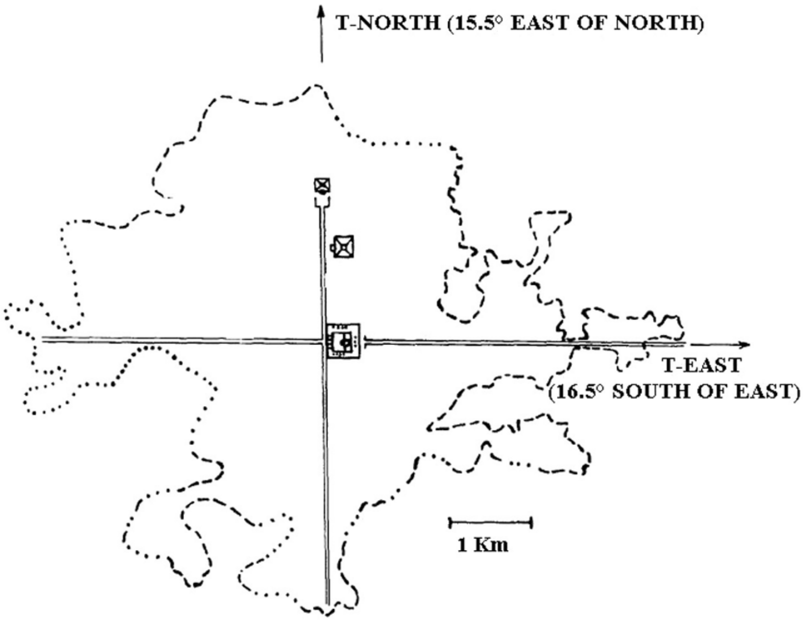


Figure 8.4: Schematic plan of Teotihuacan

We know for certain that the two main divinities that existed in Teotihuacan—in fact, we encounter them to some extent in all Mesoamerica—were the Rain God and a creator-divinity portrayed as a plumed serpent. We use the Aztec names Tlaloc and Quetzalcoatl for these divinities, since we do not know their original names. The name that we use for the city is also the one given by the Aztecs: Teotihuacan, the City of the Gods.

It is no coincidence that it was given this name. You get a strange feeling, one of unease, especially in the early hours of the morning, before the assault of frenetic tourists, when the city is seen gradually emerging from the mist. You feel the weight, the almost tangible presence of a remote, far-off sense of antiquity—silent and hard to fathom. In the first place, the sheer scale on which the city was conceived is staggering. In fact it was designed meticulously on the base of a main axis 2.5 kilometers long and 40 to 95 meters wide, designated (with a rather inadequate name that some attribute to the Aztecs but that I think more likely to be a Spanish invention) the Avenue of the Dead. Before tracing out the avenue, for reasons that are difficult to hazard and that we shall return to, the nearby San Juan River was canalized so that it intersected with the avenue itself at an angle of 91 degrees, and extensive underground hydraulic works were implemented to drain off rainwater, which was then channeled off into the river. At the far north of the avenue, and on the east side, two large and nowadays anonymous pyramids were erected, traditionally called, without any historical justification whatsoever, Pyramid of the Sun and Pyramid of the Moon (Plates 15, 16). To the southwest, we find another monumental complex, known as the Citadel, which includes a further pyramid, clearly dedicated to the Plumed Serpent, stone heads of which emerge from the terraces at regular intervals. The southern end of the avenue does not appear to have featured any particular structure on it, but this is in itself curious, and new excavations may yet come up with something interesting. What is certain, however, is that the city had no walls or defensive structures of any kind.

Situated in the ideal center of the city, but located laterally in relation to the Avenue of the Dead, the Pyramid of the Sun is one of the largest artifacts in the world. Its base originally had a 215-meter-long side, which then was extended to 225 meters, and it was 63 meters high. Today it is made up of five platforms, but one of these is the result of a disastrous 19th century restoration. There was probably a temple on the top, but we know nothing about its form. Beneath the pyramid there is an extensive artificial grotto, which was used for burials.

The Pyramid of the Moon, smaller but equally elegant, faces on to a large square at the north end of the Avenue of the Dead. Going along the avenue, the silhouette of the pyramid in the distance seems to blend with the profile of the Cerro Gordo; it is as though someone had made a scale copy of the mountain. The same impression is gained when the Pyramid of the Sun is glimpsed from the north, with the profile of the Cerro Patlachique in the background (Broda 1993, 2000).

It was customary in Mesoamerica to remodel pyramids cyclically, that is, incorporating an existing structure into a larger one, with the outer one acting as a kind of wrapping or casing. It had been known for considerable time that the Pyramid of the Moon must have contained previous structures, but only in 1998 were systematic excavations begun. Today we know that the structure was rebuilt (or "accreted") seven times, and that ritual offerings, consisting of objects and animal and human sacrifices, were laid on each of these layers.

We know only a little about how the city was planned. Imagine being a town planner who is told to design the plan of a city that is to be built. Certainly, today this is unimaginable, but we could perhaps think in terms of, say, a housing project. The planner would adopt the most anthropocentric criteria possible (taking account of the needs of the future inhabitants), adapting them when faced with external problems relating to the geology or morphology of the terrain in question (such as a river flowing through the area, which would entail a modification). Where possible the planner would follow criteria of simplicity, preferring right angles and choosing the main directions according to the best possible ventilation or sun warming. Alternatively, if we are talking about a more inventive architect, he would try perhaps to break the mold, with fanciful constructions, bold angles, and unexpected shapes.

In Teotihuacan, neither method was adopted. But the planning was by no means a random hit-or-miss affair. The planners decided that the city should be built on the basis of a grid directed toward the cardinal points, but the cardinal points were to be decided by the planners; instead of the north they used the direction of azimuth 15.5 degrees east of north and instead of east they used the direction of azimuth 16.5 degrees south of east. To survey their chosen directions the builders used *pecked crosses*, concentric circles carved on the rocky terrain, at the center of which a pole was placed to act as a reference for surveying. It is as though for some reason there existed a Teotihuacan north–south axis displaced 15.5 degrees to the east of ours, on which the Avenue of the Dead was oriented, and a Teotihuacan east–west axis, offset 16.5 degrees to the south of ours (I shall refer to these Teotihuacan cardinal directions with a "T-" prefix).

Our cardinal axes, inherited from Greek and Roman city planning, form an angle of 90 degrees, that is, they are perpendicular to each other; the two Teotihuacan axes, however, do not form a right angle, but an angle of 91 degrees. Yet considering the accuracy of the Teotihuacan architects, we have to deduce that this choice was deliberate. So if we want to visualize how the city was designed, we cannot just think about our cardinal directions arranged in a cross and rotate them with an a rigid movement because we also have to rotate the east-west axis one degree further towards the south. Why? We merely have to note that the planners were forced to build an artificial canal to divert the river in order to fit the direction in with their overall plan, to conclude that the cardinal T-axes do not conform at all with the features of the ground. To try to understand the reasons behind such a complex urban system, we must realize that Teotihuacan is one of the most extraordinary examples of sacred landscape, a place where a monumental replica of the natural landscape bestowed power and prestige. The mountains were indeed undoubtedly sacred and this would explain the orientation of the Avenue of the Dead toward the Cerro Gordo, the fact that the Pyramid of the Moon is placed on the line of sight of its counterpart (the Cerro Gordo), and the fact that the Pyramid of the Sun faces its counterpart Cerro Patalachique (which explains why it was located on the east side of the avenue).

All this was surely the driving force behind the choice of the place and the structure of the city. As I have said, at Teotihuacan the idea was to replicate the mountains. Nevertheless, the extension of the Avenue of the Dead does not pass over the summit of Cerro Gordo (it is off by a couple of degrees), and since Teotihuacan designers had no problems in determining directions with errors well below half a degree, it follows that the precise direction of T-north must have a further significance.

One sensible suggestion that might explain the T-north orientation hinges on the fact that the direction orthogonal to it points to the setting of the Pleiades (Dow 1967). In Teotihuacan in the first centuries AD, the Pleiades underwent heliacal rising on approximately the same day as the first zenith passage of the sun (the zenith passage occurs when the sun passes vertically above the observer's head at noon; see Appendix 1), and thus their first appearance may have served as a signal for this important phenomenon. Further, the Pleiades culminated near the zenith at Teotihuacan, and it may be that this coincidence strengthened the link between these celestial bodies and the sun. According to many scholars (Aveni 2003, Drucker 1977, Sprajc 2000a,b), the passage of the sun to its zenith should also be at the origin of the orientation of the other axis, due to a rather complicated mechanism, which I now shall try to explain.

The T-east axis does not indicate the setting of the sun on the dates it reaches the zenith at the latitude of the city; these dates are May 18 and July 24, whereas the sun sets in alignment with T-east on April 29 and August 13. It should be noted, however, that the latter two dates are more distant from the summer solstice than the former two; hence, there undoubtedly exists a latitude that is *lower* than that of Teotihuacan, at which the sun passes to the zenith on those dates. We should also note that these dates are separated by 260 days. In the whole of Mesoamerica (especially among the Mayas, as we shall see in more detail in Chapter 9), the calendar included two distinct cycles, one of which was 260 days. It is likely that this is the number of days that separates the two zenith passages of the sun in the place where the calendar was originally calculated, which should correspond to the parallel at 15 degrees north latitude. The great classical Mayan city of Copan, in modern Honduras, is located on it (Malmstrom 1978, 1997), but the calendar had already been documented in earlier times (in the final Olmec period, around the 4th century BC), and thus it is more likely that it was codified at a preclassical site, possibly Izapà, in Mexico, which is situated on the same parallel as Copan.

Thus, the T-east orientation seems to have the aim of indicating the number of days of the 260-day calendar. Since, as has been said, Teotihuacan is much further north than the places where the calendar was codified, such an orientation did not correspond to any special astronomical phenomenon, such as solstice or zenith passages. It thus represents an example of *codification* of astronomical information in an urban context.

Some scholars have rejected this explanation and more generally the interpretation of the cycle of 260 days based on the zenith passages, putting forward other explanations (such as the average human gestation period) or attributing it to chance. It is difficult to gain definitive proof that the astronomical-symbolic interpretation is the correct one. But one fact is certain: the Teotihuacan people's interest in the zenith passages of the sun was enormous. So interested were they in this phenomenon that they endeavored to find the place where the Sun "turns back."

8.3 The Place Where the Sun Turns Back

The Tropic of Cancer is the northern parallel at which the sun passes to the zenith on one day only, the day of the summer solstice. If we consider, instead of the movement of the rising point of the sun on the eastern horizon throughout the year, the movement of an observer who watches the maximal height of the sun at midday during the year shifting each year further north, we can think of the tropic as a *zenith station*, a point at which the movement of the shadow projected by the post of the observer finally reaches zero only once a year, at the summer solstice. The tropic is therefore a limit from which, descending again toward south, the shadow "turns back." I have produced such an utterly complicated reasoning because it should help to understand why the Teotihuacan astronomers moved toward north, and it is indeed certain that they did this.

The Tropic of Cancer passes through the north of Mexico, very close to the top of a hill known as El Chapin. Nestling in the foothills, on a parallel less than three arc minutes from the tropic and on the same parallel as a hilltop known as Picacho Peak, about 8 kilometers away, we find Alta Vista, one of the heartlands of the so-called Chalchihuites culture. First studied by Manuel Gamio in 1908, the site, which displays very clear Teotihuacan influence, was subsequently investigated in depth by J. Charles Kelley beginning in 1970. What Kelley wished to understand particularly was why the city had been built on an open plain that was impossible to defend (while various other settlements of the same period sprang up on hills or mountainsides) and that was over 2 kilometers from the nearest river.

The first construction to be built at Alta Vista was the Hall of Columns. This structure, with its square layout oriented to the cardinal points, was designed and executed with the utmost care, in such a way as to align a diagonal with the parallel that crosses Picacho Peak. The deliberate link with

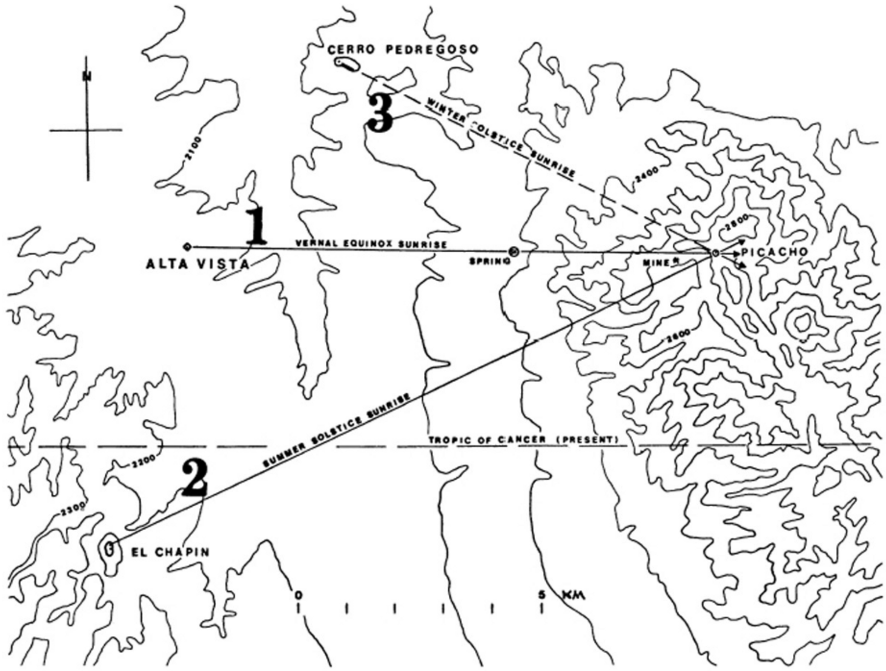


Figure 8.5: Alignments in the Alta Vista landscape. Notice the proximity of the city with the Tropic (from Aveni 2001, under kind permission)

the sky is confirmed by the fact that, near the north corner of the hall, Kelley found a multiple burial place, possibly of human sacrifices, with four ceramic pots positioned at the cardinal points. The pots allude to the divine cult that the Aztecs were to call Tezcatlipoca, a deity associated with the sky and the north. Another structure known as the Labyrinth is also aligned with the cardinal points. It consists of a series of pillared corridors, constructed in such a way that the equinoctial sun, coming up over Picacho Peak, passes over it without encountering any obstacles whatsoever. The spectacle to be enjoyed (it can still be appreciated today) from Alta Vista during the equinoxes is truly breathtaking; it is almost as if the sun wants to stay hidden behind the peak of Picacho and then pass over the city in triumph.

The Hall of Columns and the Labyrinth are among the few known examples in Mesoamerica of buildings aligned with the cardinal points, an indication perhaps of the fact that the city was somehow associated with them. It would seem, therefore, that, rather than being a direction that was somehow privileged or important at every single point, the east–west cardinal direction was identified with a specific parallel, the one at which the solar zenith has a "station", that is, the Tropic. Naturally, at Alta Vista the solstitial direction—recall that at the tropic it coincides with that of the zenith passage of the sun—was carefully measured as well, as is shown by the alignment, also very precise, between the top of Picacho peak and two pecked crosses, situated near the summit of Cerro Gordo.

All in all, Alta Vista was likely founded for strictly astronomical-symbolic (or religious, if you wish) reasons by people, probably guided by a group of Teotihuacan astronomers, who moved north in order to find the place where the sun "turned back," and to build a city there (Aveni et al. 1982). How did they manage to locate the Tropic with such amazing accuracy? There are only two possibilities, in my opinion. One is by measuring the direction of the rising of the sun at the zenith passages at regular distances, shifting successively north, and the other is by taking measures of the height of the sun on a fixed day, preferably at the solstice. Either way is a long and tricky endeavor. I thus believe that they may have developed a model that allowed them to cut down on the number of measurements required. It is certain, in any case, that as the number of days between the two zenith passages diminished, it was necessary to increase the number of measurements (or observers positioned in various places); otherwise it would have been impossible to locate the tropic so accurately.

The Teotihuacan astronomers who determined the position of the tropic of course knew that the number of days that elapse between the two zenith passages increases if one moves south. Maybe, therefore, they went to look for the equator as well. Certainly, *someone* was looking for it, and this someone was an excellent astronomer. The equator crosses not far from Quito, Ecuador. Today, tourists go to Mitad del Mundo, a village that has made a fortune out of a white line traced on the asphalt and a monument baptized the equator, to take photos of themselves with one foot in one hemisphere and one foot in the other. But whoever worked out where to draw the white line with modern instruments made a mistake: the equator does not pass through there at all, but several hundred meters to the north, on the parallel of the summit of Monte Catequilla. Here, are to be found the ruins of a pre-Columbian building, definitely pre-Inca but of uncertain date, which lies, believe me or not, *exactly* on the line of the equator.

8.4 An Ungainly, Asymmetrical Building

At the same time as Teotihuacan, but further south, in the Oaxaca valley, the culture known as Zapotec was evolving. Its main center was Monte Alban, which fortunately has remained almost intact. It is a stunning, enormous site, second only to Teotihuacan. It is in fact extremely ancient (10th to eighth century BC), but the structures visible today are those built by the Zapotecs. The complex is made up of great squares, pyramids, and a field for ball games, and there is an overall sense of harmony, of parallel lines and privileged directions, as at Teotihuacan. The orientation of the city too is Teotihuacan-style—on average 4 to 8 degrees east of true north, with only one conspicuous exception: a strange asymmetrical construction that seems to have been built carelessly, with ungainly, lopsided angles. It is called Building J and was erected in three successive stages, starting from the third century BC. The layout is equally curious: it resembles a shield, with one end facing southwest, and, as far back as 1935, the archaeologist Alfonso Caso suspected that it might have something to do with astronomy. Now we know that the monument is associated with astronomical observation, indeed the oldest of this type known in Mesoamerica.

The structure has two main alignments. The southwest tip faces the region where the stars of the Southern Cross were setting at around 250 BC, while the flight of steps to the north is directed toward the rising of Capella, one of the brightest stars in the sky, in the same period. At Monte Alban, Capella had the same function as the Pleiades at Teotihuacan (which lies about 500 kilometers further north), that is, it had heliacal rising on the same day as the first zenith passage of the Sun (Aveni and Linsley 1972). *Building J* is not unique; there is a close copy at the site of Caballito Blanco,

Figure 8.6: Building J at Monte Alban

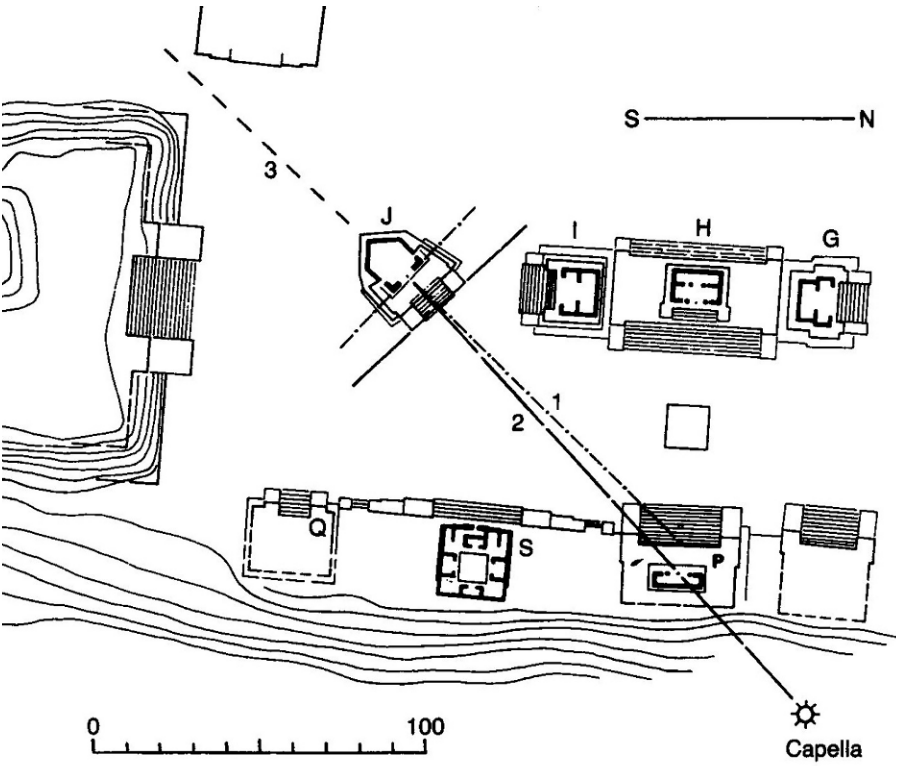


Figure 8.7: The astronomical alignments of Building J at Monte Alban (from Aveni 2001, under kind permission)

50 kilometers from Monte Alban, that is oriented toward the setting of Sirius.

Not far from Building J, and ideally linked to it by astronomical alignments that pass overhead, is another structure, Building P. Inside is a chamber connected with a vertical shaft with a hole in the top. Due to its reduced size, the hole offers a somewhat restricted view of the sky and was thus probably used as a device—a "zenith tube"—indicating the days around those of the zenith passage of the sun (a similar structure, with a terminal chamber carved in the rock, exists at Xochicalco, some 70 kilometers south of Mexico City (Lebeuf 1995)).

8.5 Urban Imitation of T-North

The Teotihuacan civilization wielded, as I have already mentioned, enormous influence throughout all of central Mexico. Of the great centers

Figure 8.8: The Cholula Pyramid

of Teotihuacan influence that flourished at that time, one of the most important was Cholula, which developed between the second and fourth centuries AD. Cholula is about 2 hours by car from Mexico City, and is situated on the Puebla plateau, 12 kilometers from Puebla City.

On arriving in the city, you catch sight of a yellow church on the top of a bulky hill, in the distance. Except that this is not a hill but rather a pyramid, constructed from sun-dried mud bricks. It is the largest pyramid ever constructed by humans in all history, the biggest *object* that humans have ever created; 62 meters high and 460 meters wide at its base, the pyramid has a volume estimated at over three million cubic meters, which makes it bigger than the Great Pyramid at Giza (which has a volume of about 2,200,000 cubic meters). The structure was built over many centuries, in various stages. We know about the stages because of a series of galleries that have been excavated by archaeologists on the sides of the hill, thus allowing its evolution to be studied. The first stage was the construction of a pyramid with a virtually square base (107 by 113 meters), about 43 meters high. The style of this structure was similar to that of the temple of Quetzalcoatl at Teotihuacan. The pyramid was subsequently enlarged by the addition of various terraces and staircases, until it was eventually incorporated into the hill we see today.

In these excavations, archaeologists have also managed to find, in the core of the pyramid, numerous splendid frescoes, including the *Mural of the Drinkers*, 70 meters long, which depicts a serious of figures engaged in drinking or perhaps involved in a fertility ritual. From other data we have acquired in the excavations, we know the orientation of the first Cholula pyramid, which was 17¼ degrees east of north (the orientation was later changed, and that of the last construction is solstitial).

After the collapse of Teotihuacan (around the end of the 10th century AD, for reasons that are far from clear), peoples speaking the language known as *Nahauatl*—the Mixtecs, Toltecs, and finally the Chichimecs—spread throughout Cholula and the whole of central Mexico. The Toltecs especially were to exert an enormous influence, and their capital, Tula, was the main town of the region for centuries. Subsequently, toward the end of the 10th century AD, Toltec groups emigrated to the Yucatan, where they somehow gained supremacy over the Mayas, imposing on them their own version of the cult of the rain god Chaac, which involved human sacrifices, whose hearts were then offered up to the characteristic statue of the semireclining figure called Chaac-Mool. The most important Maya-Toltec site is Chichen Itza, where many monuments closely recall those of Tula, and which curiously lies at a latitude very close to that of Tula as well (we shall discuss Chichen Itza in Chapter 9).

The archaeological site of Tula, which today is swamped by oil fields, still

Figure 8.9: The huge statues on the top of the temple platform at Tula

makes for an emotional visit, especially when you reach the top of the main temple. The building, dedicated to Quetzalcoatl in Venus–Morning Star guise, houses four giant statues, over 4 meters tall (re-erected in the 1950s). The orientation of the Temple of the Morning Star is similar to that of the Cholula pyramid, 17.5 degrees east of north. Indeed, a great number of buildings in central Mexico, constructed over a span of over a thousand years, are oriented in a direction very close to 17 degrees east of north, making up a veritable "17-degree family," which also includes, for instance, the pyramids of Tenayuca and Tepotzteco (Aveni and Gibbs 1976). This concentration of alignments should have had something to do with the direction of the Teotihuacan north–south axis, the axis we called T-north and that was oriented 17.5 degrees east of north. In turn, as we have seen, the choice of the T-north direction at Teotihuacan can probably be explained by the fact that the Pleiades set in an orthogonal direction. And yet, due to precession, stellar alignments depend on time, and if this direction still had the same meaning in Cholula in the second century AD, it would certainly no longer have it in the ninth century in Tula. We are thus dealing with a phenomenon of *urban imitation*; the buildings were oriented 17.5 degrees east of north *because* that had been the orientation at Teotihuacan. One of the interesting aspects of this phenomenon is that it is a genuine imitative process, springing perhaps from respect for the past, and different therefore from what happened in the Roman Empire, where it was the Romans themselves who planned and replicated cities on the basis of the (ideal) layout of the city of Rome (see Magli 2008a).

It is a delicate and moot point whether the urban planners of the 17-degree family were aware of the reasons for which this particular orientation was chosen, and, if they were, whether they realized that it originally corresponded to the Pleiades, and that the astronomical connection was lost due to an extremely slow phenomenon that displaces the rising point of the stars on the eastern horizon over the centuries. In any case, a couple of centuries later, the Aztecs were to show that they had assimilated not just knowledge of astronomy, but also great respect for the past, from the peoples they had conquered.

8.6 Tenochitlan

The Mexica, later to be called the Aztecs by the Spanish, were a bellicose tribe who, impelled to migrate from the north for unclear reasons, settled in the rather inhospitable area of Lake Texcoco, in central Mexico, in around 1300 (Townsend 1999). The birth of the Mexica state was recounted by the people themselves; it can be read (though in somewhat novelistic form) in the *chronicles*, the manuscripts edited immediately after the Spanish conquest. When they reached the valley of Mexico, the Mexica founded a city, Tenochitlan, in the place, as tradition has it, that the god of war, Huitzilpochtli, had indicated by means of an eagle perching on a cactus. The city was probably founded in 1325. The Mexica were evidently highly skilled in waging war and forging alliances. Indeed, Tenochitlan, ruled over by a sacerdotal monarchy, quickly began to expand its domination throughout central Mexico. The chronicles mention a "threefold alliance" with the Chichimec cities of Texcoco and Tlacopan, on the basis of which a full-fledged empire was built. Around 1440, the Mexica empire managed also to take over extensive areas populated by Mayas. The splendid empire that Cortes conquered in 1521 with a handful of men had only existed, therefore, for less than 100 years.

The Mexica state was based on clans, or families, that had their own chiefs, protective deities, temples, and lands. There were 20 clans joined in four "confraternities"; each clan had a representative in a council that, at least theoretically, elected its supreme chief, who was practically a hereditary monarch. The economy was grounded in agriculture, using extremely sophisticated techniques, and trade; very few species of domestic animals lived there, virtually only dogs (bred as comestible animals) and turkeys. Therefore, there were no animals suitable for pulling carts in Mexico, and the lack of such animals is the obvious explanation for the fact that no wheeled vehicles have ever been found. However, it is still possible to read or hear about (now, in the third millennium) nonsense statements like "the Mexica had no knowledge of the wheel". Whatever would those Mexica children who played with their little toy dogs on wheels—today on display in the Archaeological Museum of Oxaca—think of we, the people of the third millennium, nobody knows.

The capital of the Aztec empire, Tenochitlan, now Mexico City, grew rapidly in parallel with the Mexica state, eventually becoming a splendid metropolis. The monumental center of Tenochitlan was located exactly where the center of the modern city is today. As a result, accidental finds of important Aztec monuments have been made over the years. On December 17, 1760, for example, the so-called Stone of the Sun, an enormous stone disk 4 meters in diameter and weighing 4 tons, was discovered. Now housed in the National Anthropology Museum, the stone's center contains a depiction of the sun god in the act of devouring human hearts, and it is steeped in complex, though still fairly obscure, symbolism (see, for example, Krupp 1983).

On February 21, 1978, workers on the electricity network came across another enormous stone disk, on which the moon goddess is depicted, dismembered, with two snakes coiled around her. At that point it was finally decided to try to unearth at least a few of the ancient structures buried there. Thus it was that, almost miraculously, the main temple of Tenochitlan—today called the *Templo Major*—emerged from the ground right in the heart of Mexico City, between the cathedral and the president's palace. Today it is an exciting experience to visit the temple, which is almost intact, using the chronicles of the conquest as a "tour guide".

The building was reconstructed several times, adding an outer "coat" and enclosing the preexisting temple in masonry work. This was really a renewal operation that had ritual-fetishistic significance. The temple, the true center of the Mexica universe, was left intact in its previous incarnation, which thus became the foundation (symbolic and physical) of the next stage. Each time the operation was carried out, offerings were left, and these were subsequently found and have allowed us to broaden considerably our knowledge of Aztec religious customs. It appears that the Mexica filtered autochthonous elements of the religions of those they conquered into their own religion with great ease. They clearly nurtured veneration and respect

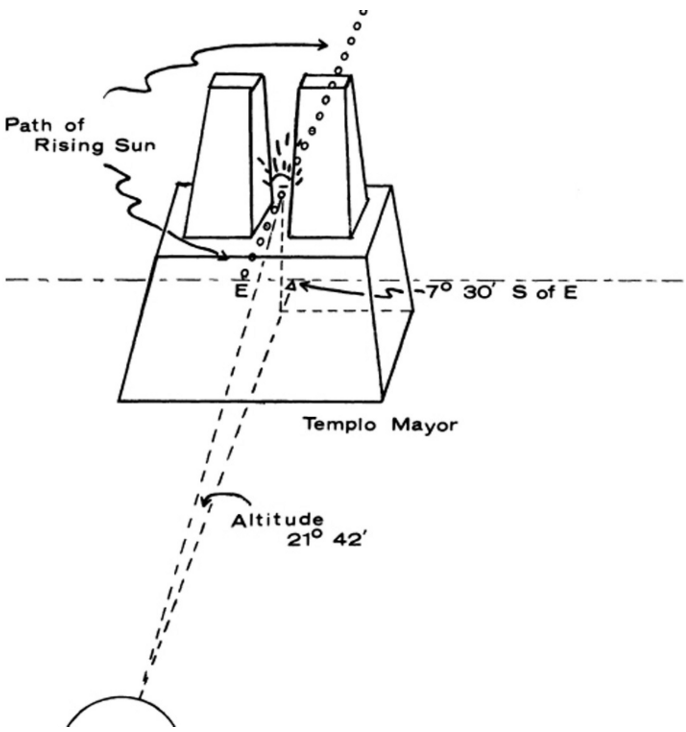


Figure 8.10: The astronomical alignment of Templo Major (from Aveni 2001, under kind permission)

for the past, as is testified to by the discovery of offerings of Teotihuacan and even Olmec masks, which were already 1500 years old when they were put in place.

The Aztec religion was steeped in Toltec elements and, like the latter, deeply rooted in human sacrifice: killings (of prisoners of war, slaves, or children) had the aim of actually "feeding" the gods in an exchange between the existence of humans and the survival of the gods themselves. Evidence of such customs can be seen clearly in the Templo Major. The temple is dedicated to the two main gods of the Aztecs, Huitzilopochtli, the god of war of tribal origin, and Tlaloc, the rain god. Two chapels devoted to them are found on top of the pyramid. Sacrifices were performed on a huge sacrificial stone, and the hearts of the victims were subsequently placed on the Chack Mool (the statue of a semireclining man, of Toltec origin), which is still in its place today on top of the temple.

One of the chroniclers, Motolinia, writes that the temple acted as an indicator for marking the beginning of the festivity known as Tlacaxipeualiztli, which took place during the equinox (and included some cruel aspects). The beginning of the feast was supposed to coincide with the rising of the sun in the middle of the temple, but, due to a planning error, this did not occur at the right moment. Montezuma, the last Mexica sovereign prior to the arrival of the Conquistadors (again according to Motolinia) was furious and wished to have the building demolished and rebuilt from scratch.

Following this account, one might expect to find the Templo Major directed toward the cardinal points, possibly with a slight error. However, the temple is oriented 7.5 degrees south of east, far too large a deviation to be the result of an error. A likely reason is that the equinoctial sun was not intended to be viewed in alignment with the upper platform itself but from the adjacent square. Consequently, the rising of the star was not observed *on the horizon* (obscured by the presence of the temple), but at a certain height, on top of the temple itself, between the two chapels. This orientation is somewhat difficult to determine since one has to take account of the trajectory that the sun completes after rising in the east, and besides, the alignment depends crucially on the height of the building (Aveni et al. 1988, Sprajc 2000a,b). Perhaps when the temple was refurbished under Montezuma it was also raised by a few meters, and this caused the error that put the monarch in such a rage (we can only guess what consequences ensued).

The Templo Major, then, is one of numerous instances where an astronomical analysis of monuments of the past can surprise us, and Mexico City still has some surprises in store for us. The temple was just one of the elements of a complex, sacred landscape, astronomically related, which is in some ways analogous to the complicated and fascinating *ceque* system of the Incas (which we shall discuss in Chapter 10). The Tenochitlan plan was articulated according to radial directions that, starting from the Templo Major, pointed toward mountains deemed to be sacred. In particular, the chapel of the god of war on top of the Templo Major was the ideal center of the city and hence of the world, from which two main axes branched out. The most important alignment was the one obtained by prolonging the main axis of the temple eastward. The line passed at the horizon, 44 kilometers away, between two mountains. One of them, dedicated to Tlaloc, was considered the home of the god of the rain and an annual feast was held there (again with some gory aspects). On its peak, at a height of over 4000 meters, there is a rectangular construction whose long access corridor points toward the Templo Major (today it is impossible to view one building from the other owing to pollution). The walls of the corridor were originally over 3 meters high, and so, on entering, one passed along a tunnel ("processional way") and could not see up to the end of the corridor and the splendid view of the volcanoes Popocatepetl and Ixtaccihuatl that dominate the Valley of Mexico.

Coming out of the tunnel into the courtyard on the top, the visitor probably was in front of a building (with walls made of perishable materials and no longer extant) in which rites associated with the end of the dry season took place. The structure of the enclosure on the mountaintop was quadripartite, like the city itself, with piles of rocks marking the four cardinal points, while on the eastern side there was a deep well, a "navel," a communication passage with the earth (Iwaniszewski 1994).

Just as rain, with its connotations of fertility, was linked with the male deity Tlaloc, so also water, flowing over the earth, in rivers and lakes, was associated with the female deity Chalchiuhtlicue.

Just as Tlaloc was linked with Mount Tlaloc, so Chalchiuhtlicue was associated with Mount Tetzcotzingo. The monuments at Tetzcotzingo were built by the sovereign of Tetzcoco (one of the great cities of the Tenochitlan league) around 1450 AD. The summit was encircled by a processional pathway that wound around its base along the entire perimeter. There were also four basins, each corresponding to a cardinal point, supplied with water from an aqueduct. The east–west axis, which followed the crest the mountain up to its peak and then sloped down again as far as this path, was marked with stations symbolizing or replicating the path of the sun on its daily trajectory. On the top there was a stone temple, of which the foundations and a number of carved images of Tlaloc remain, while other sculptures are to be found in a cave located inside the base of the hill in order to symbolize the relationship with the mountain and earth.

The Age of the Pyramids 16

> Men fear time, but time fears the pyramids.
>
> —Ancient Arab proverb

16.1 From Pre-Dynastic Egypt to the Age of the Pyramids

As we saw in Chapter 4, the sciences in Egypt in general, and in the Old Kingdom in particular, have been given rather short shrift by most scientific historians, to the extent that Neugebauer even concluded that Egypt "has no place in a work on the history of mathematical astronomy." This is, as we shall see, patent nonsense.

The fact, however, that Egypt—especially the Old Kingdom—has been largely ignored is a stroke of luck for us, a not-to-be-missed chance to test all the notions we have painstakingly acquired regarding the ancients' relationship with the heavens without being fazed by too many preconceptions. To learn about the Old Kingdom astronomy, we have to start with what we have, *everything* we have, whether objects, texts, or even monuments weighing millions of tons, such as the pyramids. Indeed, the Old Kingdom is distinctive for being what we might call the Age of the Pyramids, a short, intense burst in human history in which the most amazing funerary monuments of humanity were created. We know little about how the decision to build such grandiose monuments was made; all we can do is seek to understand how the funerary cult of the first centuries of Dynastic Egypt evolved. Before doing this, a premise is required: no pharaoh of the Old Kingdom has ever been found buried in his pyramid. (with the possible exception of Neferefre, see Verner 2002). Egyptologists blame this frustrating lacuna on the theft and desecration that took place over the centuries, though this explanation seems, at least in some cases, rather weak.

The unification of Egypt under a unique ruler, the pharaoh, took place around 3100 BC (Grimal 1994, Shaw 2004). The tombs of the pharaohs of the

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_16,

first two dynasties are to be found at Abydos, about 100 kilometers along the Nile from Luxor. These tombs, covered with small sand tumuli held in place with rough mud-brick walls, contain one or two rooms carved out of the rock, in which fairly convincing evidence of human sacrifice has been found. We do not know much about the significance of the human sacrifice in Egypt; for example, sometimes we find in funerary iconography the so-called *tekenu*—a man curled up on a sled, carried by bearers, possibly being sacrificed on the occasion of a royal funeral.

No remains of the pharaohs have ever been found in the graves at Abydos. However, in 1935, other royal tombs relating to the first two dynasties were discovered at Saqquara, not far from Cairo. These take the form of *Mastaba*—basically a large parallelepiped building, much shorter than it is wide, equipped with inner rooms and funerary chambers carved out of the rock (the Arabic word mastaba means "bench"). The rulers of the early dynasties thus had two tombs, one in Abydos and one in Saqquara. One of the two tombs (usually the one in Abydos) is called cenotaph, or symbolic tomb. Various theories have been put forward, for instance, that the double tomb denoted the duality of the king (the King of Upper and Lower Egypt). Another theory, not necessarily conflicting with the first, hinges on the fact that Abydos was the main center of the cult of Osiris, father of Horus, and also the place where Osiris's tomb was identified, a tomb equally as lacking in function as the cenotaphs. Indeed, at Abydos we find an extraordinary structure dedicated to Osiris (connected with the New Kingdom temple of Seti I, but not necessarily contemporary with it) called the Osireion, whose architectural style, characterized by enormous megalithic triliths, is much more similar to the style of the temples of the great pyramids of the Old Kingdom (a style we shall discuss shortly) than to the style of the New Kingdom.

Due to the presence of the Osiris tomb, the reason for the Pharaohs' cenotaph being at Abydos may have been connected with the very foundations of their power, which was traced back directly to a divine descendance from this God. One has indeed to bear in mind that the Egyptian state was to survive, despite various troubles (see Chapter 4), for three thousand years, and the fundamental, unifying power of this state derived from the divine nature of the pharaoh. Asserting this divine nature required, in the course of the millennia, different but equally impressive manifestations of power in the form of monuments—tombs, cenotaphs, and temples—constructed in strategically placed sites. The first such site was the Sun Temple of Heliopolis, a city located on the east bank of the Nile near the apex of the Delta, today submerged by the buildings and the airport of modern Cairo. Heliopolis was the place where the so-called Great Ennead, the cosmological doctrine that underpinned the divine nature of the monarch, was formulated. According to this doctrine, the temple marked the place of a pyramid-shaped stone, the *ben-ben* (very probably an iron meteorite). The stone was linked with sun worship, in that it marked the spot of the "first sun," which arrived in the world in the guise of a bird, the *bennu*. The "first sun" was the first God, Atum, who had created the sun, which had been incorporated with him. Adopting the appearance of a bird, he flew to the stone ben-ben, on which he perched. He then created the first divine couple, Shu and Tefnut (air and water), who in turn begat Geb and Nut (earth and sky). And so the world was created. From Geb and Nut came forth Seti, Nephthys, Osiris, and Isis, the latter two being the parents of Horus. Since the pharaoh credited himself as the living Horus, the royal power was directly resting on the descent from the Gods.

16.2 The Step Pyramids

The building of the first pyramid in Egypt is attributed to the first pharaoh of the third dynasty, Djoser (around 2680 BC), who commissioned his mortuary complex at Saqquara. The project probably kicked off with the construction of a large mastaba, but then underwent various additions and adaptations until it became a sort of giant funerary town 544 meters long and over 270 meters wide, enclosed by a wall over 10 meters high and dominated by the construction today called Step Pyramid (for a comprehensive, up to date reference on Egyptian pyramids see Lehner 1999, Verner 2002).

The Step Pyramid is a magnificent artifact, erected on the base of the preexisting mastaba with the addition of successive terraces, thus similar to Mesopotamian ziggurats, but without their ascending ramps. Sixty meters tall, the pyramid is "filled" (i.e., it has no interior spaces), but it stands on a maze of underground chambers carved out of the rock, connected by long corridors. Apart from the pyramid, the complex boasts large storehouses, in which thousands of stone pots have been found, and numerous other curious buildings, full of narrow rooms, false doors, half-columns, and stone decorations imitating analogous wooden structures. The most curious of these structures is possibly the "T Temple," whose function is unknown but which may have been connected, together with the southwest wing of the complex, with rituals relating to the *sed* festival, during which the pharaoh would symbolically reassert his rights over the kingdom. On the north side of the pyramid we find a small, completely sealed building, which contains a statue of the pharaoh (today replaced with a copy). It is the chamber known as the *serdab*, which was designed to accommodate a statue of the deceased

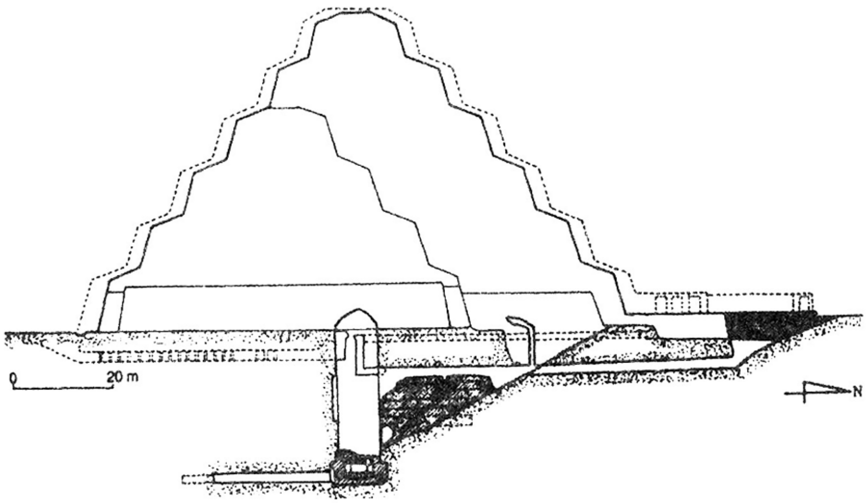


Figure 16:1: Section of the Djoser Step Pyramid, with the subsequent construction phases according to Lauer.

(this was mentioned in Chapter 4, and will crop up again later). The south side of the complex houses a second mausoleum, whose internal layout resembles that of the underground maze of the pyramid, even though the main chamber—made of slabs of granite—would appear too small to contain a coffin. The mummy of Djoser, as with all the other pyramid owners of the Old Kingdom, has never been found in his pyramid, or anywhere else, for that matter. The design of the Step Pyramid has been imputed to the genius of the royal architect Imhotep, whose seal appears in the inscription at the base of the statue of the pharaoh in the Serdab. Imhotep himself was deified at a later date, yet we know little about his tomb, which has never been discovered, in spite of numerous efforts to locate it.

It is difficult to determine who succeeded Djoser, since the royal lists do not agree, and there is still debate about the sequence of the third dynasty pharaohs (the problem of dating the Old Kingdom dynasties is compounded by the fact that there are no astronomical anchors to tie them to the Sothic cycle; see Chapter 4). However, we are aware of two other step pyramids attributable to two pharaohs who came after Djoser. The first stands at Zawiet el Arian and is traditionally called the *Layer Pyramid*. It is of uncertain attribution and has been poorly studied. The second is probably the burial place of the Pharaoh Sekhemkhet, and provides one of the most fascinating (and unfortunately also sad) enigmas in all Egyptological studies.

Sekhemkhet's funerary complex is situated near Djoser's, but was

Figure 16.2: The Step pyramid

unearthed only in 1951, by the Egyptian archaeologist Zakaria Ghoneim. It had not been discovered earlier because the pyramid was unfinished (with maximum height of about 8 meters) and was completely submerged in the sands (Ghoneim even thought that the entire complex had been intentionally buried in ancient times). Although the pyramid, whose base side measured roughly 120 meters, was merely hinted at, the underground part had been dug out entirely, creating a room 32 meters deep in the bedrock. When Ghoneim penetrated the chamber, he beheld a magnificent alabaster coffin. It appeared to be intact, still sealed by a sliding lid, and on top of it lay the remains of a floral wreath, which someone had laid there almost five thousands years before. Thus Ghoneim was faced with the real possibility of finding, for the first and only time in the whole history of Egyptology, the body of a pharaoh entombed in his own pyramid. Unfortunately, he had the idea of inviting journalists and local dignitaries to attend the great moment of the opening.

Egyptologists seem to be tragically fated never to find the bodies of pharaohs in their pyramids. It seems that Sekhemkhet's pyramid was the last left to explore, and the alabaster coffin turned out to be completely empty. Ghoneim then went on to insist that the coffin was a ritual burial place and that Sekhemkhet's corpse would be found somewhere else in the complex. Alas, however, the great but ill-starred Egyptian archaeologist was to find himself victim first of considerable envy and then of the most bitter sarcasm. He was also the subject of unjust accusations regarding the disappearance of some finds—all of which culminated in his suicide in 1959 (the south tomb of Sekhemkhet's pyramid was in fact discovered in 1966, as empty as the other one, though).

16.3 Meidum

In the period at the end of the 27th century BC, encompassing the reign of the last pharaoh of the third dynasty, Huni, and that of his successor, the first pharaoh of the fourth dynasty, Sneferu, we may place the construction of a building that has always been seen as marking the transition from the step pyramid to the *geometric* pyramid, that is, the one with smooth sides.

This structure, the *Pyramid of Meidum*, is located about 100 kilometers south of Cairo. Today it looks like an enormous three-story tower, almost 65 meters tall and 144 meters wide at its base. However, what we have here was originally a step pyramid, built—at least according to probes carried out—with concentric layers, one leaning on top of another. It was subsequently transformed into what is believed to be the first geometric pyramid, with a gradient of 52 degrees. As is clear from the present condition of the monument, surrounded by a mountain of debris, the last tier collapsed, or was eroded, revealing the innermost parts. Nobody has so far been able to determine if the collapse occurred at the time of construction, perhaps due to the changes in the project, or at a later date as a result of the building being utilized as a quarry with handy ready-for-use stone blocks. In any case, I am somewhat skeptical about the idea that the design was based on accretion layers and that it was altered during the construction, and I think that a new analysis of the monument would be worthwhile.

In fact, the inner structure of the Pyramid of Meidum was unquestionably planned right from the start to be able to support the huge weight of the monument above. This was, indeed, the first time that a pyramid was built on the basis of "above ground–underground" connecting structures, that is, structural elements aimed at connecting the underground rooms with the pyramid mass above. Before Meidum, the underground chambers were excavated completely in the rock, as well as their entrance passages and pits. In Meidum instead only the "box" of the funerary chamber was excavated at ground level, while the ceiling was constructed above ground. The chamber is accessed via a passage (called *descending passage*, from the point of view

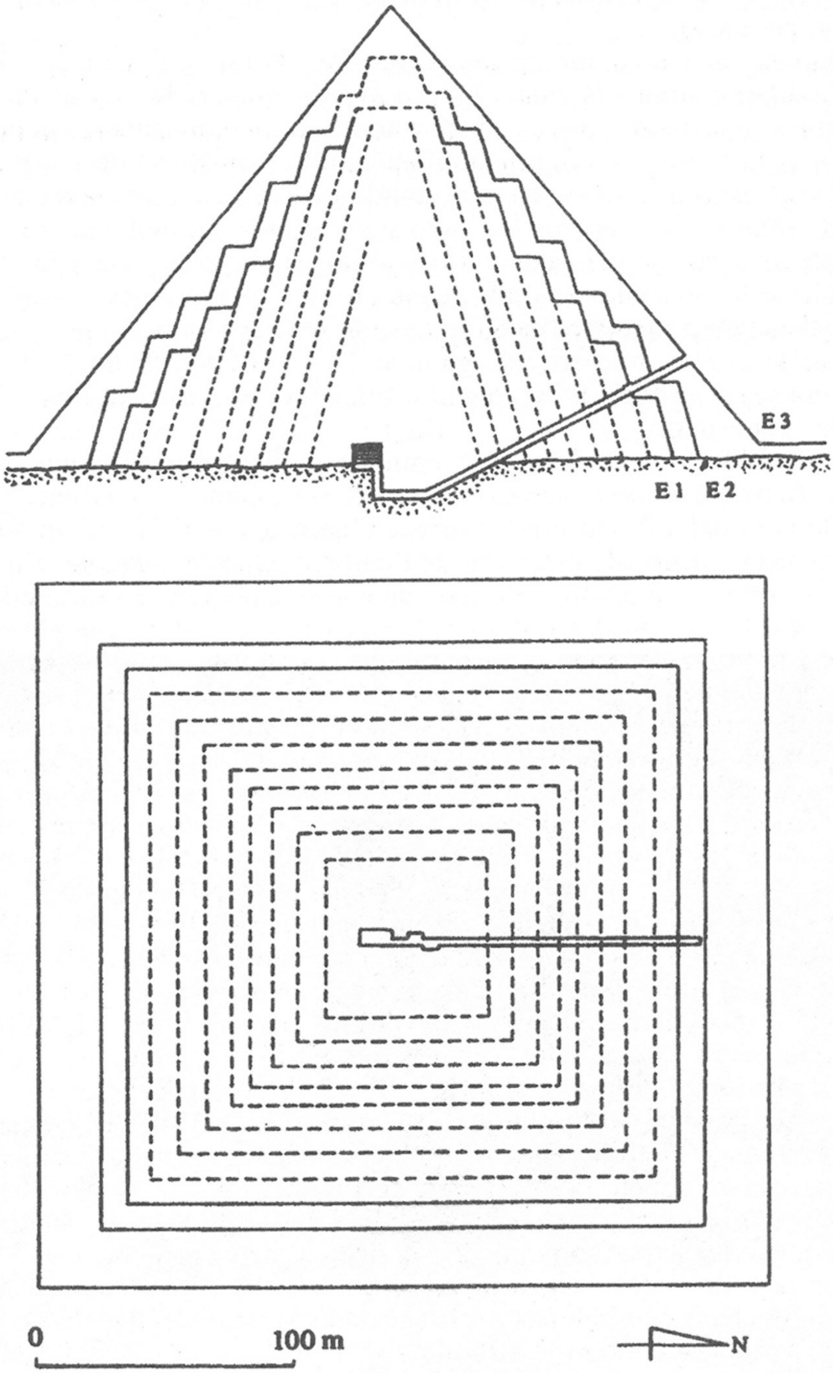


Figure 16.3: Section and plan of Meidum pyramid according to Burkhart

of someone entering), which goes down starting from the north face at a height of about 15 meters, thus crossing part of the building diagonally. Therefore, both the ceiling of the chamber and the descending passage are elements that, from an architectonic point of view, act as connections between the internal arrangement and the mass of the pyramid that stands on them.

These two elements were to become a popular feature in all pyramids of the fourth dynasty, only to disappear again under later dynasties. Their appearance usually passes nearly unnoticed, but they are a far from negligible component. One has to remember that it is much simpler creating "filled-in" pyramids, making descending passageways and rooms only in the *substructure*, by digging into the rock below the building, than building inside rooms (with the risk of collapsing ceilings) and, even worse, sloping corridors. To make a passage that crosses the pyramid diagonally, one has to prevent not only the roof of the passage from caving in, but also the sloping walls from *sliding down*.

The ancient Egyptians solved the problem of "relieving" the massive weight from the ceiling by means of inverted V-shaped vaults or using corbeled vaults, and both these two solutions appear in Meidum. To have a clearer picture of how they work, let's imagine the ceiling of a room like the shelf of a bookcase. If we overload it with books, it warps and risks breaking in two, toppling all the books onto the shelf below. To avoid this, we must "transfer" the vertical weight of the books to the sides of the bookcase. There are two ways to do this. The first is to arrange two identical wooden axes, forming an angle (an upside down V) in the center of the shelf and then cover it with books. The second is to arrange short wooden axes in succession, each projecting over the other, so that the upper one sticks out a bit in relation to the lower one (this is the technique known as corbeling). For unclear reasons, in some cases the vaults were executed directly in the main rooms while in others the Egyptians built service chambers above the ceilings to house these structures, which were sealed when complete. Today these spaces are usually called, questionably as we shall see in more detail later, *relieving chambers*. Famous examples of this kind of structure are in the Khufu pyramid, but recently relieving chambers have been discovered at Meidum too (Dormion and Verlhurst 2000). This is a system of rooms running along above the horizontal length of the inside passage up to the point of contact with the funerary chamber. The rooms were not entered physically by the discoverers, but accessed by means of little holes into which a fiberoptic video camera was inserted. Unfortunately, few details of this research have been reported. In any case, the finds in the Pyramid of Meidum have shown for the first time incontrovertibly—whether the uncovered rooms are really relieving chambers or have a more complicated significance—that the odds of finding undiscovered rooms in the pyramids, though difficult to credit, nevertheless exist.

The Pyramid of Meidum is ultimately a complex, sophisticated engineering work. Its internal structure shows no signs of sagging or of any experimenting or afterthought on the part of the builders, and stands nearly intact, 4700 years after construction. Furthermore, we do know that a relevant part of it has never been accessed since then. The afterthoughts about its construction, if indeed there were any, only related to the size and the external shape.

Who commissioned the construction of this pyramid? Its construction must have taken place during the reigns of Huni and Sneferu. But the names of Huni or Sneferu (or anyone else) do not appear anywhere on the building, or if they did, they have been scrubbed off. So it is a monument without a owner; attribution to Huni, the last pharaoh of the third dynasty is purely hypothetical, while the attribution to Sneferu is based on Middle Kingdom inscriptions (hence many centuries after Sneferu), found in a small building on the east side of the complex, which is most likely the first example of a mortuary temple associated with a pyramid. It has a somewhat strange plan, consisting of a S-shaped corridor, which leads to a courtyard containing two monolithic stelae.

In the 1970s, a theory regarding the Meidum pyramid was proposed by the physicist Kurt Mendelssohn (1974), which generated considerable debate. He claimed that the construction of a pyramid should not be associated with any single pharaoh. He argued that, on the contrary, pyramid building was a continuous process. Each time a pyramid neared completion, another pyramid was begun, thus keeping the mass of farmer/laborers busy during periods of inactivity when the Nile had flooded. The pyramids were thus, according to Mendelssohn, a sort of mandatory public service that acted as social "stabilizer." Mendelssohn conjectured that the outer part of the Meidum pyramid had collapsed suddenly while its conversion to smooth-faced geometric pyramid (with the incorporation and covering of the steps) was reaching completion. The builders, Mendelssohn alleged, who were already at work on the their next project, the Bent Pyramid at Dashour (see next paragraph), blamed the collapse at Meidum on the excessive inclination, and therefore resolved to "soften" the slope of the other pyramid under construction, thus creating its bend.

I do not endorse Mendelssohn's theory. Today indeed we are quite certain, thanks to important excavations in the workers' quarters, carried out by Mark Lehner (1999) and Zahi Hawass (2006) at Giza, that the pyramids were not constructed by massive hordes of slaves or peasants, but rather by a reasonable amount (say 10,000) of well-nourished, well-cared-for, skilled workers, which refutes the social stabilizer theory. Mendelssohn's approach is interesting, nonetheless, since it shows that our knowledge is often so fragmentary and uncertain that it does no harm to put forward reasonable new hypotheses regarding Old Kingdom pyramids—hypotheses, of course, that must be tested in the light of known facts.

I shall propose one to you at the very end of the book.

16.4 The Geometrical Pyramids

If the widely accepted chronology is to be trusted, the first geometric stone pyramids were constructed at Dashour, immediately after the Meidum pyramid, by Sneferu. Abruptly, thus, around 2600 BC, Egyptian architects set about building with successive, horizontal courses of heavy blocks of stone. They erected five—two at Dashour and three at Giza—and began two others, one at Abu Roash and another at Zawyet el Arian, that were never completed. And then they simply stopped. All subsequent pyramids are greatly inferior, not just in size but, more importantly, in the quality of workmanship (for this reason they are in very poor condition today).

Describing one of the five geometrical pyramids is relatively simple. The basic structure is simply a series of layers of large limestone blocks (normally the size of three washing machines put side by side) weighing 2 to 3 tons, laid one on top of the other and fixed with mortar. The layers were tiered so as to create a fixed gradient, and once this nucleus had been completed, the pyramid was covered with a casing of slim limestone blocks, sculpted in such a way as to look smooth. Unfortunately, many of the blocks forming the casing were removed, probably during the Middle Ages, and today the unique nearly intact casing is that of the south pyramid at Dashour; at Giza, we have left a few blocks around the top of the second pyramid, and a huge block on the north side of the Khufu pyramid (the casing of the Menkaure pyramid is discussed below). The pyramids had no underground foundations, and the only expedient used when beginning the layering work was the digging of a ditch in the rock to accommodate the first course. In some cases, however, preexisting natural features were incorporated into the lower layers to make them more stable (examples of this can be found in the core of the first Giza pyramid and in one corner of the second).

Ramps must have been used to move the blocks when working up high, although it is unclear what kind of ramp or combination of ramps was used. But it would not have been possible to use a single, straight, external ramp

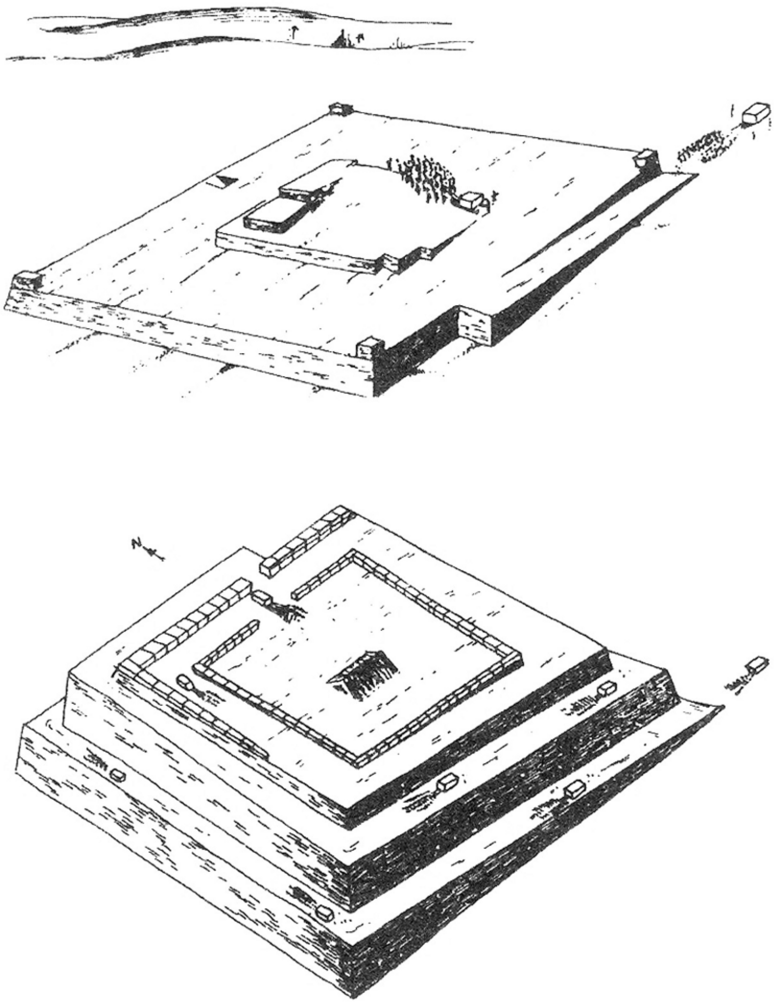


Figure 16.4: A reconstruction of the building site of the Great Pyramid (the dimensions of the blocks are exaggerate however).

for carrying materials to the top, which would then have needed be lengthened and raised as the work progressed, because the ramp would have been an engineering feat comparable to the building of the pyramid itself. A more likely possibility seems to be a spiraling ramp or a zigzagging sloping surface, partially covering the pyramid itself during construction. The French architect Jean Pierre Houdin even suggested that the spiral ramp of the Great Pyramid may have been internal, a kind of tunnel made inside the structure, which should therefore be still in place, over a kilometer long and probably still practicable. However, the whole length of the corridor suggested by Houdin would have had to be relieved from the weight of the huge mass above by the building of an inverted V-vault, also a kilometer long. I thus believe that we are still far from understanding exactly how the pyramids were built.

The unit of measurement used in Egypt, since the Old Kingdom, was the *cubit*, equal to 52.5 centimeters (a splendid example of a cubit, covered in gold, can be seen in the funerary work of the architect Kha, today at the Egyptian Museum in Turin). We prefer to work and think in integer multiples of a meter, and similarly the Egyptian architects thought in terms of integer multiples of a cubit. As a result, almost all the measures of the pyramids can be written as integer multiples of a cubit. However, I shall continue to use the meter to keep things simple.

Pyramid construction necessitated the solution of numerous geometrical problems, although the Egyptians only had to make *implicit* use of trigonometry, since they regularly used ratios between integers. In particular, to define the tangent of an angle (i.e., the ratio between sine and cosine), and therefore the slope of a pyramid, the architect only had to give the legs of a triangle as integers. For example, the tangent is 14/11 for the pyramid of Khufu and 4/3 for the pyramid of Khafre. In this way, to cut the casing blocks with the correct angle, the quarrymen did not have to use the cubit. For Khufu all they had to do was to count 14 (arbitrary) units vertically for every 11 of the same units counted horizontally. It was even easier for the pyramid of Khafre because the triangular section of the casing blocks formed a Pythagorean triangle with all integer sides 3-4-5 ("sacred triangle"), thus the hypotenuse could be checked immediately by counting five units on it (in many publications about the Great Pyramid it is noted that, due to the 14/11 slope, the ratio between the base perimeter and the height is 44/7, a number which coincides with 2π up to the third decimal; this fact has given rise to a series of theories, including a famous one claiming that the pyramid was conceived of as a model of a sphere and, by analogy, as a model of the earth, which are nothing but sheer nonsense).

All casing block cutting operations, probably effected with copper saws and abrasive sands (the limestone used is not particularly hard, so this method is effective), were in any case carried out with the utmost care since any unevenness of corners, however minimal, would accumulate in such a way that they could not be remedied retrospectively. It is likely indeed that the pyramid was only partially visible during the building work, since it was enveloped in ramps. It would thus emerge, like a jello from a mold, only when all the support apparatus was dismantled. The trickiest problem of all was undoubtedly the cutting of the corner blocks, that is, the casing blocks placed on the corners of the pyramid, joining two faces. To see how tricky this is, try drawing one of these blocks and calculating its measures; it is quite an instructive exercise.

Each pyramid had it own name; for example, the Khufu pyramid was called *the Horizon of Khufu*. We know these names from inscriptions that do not date from the time of building, but from a somewhat later date; in particular, relevant inscriptions are to be found in the mastaba of Qar, an important royal functionary at the time of Pepi II, about 200 years after the construction of the third pyramid of Giza.

Pyramids were fitted with architectural "annexes" that began to appear at Dashour and became standard at Giza. There were other much smaller pyramids, including queens' pyramids—though not all of them have inner rooms suitable for housing a sarcophagus, and no mummies have ever turned up in any of them—and the tombs of dignitaries and kinsfolk of the pharaoh who were hoping to participate in his rebirth. On the east side of each pyramid, a structure known as the "funerary temple" was erected. It was connected by a causeway, that is, an elevated monumental path several hundred meters long, with another structure, the "valley temple," normally located at the outer edge of the Nile flood plain or on the shore of an artificial lake linked by canals to the river, allowing convenient arrival by boat. This also facilitated the transport of building materials to the site and perhaps also the approach of the royal funeral. These temples and causeways were architectural masterpieces in their own right; the complex in best condition today and also the most celebrated and studied is the one surrounding the second pyramid of Giza.

To summarize, building a pyramid entails excavating limestone blocks, transporting to the site, and placing them one on top of the other. But doing this for 2,200,000 blocks, as with the Khufu pyramid, requires teams working in shifts for 24 hours a day for 365 days a year, excavating, transporting, and laying one block every 5 minutes, if it was to take the 20 years traditionally attributed to the construction of the monument; simultaneously the workers also had to slave away on the construction of two megalithic temples, made of blocks weighing hundreds of tons, as well as a causeway stretching several hundred meters.

Listing all the problems they had to face in order to bring off such a feat would be too much of a digression here. It will suffice to mention that to do similar demanding work today using electric machinery, we require a similar length of time and equally enormous organizational and technical efforts. As for the pyramid builders, we are still very far from knowing how they solved their problems; we only have some hypotheses, which would have to be tested seriously, not in the haphazard way of some recent debatable satellite television ventures (about which I will say no more).

16.5 Dashour

The Dashour site, although being open to public and easily reachable, some 40 kilometers south of Cairo, is usually not on the route of most guided tours, so one can even have the chance of visiting two of the most important monuments in human history in the dreamy peace of the desert and, believe me, it is an unforgettable experience. These two monuments are the great stone pyramids named the Bent Pyramid (south Dashour) and the Red Pyramid (north Dashour) (Plates 27, 28).

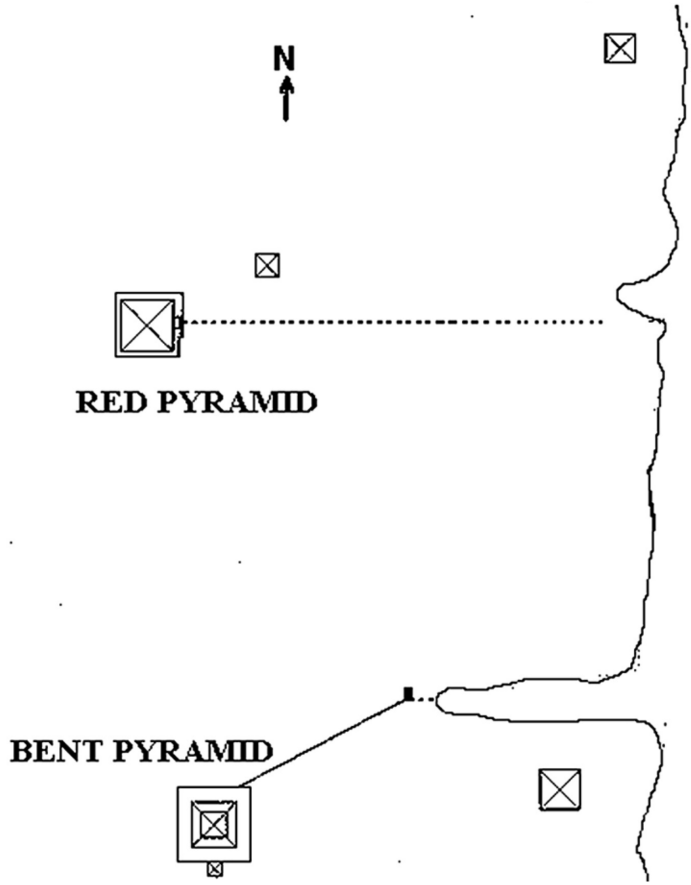


Figure 16.5: A plan of Dashour. The pyramids not labeled are mud-bricks pyramids of the Middle Kingdom.

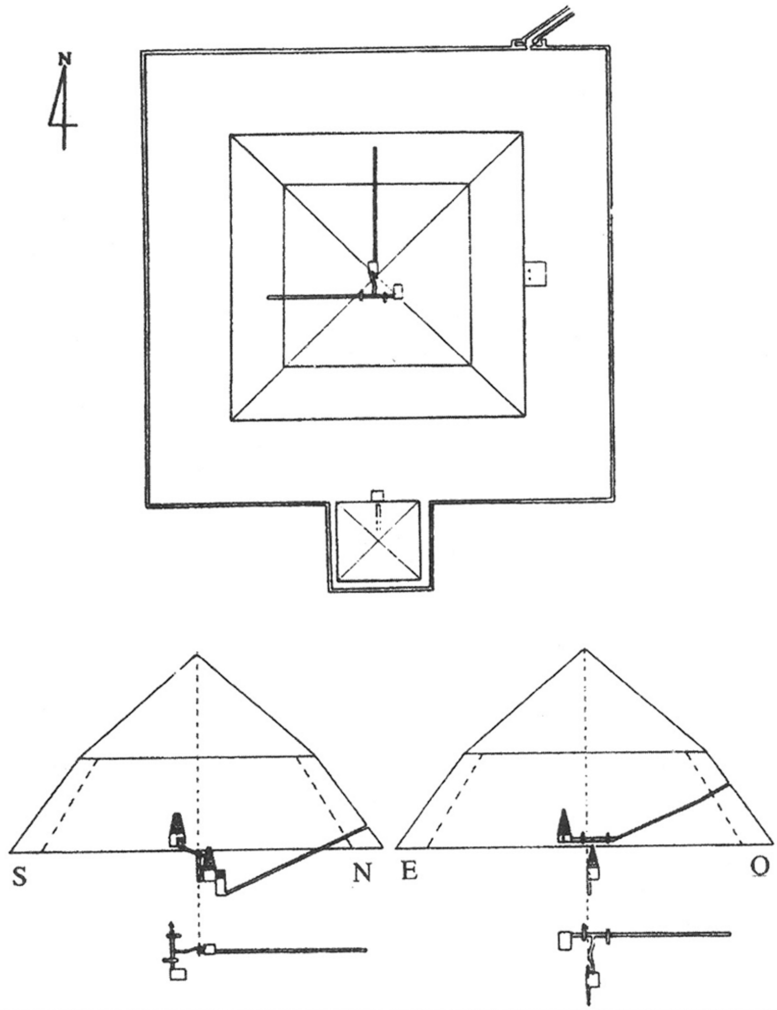


Figure 16.6: Plan, N-S and E-W sections of the Bent Pyramid.

The Bent Pyramid owes its name to a sudden softening of its inclination, which was effected when the construction had reached 49 meters (the initialinclination of 54°3′ drops to 43°21, thus forming an angle in the pyramid's profile). It is rarely shown in documentaries on the pyramids, and when it is shown, it is presented as an example of an imperfect pyramid, as if it were a botched job or a stage of evolution toward the perfection of the Giza pyramids. Some Egyptologists have even dubbed it the "failed pyramid" (Romer 2007). Of course, I do not agree.

The Bent Pyramid is one of the ten largest and heaviest objects ever created by mankind throughout history. It has a 189-meter-wide base and is

105 meters tall, similar to a modern skyscraper of over 30 stories, and I consider it to be an object of quite unique beauty and charm. Among other things, the slim limestone casing blocks were skillfully arranged to jut out—the only instance of this in Egypt (only the Greek pyramid of Helleniko, in the Peloponnese, is remotely comparable (Liritzis et al 1997, Liritzis 1998)). The result was that the casing was so solid that medieval quarrymen abandoned attempts to remove it, so the Bent Pyramid is the only pyramid that can be seen today as *all* must have looked at the time of their construction—smooth.

The north pyramid of Dashour, or Red Pyramid, owes its name to the reddish hue of the limestone used to build it. It, too, is rarely seen in documentaries on pyramids, and if it is, it is usually shown in long shot without any frame of reference, so it is impossible to grasp how enormous it is. It measures 218.5 by 221.5 meters (the base), is 104.4 meters tall, with a gradient of 43°36', virtually identical to that of the upper section of the south pyramid.

The two Dashour pyramids are relatively far apart (about 1850 meters) and are not on the same meridian (the distance between the meridians passing through the tips of the pyramids is about 300 meters). The Red Pyramid is also so far from the Nile flood plain that a 2-kilometer-long causeway would have been needed (it was never completed). These facts

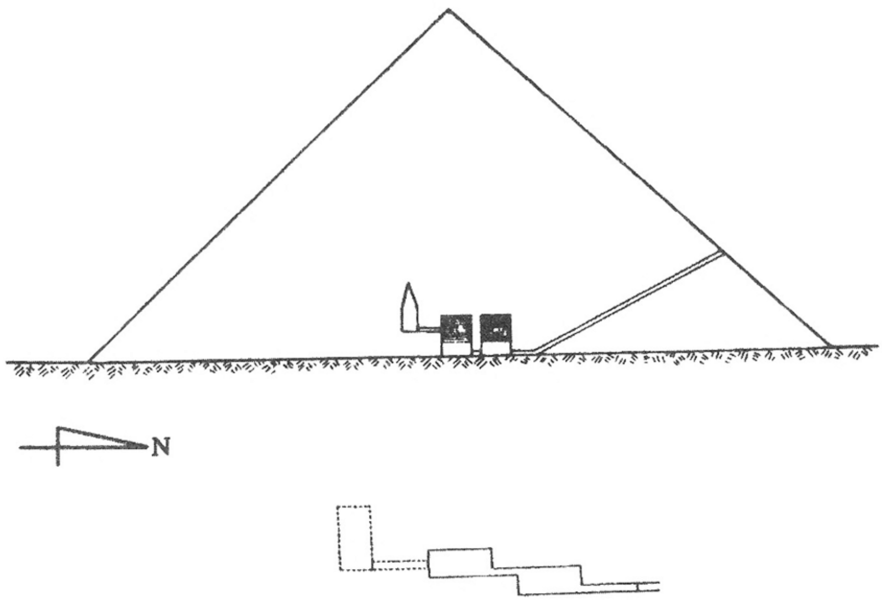


Figure 16.7: Section and plan of the Red Pyramid

would appear to warrant an explanation. The distance between the two complexes (as well as from the river) entailed long and laborious modification of the roads along which materials were transported, and the provision of new workers' quarters, a series of logistical difficulties that might have been easily solved by the simple expedient of building the two pyramids nearby and on the same meridian, a possibility that would not have been hindered by any particular geo-morphological factors. The situation becomes even more incomprehensible if we consider that the two complexes seem to have been built by the same pharaoh, Sneferu (predecessor and father of Khufu). This attribution is based on the discovery of quarry marks, that is, indications in hieroglyphics painted on some of the blocks of the Red Pyramid specifying quarry teams (and hence the provenance of the blocks) and assisting in their positioning. These marks bear Sneferu's name and year of rule (to be precise, the "year of the ox count," which took place every two solar years); Sneferu's name is also alleged to appear on an inscription in the Bent Pyramid.

The pyramids of Dashour, like all the others (with the exception of the Great Pyramid of Khufu; see below) have no internal spaces above ground level, apart from the descending passage with access at a certain height on the north side. The passage proceeds until it meets the bedrock and is joined, below the pyramid, by a passage of the same dimensions that gives access to the subterranean chambers (or rather semi-subterranean, in that the ceiling of the chamber is typically at ground level), which most probably contained the pharaoh's sarcophagus and funerary accessories (which were never found). The Bent Pyramid (a one-off project) contains another copy of these funerary apartments (as well as, possibly, yet undiscovered conduits, since various accounts indicate the presence of an airflow of unknown origin inside the pyramid). One of the two apartments is accessed, as in all other pyramids, from the north side, while the other is accessed from the west side (the two chamber systems are linked only by a narrow tunnel); corresponding to the base center, a "chimney" of unknown function can be accessed from the northern set of chambers.

Thus we have three tombs—one in the Red Pyramid and two in the Bent Pyramid—available for Sneferu at Dashour. It is unclear why Sneferu was so obsessed with the afterlife. Generally, it is believed that the Red Pyramid was the real tomb and was erected because the Bent Pyramid became structurally unstable during its construction, the chief reason for it being branded as "failed." The generally accepted chronology is as follows:

1. The Meidum pyramid collapsed (or rather, "eroded," since the core structure remained intact, as did the inner chambers) and was abandoned.

2. Sneferu moved the building site to Dashour and began the construction of the Bent Pyramid.
3. The Bent Pyramid was in danger of collapsing, so the gradient was softened.
4. It was decided to build a new pyramid anyway, the Red Pyramid, with the same gradient as the toned-down section of the Bent Pyramid.

However, there is no convincing proof that the gradient of the south pyramid was modified because it was thought to be in danger of subsiding. This is the situation today: the casing has a number of cracks, many of which were patched up in ancient times; some foundation stones are also badly cracked. Nevertheless, the structure is completely stable, which means that the cracks must have appeared during a sudden and rapid self-rearrangement; all the inner rooms remained standing and they are perfectly sound and accessible 4500 years after being built. There are no significant signs of subsidence, although in some rooms we can see cracks that were enameled over in ancient times (in others cedar beams are visible, which have sometimes been incorrectly interpreted as wedges put in place by the builders to prevent collapse). The only clear sign of any serious structural problem can be seen in the downward corridor, about 10 meters from the entrance, where there is a quite striking rift, which indicates that a slip of a whole external "mantel" of blocks must have occurred there.

All in all, I agree with the Italian scholars Vito Maragioglio and Celeste Rinaldi (1966) that what really transpired in the pyramid was a displacement of the entire upper casing of blocks within the overall structure (many thousands of tons shifting and sliding altogether). The blocks, however, rearranged themselves immediately into a new position of equilibrium, and this movement produced the great fissure mentioned above. The corridor had been built so ably that it stood up to the displacement, and the inner apartments today are still quite sound. We do not know when this movement occurred, and I would not even be too sure that it happened before the builders decided to alter the slope, and that therefore the movement itself was the cause of its modification. Indeed, it is illogical to think of stopping a collapse by reducing the weight that *still* has to be added. Clearly, the builders knew how to calculate the volume of what they were building. Thus, they knew that the ratio between the volumes of two pyramids with the same base side is equal to the ratio between the tangents of their respective angles of inclination. Applying the formula with the two angles of inclination of the Bent Pyramid, we find that this ratio is 2/3, which means that the reduction in the weight that was added compared to that anticipated—assuming for argument's sake that the original design did not already envisage the change in the gradient—was only a third (the volume of the pyramid is about 1427 million cubic meters, whereas the volume it would have had if it had been completed with the original inclination would have been about 1556 million cubic meters). It is therefore extremely doubtful whether there is a relation of cause and effect between the problems of static that the pyramid effectively faced and the change of slope.

Besides, this theory does not answer the following questions:

1. Why did the Bent Pyramid have two funerary apartments?
2. Why was it decided to abandon the Bent Pyramid, even though its stability (exactly as it is today) must have been quite obvious once the building had been finished?
3. Why was the Red Pyramid built so far from the Bent Pyramid? And why was it not built on the same meridian?

Curiously, the problems raised by the pyramids of Dashour are so complicated that we might be tempted to be satisfied with the few things which look sure, though they are not actual fact. Indeed, even the relative chronology of the two pyramids is far from certain; in other words, we cannot even say for sure whether the Bent pyramid was constructed before the Red or not. According to the literature, dated quarry marks are found only on the Red Pyramid, while the Bent Pyramid has been attributed to Sneferu on the basis of an undated royal cartouche. It might be thought, then, that the Red Pyramid was built first and that, afterward, the desire to try out a steeper inclination led to the Bent Pyramid. In the light of the famous structural problems, the architect at this point would have gone back to his original tried-and-tested slope for the completion of the monument.

This is an alternative, technical explanation for the double gradient. I have cited it to demonstrate how difficult are the problems in studying such magnificent monuments. I think it more likely that the real explanation for the riddles of the Dashour complex are to be sought at a more symbolic level however. I believe that the sacred landscape of Dashour was devised and executed according to a design that, far from being the incoherent patchwork job cobbled together by vague, illogical architects that some Egyptologists would have us believe, was planned in a uniform fashion. What particularly arouses suspicion is the duality apparent in the site—two enormous pyramids, two slopes, two funerary apartments in the south pyramid— prompting some scholars in the past to suggest that the pairing represents, yet again (as in the case of the "double tomb" of previous dynasties), a tribute to the tradition of the Pharaoh as the ruler of unified Upper and Lower Egypt.

16.6 Giza, Abu Roash, and Zawiet el Arian

The greatest and most sophisticated monuments that man has ever dared to build are the pyramids of Giza. To avoid needless complication, in this chapter I shall follow the commonly accepted chronology and pretend that the traditional pairings of these pyramids with their pharaohs, and the chronological sequence of the buildings, are all accurate. But I shall return to this subject in Chapters 18 and 19.

According to the conventional chronology, then, Khufu, son and successor to Sneferu, moved the location of his own pyramid from Dashour to Giza, for unknown reasons. At Giza he built the largest stone pyramid as well as one of the largest buildings ever constructed on earth, in terms of material displaced. It is outstripped only by the Pyramid of Cholula (Chapter 7), but that is made of mud bricks, not stone; no modern building even comes close to either of these two in terms of the sheer quantity of material involved (Plate 29).

The successor to Khufu, Djedefre, commissioned his own pyramid, never completed, at Abu Roash, a hill northwest of Giza. Then Khafre and Menkaure returned to Giza. Another unfinished pyramid stands south of Giza at Zawiet el Arian (different from the Layer Pyramid already discussed). Its owner is unknown, but judging by its style, size, and building techniques, it is certainly of the same period.

When the pyramid of Khufu, or Great Pyramid, comes up in conversation, some bright spark never fails to remind us that it is the only surviving exemplar of the "seven wonders of the world." It is unclear why this rather banal idea of the seven wonders has had so much hype (its source is not clear, since it is supposed to have originated with a certain Callimachus of Cyrene, third century BC, but his work, "Collection of Wonders," has not come down to us, and the list first seems to have been drawn up by Antipater of Sidon about a century later). But the Great Pyramid *is*, in all respects, a real wonder:

1. Its base sides measure on average 230.35 meters with maximum deviation between the measures of different sides of less than 20 centimeters.
2. It has a slope of 51°51′, from which it can be deduced that the original height (the top is missing today) was 146.6 meters. The pyramid was thus as tall as a 40-story skyscraper.
3. The orientation of the sides to the cardinal points is with a precision on the order of 3 arc minutes, that is, a 20th of a degree.
4. Its core consists of 210 courses of limestone blocks piled on top of each

other, making a total of no less than 2,200,000 blocks (a small rocky outcrop was incorporated into the first layers of blocks, making it difficult to determine exactly the volume of stones employed).

As a matter of fact, the Khufu pyramid, like its quasi-sister Khafre, is an artificial mountain. It is as if someone had wanted to extract a mountain from the rock of the Giza plateau, to then reconstruct it above ground.

The casing, which helped to make it geometrical and hence smooth, consisted of scores of thousands of huge limestone slabs (from the quarries at Tura, on the opposite bank of the Nile). Almost all of these casing blocks were removed in the Middle Ages and used in the building of the Cairo Citadel. One can have a vague idea, however, of what a colossal feat the casing of the pyramid must have been by looking at the enormous block that has miraculously remained in position at the base of the pyramid on the north side.

Unlike all the other pyramids (which, as we have said, lack an internal structure above ground), the Great Pyramid is a "building," in that it has corridors and rooms. These were created during the construction, just at the moment when the work had progressed to the appropriate layer of blocks; once the new tier had been laid, it was impossible to go back and create further internal spaces, so they had to be planned meticulously before reaching the height at which they were envisaged.

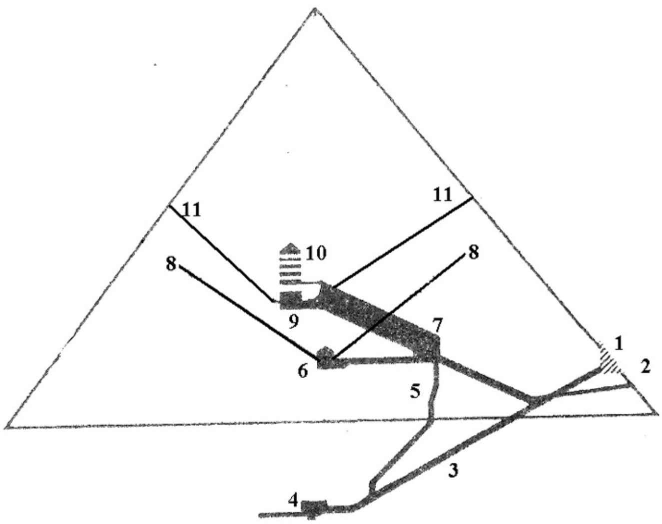


Figure 16.8: Section of the Great Pyramid. 1) Original entrance 2) Mamun's hole 3) Descending corridor 4) Subterranean Chamber 5) well shaft 6) Queen's Chamber 7) Great Gallery 8) Lower shafts 9) King's chamber 10) "Relieving Chambers" 11) Upper shafts

Entering the Great Pyramid from the original entrance on the north face, we come into the descending passageway (today access is by a slightly lower passage, possibly hewn out by looters in the Middle Ages and known as "Mamun's Hole"; see below), which leads to a chamber carved out of the bedrock, called the Subterranean Chamber. Egyptologists consider this chamber to be incomplete. In fact, it was never dug out completely; the last part was only excavated to half its presumable height, with a central passageway.

Halfway down the descending passageway, an ascending passageway veers off, but it is blocked off since the time of construction by a "plug" made of huge blocks of granite. "Mamun's hole" was actually a way of getting around the plugs (it is not known how they managed to work out the right direction and height) and so today one goes through the "hole" and comes out the side of the plug blocks. It is thus possible to see in cross-section the unique arrangement of the passages, with the downward passage penetrating the living rock and the upward passage disappearing from view up above. The passage rises with a gradient of 26 degrees for 39 meters inside the pyramid, before continuing horizontally for another 36 meters and emerging in a second chamber, which is also, like the subterranean chamber, on the vertical axis of the building and measures 5.74 by 5.2 by 6.2 meters. It is convenient to use the traditional terminology, and so I shall call this room the queen's chamber, but it is universally accepted that the room had nothing to do with any queen. The chamber has a projecting corbeled niche (with blocks sticking out a bit one on top of the other) on the east wall; otherwise it is totally anonymous. Two little openings, each the size of a handkerchief, are visible on the north and south walls respectively, though. These openings give access to narrow, square-sectioned shafts, which, after a brief horizontal stretch, veer upward diagonally. One has a strange sensation looking inside these shafts, as if they were pneumatic dispatch tubes, not designed for transit (only a hamster would venture in), but for some kind of communication. The shafts were originally closed off by the builders, and were discovered in 1872 by the English engineer Wyman Dixon. As we shall see in more detail later, until the beginning of the 1990s they were considered unfinished, and it was believed that the builders had interrupted their work almost immediately. It was indeed thought (and is still thought by some Egyptologists) that the designer had the queen's chamber built after changing his original plan, which envisaged only the subterranean chamber, but then had second thoughts, leaving the queen's chamber unfinished too, and moving on to construct one of the most outstanding masterpieces in architectural history—the grand gallery.

This high-ceilinged gallery starts from the point where the horizontal shaft branches off from the ascending passage. It is 46.6 meters long and has the same gradient as the ascending corridor, but, in contrast, is 2 meters wide and reaches a height of 8.54 meters, using a technique we have encountered before—overlapping vaults, one jutting out over the other (the gallery has to sustain the massive weight of stone above, right up to the cap of the pyramid). The spell that the grand gallery casts over the visitor is enhanced by the fact that one emerges into it abruptly from the cramped passageway (a low platform with regularly spaced recesses runs along the sides of the gallery; otherwise the space is utterly bare and anonymous).

The gallery ends with a step (usually called the *great step*), leading into another narrow horizontal passageway. This passes through a small antechamber, which contained a complicated locking system of granite portcullises. Eventually the antechamber takes us to a room that is traditionally called the king's chamber. This chamber would appear to be, at last, the actual burial chamber. The room, 10.47 meters long, is a granite-encased parallelepiped, whose base is made up of two squares and whose height is nearly equal to half of the base diagonal. The internal walls were made of perfectly smoothed blocks of granite from Aswan, about 800 kilometers away.

This room engenders a sense of unreality with its total anonymity. There

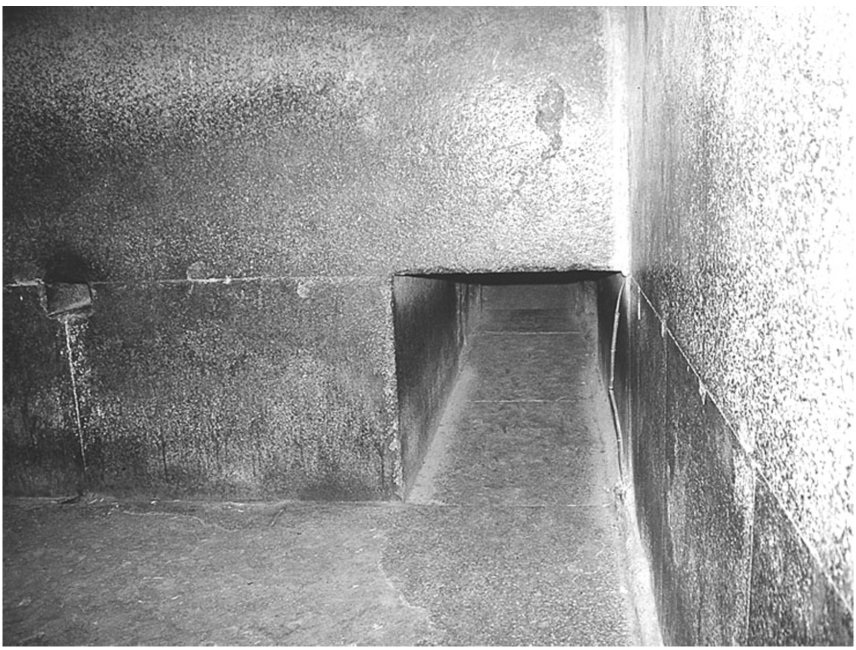


Figure 16.9: Entrance to the King's chamber viewed from inside. On the left, is visible the "mouth" of the northern channel.

is only a rectangular, open "tank" of pink granite, probably Khufu's sarcophagus, thought it would barely hold the dimensions of the wooden coffin of an adult man; in spite of this, it is too big to have been transported in the corridors, and therefore it was put in place before the completion of the room's ceiling. The coffin was carved with the same techniques used to pierce holes in the granite slabs of the Valley Temple of the second pyramid (see below), that is, with a core drill. The work is almost perfect, but we can see the traces of a slightly blurred perforation on one of the edges.

Besides the sarcophagus, the king's room is desolately undecorated and silent. There are, however, two curious small openings, like those in the queen's chamber, on the north and south walls. Again they lead to shafts that, unlike those in the queen's chamber, exit the pyramid through the north and south faces, respectively (this has been known since the 19th century, when Vyse, as was his wont, employed gunpowder to seek the exits). These exits are both at the same height, almost 80 meters, and since this is much higher than the king's chamber, the shafts twist sharply upward. Moreover, given that the king's chamber was not located on the central axis, but was slightly displaced to the south, the inclinations of the two channels are different, around 44.5° for the south shaft, 31° for the northern shaft at exits; we shall see later that actually it was the displacement of the chamber from the central axis that was chosen on the basis of the gradients of the shafts. The entire project was thus governed by the inclinations of two small, apparently irrelevant little shafts.

There can be no doubt that the construction of these two seemingly straightforward structural elements was in fact an extremely sophisticated and complex piece of work. If it is difficult to build internal rooms inside a 150-meter-tall structure weighing millions of tons, constantly struggling to avoid collapses, think how much more difficult it must be to work diagonally, as in this case there is not just the vertical weight to worry about but also the possible sliding of one part onto another along the diagonal (to avoid sliding, it was necessary to dovetail the diagonally laid blocks together with the utmost care). One would have to be strongly motivated, then, to create these shafts. Most Egyptologists have thought that the motivation was to allow air into the chamber, thus providing ventilation for the workers, during the construction of the room.

Above the king's chamber is a series of spaces usually called *relieving chambers*, because their purpose is held to be that of distributing the weight of the rest of the pyramid towering above and avoiding the collapse of the roof (as we shall see, this interpretation is wrong). These chambers were sealed off after construction and made with five layers of giant granite slabs, weighing over 40 tons, smoothed only on one face and alternated with empty spaces; above the last series of slabs the builders hewed out an inverted V vault. The lowest chamber, located directly on the ceiling of the room, was reaccessed by the builders to control the status of the masonry through a tunnel from the summit of the great gallery; this tunnel was rediscovered and explored by Davidson in 1765, while the upper rooms were discovered by Vyse, who, in 1837, made a number of holes (with gunpowder) in successive slabs until he reached the vault. In the chambers discovered by Vyse, there appear hieroglyphs, traced in red with a paintbrush, bearing the name of Khufu.

The internal structure of the Great Pyramid comprises also a well shaft connecting the grand gallery with the descending passage. This well is the only structural element whose section above the surface was executed retrospectively, that is, carving it out of the blocks already laid. It also holds the key, according to Egyptologists, to the explanation of how the pyramid was closed. Access to the ascending corridor is obstructed by granite blocks acting as a stopper, whose thickness is slightly less than that of the corridor and thus seal it hermetically. It is suggested, therefore, that, after the royal mummy had been entombed, the plug stones, kept in the grand gallery, were slid down until they blocked off the corridor. The idea, then, is that the grand gallery was made so large that it could thus accommodate the blocks, and that the work crew could exit after their sliding down through the well shaft.

For reasons that nobody has ever succeeded to explain, not far from the pyramid underground tunnels were dug out, bearing an amazing resemblance, in terms of size and design, to those inside the Great Pyramid, and in particular to the stretch joining the upward and downward passages. Many have suggested that what we have here is a one-to-one scale model of these passages carved into the bedrock, and in fact today they are called trial passages. However, such an interpretation makes little sense; why build a

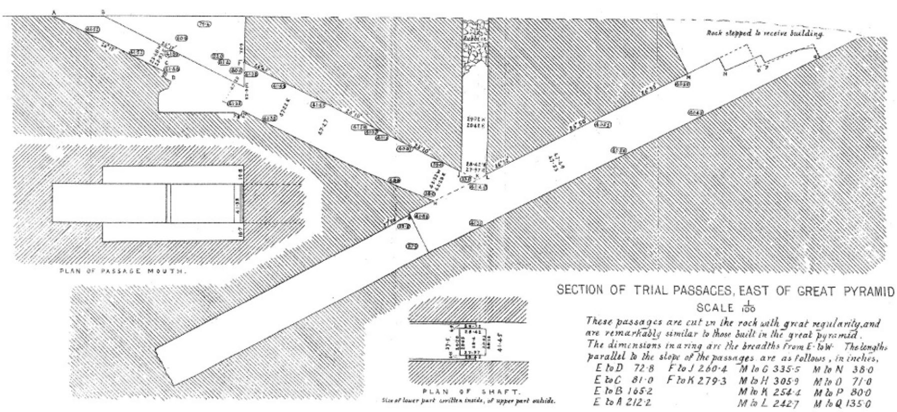


Figure 16.10: Section and plan of the ''Trial Passages'' according to Petrie

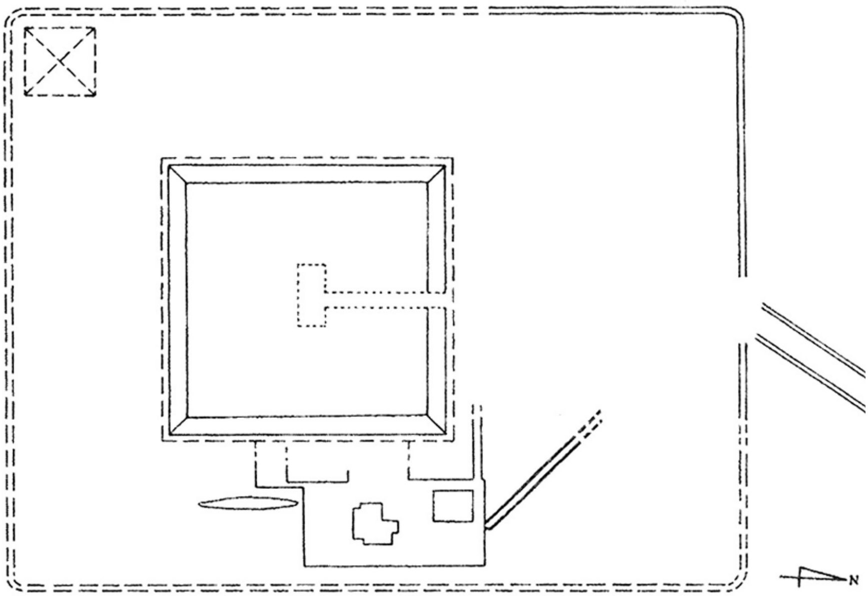


Figure 16.11: Plan of the complex of Djedefre at Abu Roash

one-to-one scale model? A possible interpretation is rather that these were underground passages intended for an auxiliary pyramid that was never built above them (Lehner 1985b).

The complex of annexes to the Khufu pyramid included the mortuary temple on the east side of the pyramid (today only beautiful paving stones made of large blocks of basalt are left), connected by a causeway, hundreds of meters long, to the Valley Temple, today located in the area of Nazet el Saman village. This building has therefore been lost, although we do have some information about it (see Chapter 19).

Djedefre apparently succeeded his father Khufu to the throne. On a hill at Abu Roash, about 7 kilometers north of Giza, there stands an unfinished pyramid that is alleged to be that of this pharaoh. Indeed, although the pyramid itself is anonymous, various fragments of statues of Djedefre were found in a ditch nearby (Mathieu 2001). The Abu Roash pyramid was designed to be 106 meters wide, with a slope of about 52 degrees, but it was only completed to a height of about 15 meters above ground (some are of the opinion that the pyramid was "dismantled" over the centuries, but I am very skeptical about such a theory). The excavation of the underground part, however, was completed, and laborers had begun to lay huge casing blocks along the walls of the ramp, hewn out of the bedrock, which, duly cased, would have become the descending passageway. The pyramid thus provides

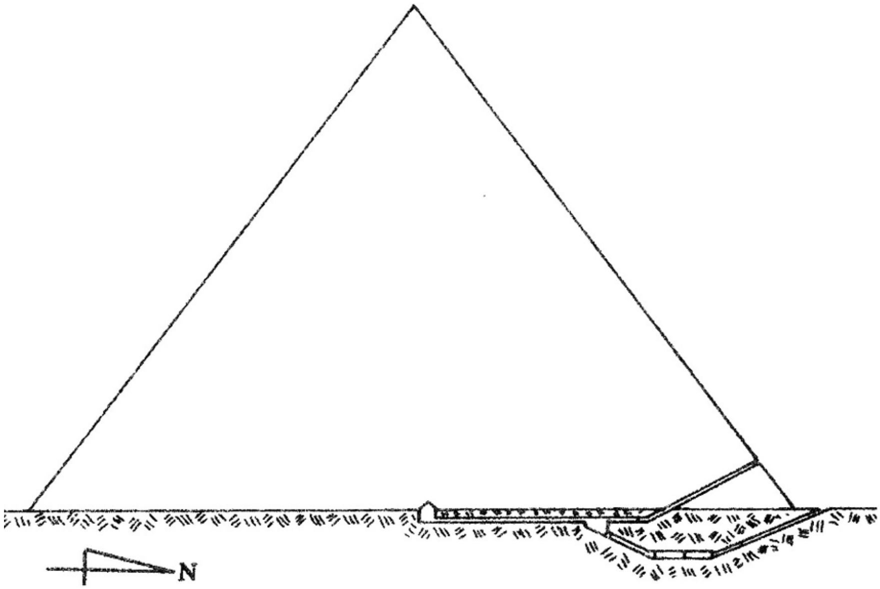


Figure 16.12: Section of Khafre Pyramid

a unique opportunity to visit a fourth dynasty pyramid building site frozen at an intermediate stage of work. Archaeologists have found a copper ax inside the ramp, which they interpret as a foundation deposit, that is to say, a place where artifacts (usually called "offerings") were laid at the moment of the foundation of a building (similar to laying the foundation stone today with dignitaries in attendance). This ritual, quite common in many civilizations, aims to invoke good auspices for the success of the building as well as the gods' good will.

According to the accepted chronology, when Djedefre died, his brother Khafre, on succeeding to the throne, decided to return to Giza to build his own pyramid. The pyramid attributed to Khafre lies not far from the Great Pyramid, and his diagonal is laid nearly on the same line. The colossal monument seems even bigger than that of Khufu, since it was built on a slightly more elevated area of the plateau and is slightly steeper, but in fact it is a little smaller—143 meters tall, with a base side of 215 meters. The first courses were cased in heavy blocks of granite from Aswan. The casing then proceeded with fine limestone; part of it is still in place, in the final courses of the building, over 120 meters high. The internal structure (as far as we know) is relatively simple and consists of an underground chamber accessed by a passage, provided with a service room and created after the abandonment of another shorter passage, maybe indicating an enlargement not included in the original layout.

Figure 16.13: The Khafre pyramid with the Great Pyramid in the background.

Figure 16.14: The magnificent granite hall of the second pyramid Valley Temple

The temple complex of the second pyramid is well preserved. There is still (commonly overlooked by tourists) the complete framework of the funerary temple, on the east side of the pyramid, built with giant limestone blocks weighing up to 200 tons. A monumental causeway starts from this temple, and proceeds downhill until it arrives in the middle between two other megalithic temples. Coming from the direction of the pyramid, to the left, just before the temples, a large trench gapes opens. In the center, carved out of a preexisting natural rock, sits the statue called the Sphinx.

The Sphinx has the body of a giant crouching animal (almost certainly a lion, though some details may be more reminiscent of a dog) and a human face. It is 57 meters long and 20 meters tall, and the width of its face spans 4 meters. The statue faces the rising sun—true east. The same is true for the Temple of the Sphinx, the enormous building downhill of the statue, which is undoubtedly of the same period, given that its huge megalithic blocks were extracted from the trench. The other temple is referred to as Khafre's real Valley Temple. This is an amazing building, consisting of an extensive colonnaded T-shaped space and a few small annexed rooms. The walls are made of colossal limestone blocks weighing up to 250 tons and stacked one on top of the other. These walls are so thick that, if it were not for various

Figure 16.15: The so-called Wall of the Crows, the original entrance to the Giza Necropolis

casing granite slabs still in place, the monument might be taken for a natural rock formation from a distance. Huge limestone blocks can also be seen on what was probably the original entrance to the necropolis of Giza. Known as the Wall of the Crows, it is an imposing megalithic wall, situated to the south of the Sphinx, near the modern parking lot for tourists' buses. It has only one entrance, whose lintel (weighing 250 tons or more) is undoubtedly one of the biggest blocks of stone ever moved in Egypt.

The Valley Temple was cased with large monolithic slabs of granite from Aswan. The columns (actually huge parallelepiped-shaped monoliths), which spread across the main area, are also of granite. The Egyptians' great skill in working with granite is evident not only in the joints between the ashlars, as perfect as those of the Incas or in the acropolis at Alatri, but also in the circular holes they made with tube drills. These holes can be easily spotted in the lintels giving access to various rooms, and they were thus used to put the door posts in place. Since the only metal at their disposal for making tools (apart from a small quantity of meteoritic iron, only used for small ritual objects) was copper, we have to assume that these drills were made using copper tools. Given, however, that it is absolutely impossible to drill through granite by turning a copper pipe above it (the granite will quietly eat up the copper, if anything), the only possibility is that highly abrasive quartz sand was continuously poured between the copper and the granite, greatly increasing the frictional force, while at the same time very high pressure was put on the rotating tube (nobody has yet succeeded in reproducing the experiment). The British Egyptologist Flinders Petrie (1883) was dumbfounded when he found in Giza the "carrots," extracted by the Egyptians during the perforation of the granite. These carrots, with their impeccable spiral markings testifying to the speed with which operations must have been carried out, can be seen today in the Petrie Museum in London.

Khafre's successor was apparently Menkaure, builder of the third pyramid of Giza (Plate 30). This pyramid, though it is small compared to the two giants, it is still perfectly respectable, as tall as a 66-meter-high building, 105 meters wide at the base, and with a gradient of $51^\circ 20'$. Possibly to make up for its reduced size, the designer conceived the idea of casing many courses, if not the whole pyramid, with heavy slabs of granite. Some of the courses are still in place, and it is difficult to determine how much of the casing has been removed and thus whether the covering had been completed (extremely unlikely) or not. Final polishing of the slabs that had been fitted was never completed, and at various points we find some roughly hewn slabs put in place, bringing protuberances identical to the ones often left by the Incas on their large andesite blocks. The casing of the enormous temple of

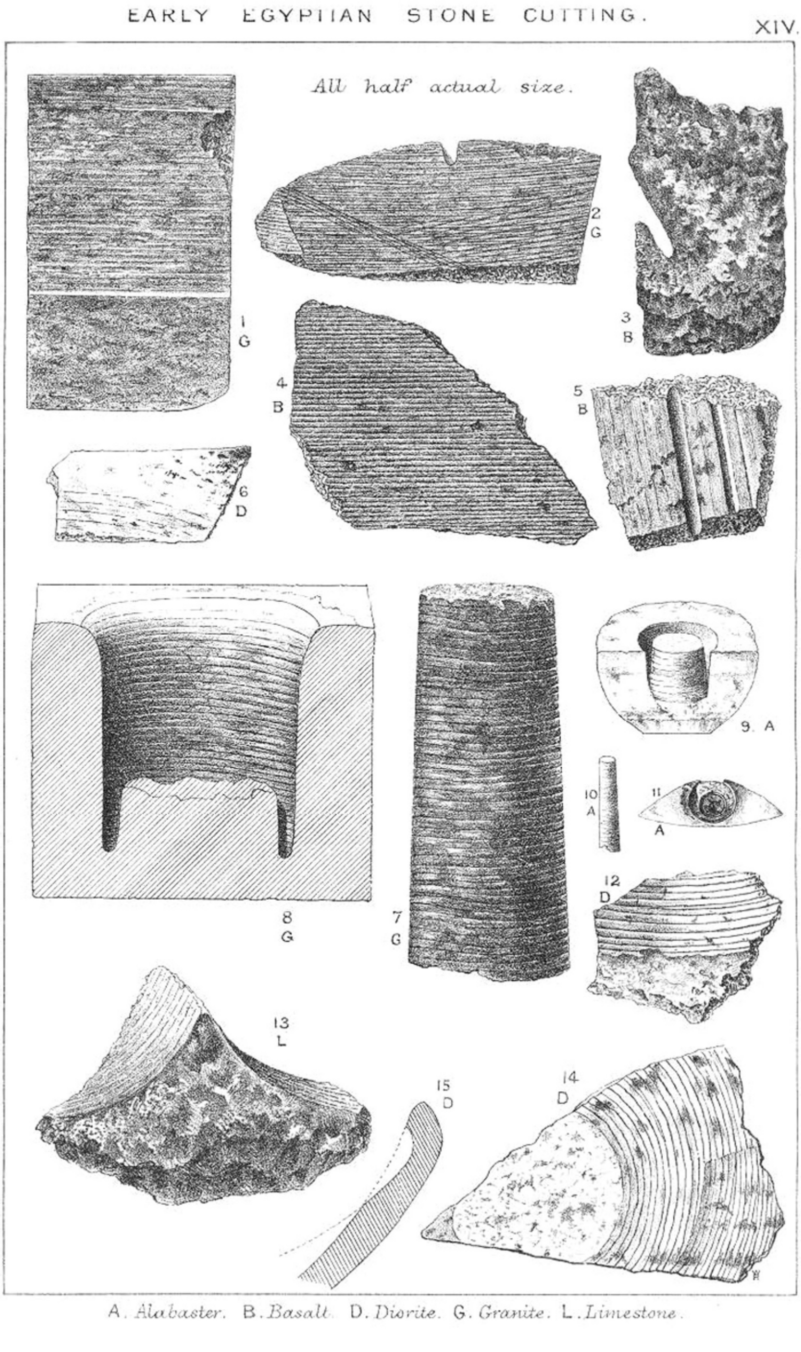


Figure 16.16: Examples of stone cutting from the second pyramid Valley Temple, from Petrie.

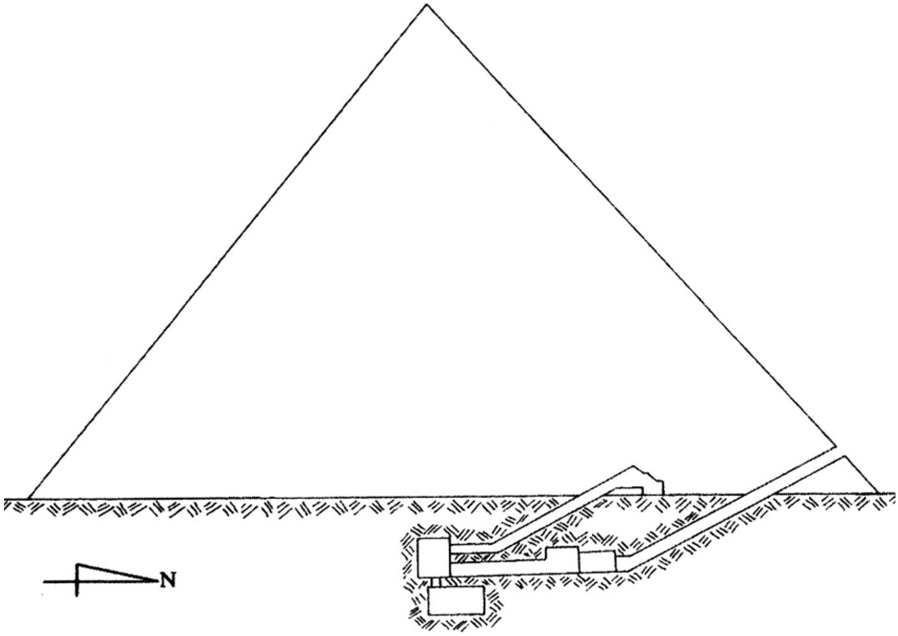


Figure 16.17: Section of Menkaure pyramid

the third pyramid—another infrequently visited place in Giza, but worth the detour—was also to be of granite, but was never completed.

The intentions of the architect of Menkaure's pyramid are unclear. Even more astonishing than the external granite casing is the arrangement of the rooms in the substructure of the pyramid. The substructure, carved out ofthe rock, is extremely complicated and envisages a set of several rooms. The last of these (the sepulchral chamber) was roofed with an inverted V-vault, made of massive slabs. Yet the weight of the pyramid does not rest on the vault, which is visible from above through an opening. Thus, its creation is very surprising, since it does not seem to have any practical purpose and it must have been a tremendous task to build.

The commencement of another pyramid on the Zawiet el Arian site has to be inserted somewhere in the timeline of the four pyramids (the three at Giza and the one at Abu Roash). It is widely held that its owner was one of Djedefre's sons, Baka, who must have ruled for some years. This conjecture is based, however, on a much later inscription, from the Middle Kingdom, found at Wadi Hammamat. All that is left of the Zawiet pyramid is the part excavated open cast from the rock, which was intended to form the substructure, of such prodigious size that it has come to be known as the Great Pit. Sources report that the site, which cannot be visited today as it is located inside a military base, contains an oval pink granite sarcophagus, and that the pyramid was originally planned to be considerably bigger than that of Djedefre, with a base side of 200 meters (Fakhri 1974).

16.7 The End of the Age of the Pyramids

After Menkaure's pyramid, dozens of others were built, both during the reigns of the last dynasties of the Old Kingdom and during the Middle Kingdom. But none of these remotely compares with the five pyramids of the fourth dynasty at Giza and Dashour.

It is thought that Menkaure's successor, Shepsekaf, had his tomb (a large mastaba) built at Saqquara, though the attribution of this building is somewhat doubtful. The fourth dynasty ended with this ruler. There followed the nine kings of the fifth dynasty: Userkaf, Sahure, Neferirkare, Shepseskare, Neferefre, Niuserre, Menkauhor, Djedkare, and Unas. The first six each commissioned a monument usually called Sun Temple, since it was undoubtedly a place of worship of the Sun God, Re. We have some information about these temples, including their names (Userkaf's is "Court of Offerings to Re"; Sahure's is "Possession of Re"), but only two have been

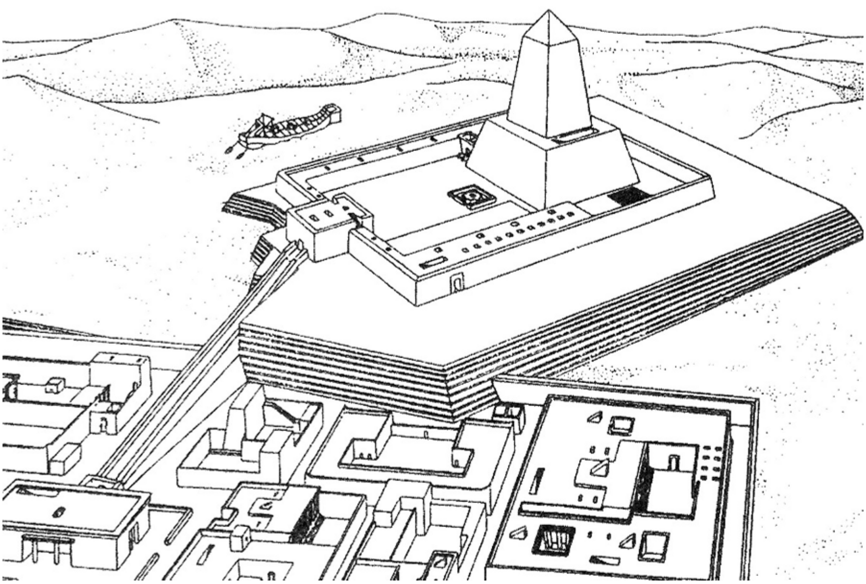


Figure 16.18: An ideal reconstruction of the Sun Temple of Niuserre

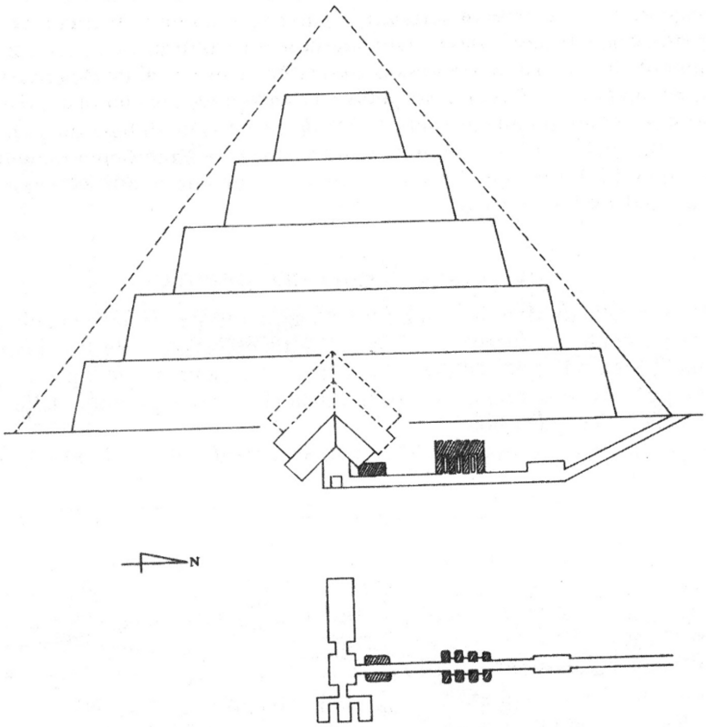


Figure 16.19: Section of the pyramid of Teti

found and only one has been studied in depth: that of Niuserre. The temple is situated in Abu Gurob, south of Giza, and is structured as follows: the complex was analogous to that of the fourth dynasty pyramids, consisting of a building set lower down, a monumental access ramp sloping upward, and a monumental area fenced in by a wall, accessed from the ramp. The center was marked by a truncated pyramid of limestone blocks, on which there apparently stood a nonmonolithic obelisk (i.e., constructed with superimposed blocks of stone). In the adjacent clearing was (and is) a large alabaster altar oriented to the cardinal points.

It is unclear why the pharaohs built these temples. We know only that in the funerary cult there existed cohabitation, perhaps with different phases, between a "stellar" and a "solar" component, which was to be codified in the pyramid texts (see Chapter 17). The start of the construction of the sun temples should fit into this context, since at the same time as the temples the pharaohs commissioned their pyramids, which, excluding the first pharaoh, Userkaf, who opted for Saqquara (his pyramid is near the northeast corner of Djoser's), were built very near Abu Gurob, on the Abu Sir plateau that overlooks the area of the sun temples from about 1 kilometer south.

Menkauhor, who ceased building the sun temples, returned to Saqquara; with his successor Unas we find the appearance of the pyramid texts in the sepulchral chamber, and these would continue to be a feature of the pyramids of the sixth dynasty too.

The Old Kingdom can be considered to end with the death of Pepi II, the last pharaoh of the sixth dynasty, and this marked the definitive demise of the age of the stone pyramids. Pyramids would be built in the future, but of brick, not stone, and not until the time of the pharaohs of the Middle Kingdom. To discuss in brief the fifth and sixth dynasty pyramids, we start observing that the Plateau of Giza offers a breathtaking view. Three massive pyramids, still as intact as when they were built 4500 years ago, stand out on the horizon. They are pyramids that even time itself fears, as the famous Arab saying has it. But if you contemplate the Abu Sir plateau, you want to avert your gaze. It looks as if someone was playing a joke: three pathetic piles of ruins, feebly trying to imitate the great pyramids of Giza. One might almost say that they are an unsuccessful replica of an already existent sacred landscape. They are the Sahure, Neferirkare, and Niuserre pyramids.

In contrast with their immediate predecessors, the fifth and sixth dynasty pyramids can be characterized as follows:

1. The projects were much less ambitious. The base side (about 100 meters) of the largest pyramid, that of Neferirkare, was roughly similar to Menkaure's.
2. The building technique was more "slovenly," with smaller-sized blocks often quite coarsely hewn. The structure was based on huge steps, as with the third dynasty, and then was integrated with a casing, with the result that the building turned out less stable and more susceptible to atmospheric erosion, earthquakes, and looting. The lack of care (in comparison to that taken by previous dynasties, that is), at both the planning and implementation stages is obvious in every aspect, including the orientation of the sides.
3. The internal apartments are never above ground; often also the underground access is simply from external ground level or from the very first courses of the north wall, without any effort being made to create passageways in the structure.
4. To create subterranean chambers, enormous, curiously oversized inverse–V structures made of blocks of granite or large blocks of limestone were often used.
5. Stunning architectural flourishes, such as columns shaped like papyrus-plants, altars, and delicately engraved granite slabs appear, almost as if the inadequacies of the size have to be compensated for by fine artistic embellishments.

Figure 16.20: The pyramids of Giza

Figure 16.21: The Abu Sir pyramids of Sahure, Neferirkare and Niuserre

It has been argued that by the time of the fifth dynasty, the Egyptians had forgotten how to build on a very large scale, which might be seen as comparable, as mentioned in Chapter 13, to our "forgetting" how to travel to the moon in the 40 years that have passed since the Apollo era in spacecraft. As with the time of the conquest of the moon, but for unknown reasons—possibly economic, social, or political—the age of the great pyramids lasted an incredibly short time, and this very brevity makes the subject all the more difficult to investigate but no less intriguing.

17 Gateways to the Stars

> It was easier to know it than to explain why I know it. If you were asked to prove that two and two made four, you might find some difficulty, and yet you are quite sure of the fact.
>
> —Sherlock Holmes in *A Study in Scarlet*

17.1 Eliminating the Impossible

Egyptologists usually maintain that they have come to understand almost everything about the project of the great geometrical pyramids and about their structural elements. Some minor details need to be studied further, but otherwise they feel that it is clear that the Great Pyramid was nothing but a messy, makeshift building site, where architects decided to change their minds from time to time. Further, one day Khufu came along and decided he wanted to be buried in another chamber while, amid all the confusion, his men were building shafts as wide as handkerchiefs and scores of meters long, set diagonally in relation to the building's plane, just to let in air for the laborers.

So the book ends here. The sacred landscape and all the other things I've tortured you with for 15 chapters have nothing to do with the Old Kingdom. As for astronomy, forget it. And if in the Pyramid Age there were no howling barbarians, well, we weren't far off it.

I'm exhausted, as the main character in Umberto Eco's *Name of the Rose* would say, my thumb aches (even though I'm writing with a computer): dreaming up nonsense is exhausting. "Nonsense" is in fact the only word to define the way most Egyptologists have interpreted the Great Pyramid in the last 100 years – as I took pains to show you in the last chapter. Why?

It is generally taken for granted that the subterranean chamber is unfinished. Yet if you abandon an underground room at an incomplete stage, logically you would simply stop excavating down any further, not meticulously carve out the whole room at half-height, creating a sort of womb-like space.

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_17,

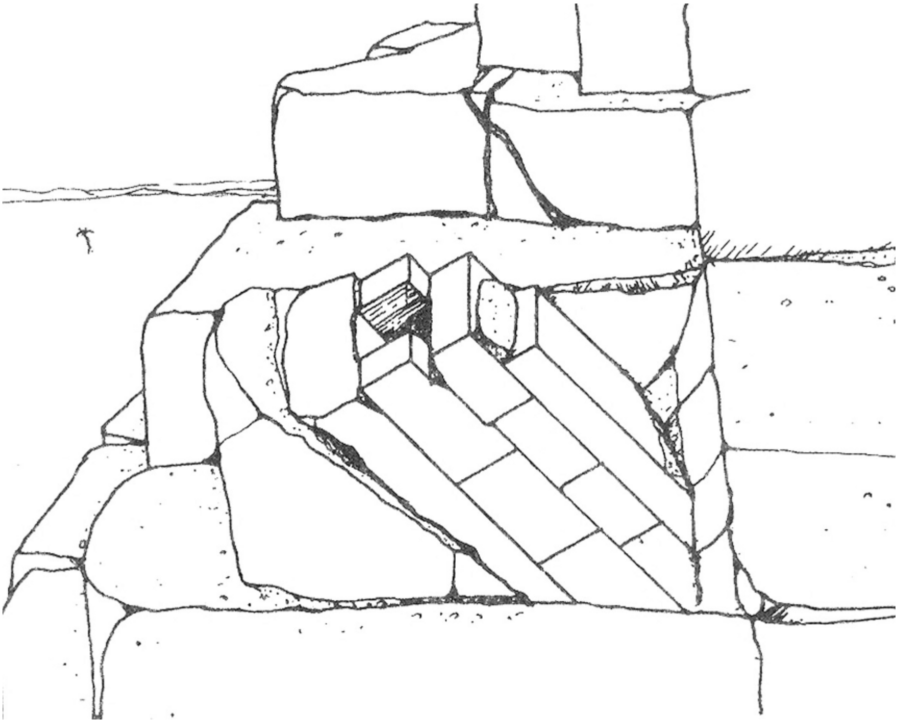


Figure 17.1: Exit of the upper southern shaft

Many people also think that the queen's chamber is unfinished, on the totally unfounded grounds that the pyramid could not possibly have rooms that did not have anything to do with entombing the mummy of the pharaoh.

Moreover, the idea that the great gallery, one of the most stunning architectural achievements ever, should be built only for the purpose of storing granite plugs sounds bizarre. Why was it over 8 meters high when the blocks, no wider than the shafts themselves, do not even reach a meter and a half? Would it not have been easier to place the plug-stones directly in the conduit, ready to be slid up and down, and create a wide area *alongside* the plugs themselves that they could be passed through?

The relieving chambers also raise considerable doubt. It is necessary only to have a *basic* grasp of statics, and reflect for a moment with the guide of the bookshelf example in Chapter 16, to realize that the only room that functions in relieving the weight above is the last one, which is covered with an inverted-V vault. It is clear that the builders were well aware of this information, since they used the same weight distribution technique in making the entrance to the passageway descending from the north face and the ceiling of the queen's chamber, even though these ceilings had to support a *greater* weight than that of the king's chamber, without feeling the need for extra "relieving chambers."

Finally, the service shaft itself is puzzling. Why construct a well that is connected with the descending passageway deep in the bedrock, if it would have been sufficient to make a "softer" one that linked up inside the structure? And how did the laborers manage to connect the well with the part dug into the rock?

In any case, the most compelling doubts come from the "ventilation shafts" in the king's chamber. Even admitting that:

1. There was not enough air to breathe. (This assertion is debatable, given that up to the 1990s there was no air-conditioning system and the shafts were obstructed, and yet the room received air flowing in through the ascending passageway).
2. The workers did paintings and inscriptions. (No evidence remains of this).
3. The architect was so concerned about his workers' welfare that he devised, not a horizontal shaft in a single layer of blocks (which would have been too simple), but a shaft lengthened in the course of the work and thus initially shorter, to allow more air to pass.
4. The same architect decided at this juncture not to create a vertical ventilation shaft (which would have been too simple), but to work diagonally (for some obscure reason of his own, which we can never hope to fathom).

Well, can anyone explain why the architect designed *two* shafts?

17.2 The Pyramid Texts

It may be that the book should not end here, after all. Actually, one of the shafts points to a particular spot in the northern sky, and the other points to particular spot in the southern sky. Perhaps, it is relevant.

The Giza pyramids are silent, giving away nothing that can be of use to us. However, there are pyramids from later dynasties in which the sepulchral chamber and antechamber are covered with hieroglyphics (in the pyramids from earlier dynasties these chambers were bare). These writings are the so-called *Pyramid Texts*, discovered by Gaston Maspero at the end of the 19th century. They are the oldest collection of Egyptian religious writings, and one of the oldest collections of writing anywhere in the world.

It is a daunting task to describe the texts. I cannot read hieroglyphics and thus I have never read the original texts but only the official and somewhat poetic translation (generally acknowledged as being definitive) by Faulkner (1998). We have to take the translation on trust, which can be tricky, as anyone translating an ancient text is bound to be influenced by his own knowledge of the period in question, and such knowledge might be imperfect or incomplete (for example, the translator's knowledge of ancient astronomy might have been derived from Neugebauer's views on ancient Egypt).

Reading the Pyramid Texts can try one's patience, as most it is obsessive repetition, with little variation from pyramid to pyramid (the texts appear in the pyramids of Unas, Teti, Pepi I, Merenre I, Pepi II, and Ibi, and in those of the queens Wedjebten, Neith, and Iput). An electronic version of the texts would be of enormous assistance in studying the main elements without all the repetitions. Another problem is trying to determine the date of the texts. Although they first appear in the pyramid of Unas, the fact that they do not make up an organic corpus but are rather a loose collection of disparate discourses most likely indicates that the material already dated from an earlier period when it was transcribed. It seems at times that the inscriber of the texts on the wall was not aware of the full significance of what he was writing. Moreover, some of the content would appear to refer to aspects of the funerary cult that had been out of use since before the age of the pyramids, prompting some Egyptologists to wonder whether the utterances had even been codified originally as far back as the predynastic period.

The texts are numbered according to their position, starting from the back of the funerary chamber. It is not clear in which order they should be read, but it *is* clear that they should be read, since each column begins with the allocution "Words to be declaimed." We have no way of knowing whether there were rituals to be performed simultaneously and what form such rituals might take.

The main subject of the texts is the resurrection of the king and his ascent to the afterlife. This journey is not easy, given that there are a number of obstacles to overcome, especially doors, which are often guarded by sentinels, that the king can pass through only by correctly answering some questions. The sky is cited continually as a place of frenzied activity, and various crowded zones of it are considered to be of great importance. Most significantly, there are *two distinct destinations* for being reborn: the "imperishable stars," that is, the circumpolar stars, which never rise or set, and the stars of the "southern constellations," close to Sirius-Isis (called *Sothis* in Faulkner's translation), which identify the Duat region (essentially Orion and Taurus). It is not clear whether there is a corresponding geographical division of the various souls, and, if there is, which soul relates to each place. There is also a solar component of rebirth: the pharaoh joins Re-Atum on the "sun boat" and they cross the sky together. A winding waterway in turn crosses the sky, which can be flooded; I share the view of many who are convinced that this must be the Milky Way, seen as a celestial counterpart of the Nile, although other interpretations (e.g., the ecliptic) have been proposed.

Numerous other allusions to heavenly bodies and events crop up throughout the texts. In particular, there are many references to iron. As we saw in Chapter 4, this would be meteoritic iron, of heavenly origin and hence to some extent divine. Indeed, perhaps the whole vault of the sky was even considered an "involucrum" of iron, and the stars seen as holes though which sunlight passed when, at night, the sun crossed the outside part of this involucrum (Lesko 1991).

To enable us to explore some aspects of particular interest to us, here are some passages from Faulkner:

1. The king joins Re-Atum on the sun boat, becomes the "lord of the four pillars," that is, the four cardinal points, and together with Re-Atum he traverses both the nights and the days:

   > Re Atum, this King comes to you, an imperishable spirit, lord of the affairs of the place of the four pillars; your son comes to you, this King I comes to you. May you traverse the sky, being united in the darkness; may you rise in the horizon, in the place where it is well with you. [Pyramid Text (PT) 217, §152]

2. The king ascends into heaven via the Milky Way:

   > Hail to you, you two falcons who are in this [bark] of Re which conveys Re to the East: may you lift me and raise me up to the Winding Waterway, may you set me among those gods the Imperishable Stars that I may fall among them; I will never perish nor be destroyed. [PT 624, §1759]

3. The king ascends to the imperishable stars, passing through the gates and placing himself near the North Pole (the "Mooring Post," Ursa Minor and Mes, Ursa Major):

   > I will cross to that side on which are the Imperishable Stars, that I may be among them. [PT 520, §1223]

   > The doors of the sky are opened for you, the doors of the firmament are thrown open for you, (even) those which keep out the plebs. The Mooringpost cries to you, the sun-folk call to you, the Imperishable Stars wait on you. [PT 463, §876]

   > The sky is clear, Sothis lives, I because I am a living one, the son of

> Sothis, and The Enneads have cleansed themselves for me in Ursa Major, the imperishable. My house in the sky will not perish, my throne on earth will not perish. [PT 302, §458]

4. The king is joined with Osiris-Orion exactly as he is joined with the Sun God. For example:

   > O King, you are this great star, the companion of Orion, who traverses the sky with Orion, navigates the Netherworld with Osiris; you ascend from the east of the sky, being renewed at your due season and rejuvenated at your due time. [PT 466, §882]

   > You will regularly ascend with Orion from the eastern region of the sky, you will regularly descend with Orion into the western region of the sky, your third is Sothis, pure of thrones, it is she who will guide both of you in the goodly roads which are in the sky in the Field of Rushes. [PT 442, §821–822]

5. Some verses seem to refer to the heliacal rising:

   > Orion is swallowed Up by the Netherworld, Pure and living in the horizon. Sothis is swallowed up by the Netherworld, Pure and living in the horizon. I am swallowed up by the Netherworld, Pure and living in the horizon. [PT 216, §151]

6. The "Opening of the Mouth" is cited several times, with the associated "adzes" of meteoric iron:

   > I split open your mouth for you l with the adze of iron which split open the mouths of the gods. O Horus, open the mouth of this King!" [PT 21, §13]

7. Just as the adze motif of the Ursa constellation is iron, so too the king's bones are iron, and his limbs are the stars:

   > This King ascended when you ascended, O Osiris; his word and his double are bound for the sky, the King's bones are iron and the King's members are the Imperishable Stars. [PT 684, §2051]

8. One wonders what role the pyramids play in the Pyramid Texts, but this matter does not seem to have received much attention. Anyway, The pharaoh has a "stairway to heaven" at his disposal:

   > A stairway to the sky is set up for me so that I may ascend on it to the sky. [PT 267, §365]

One also might wonder how the soul of the king could *find the right way* to the afterlife. Yet nobody seems to have addressed that issue until 1964.

17.3 Two and two makes four

Thus, along with the gigantic but mute monuments, crammed with things we understand little about, the most exciting of these being four shafts that point to the heavens, we have texts, written down immediately after the end of the period in which the monuments were erected, but which had undoubtedly been in existence prior to that time, full of references to the heavens and voyages to the stars. Holmes would say, what remains, is to realize that two and two makes four. However, it was not until 1964 that Egyptologist Alexander Badawy and astronomer Virginia Trimble had the idea of determining how the sky would have appeared in Giza during the age of the pyramids. They soon realized that, during the years in which Khufu's pyramid was built, between 2600 and 2450 BC, the northern shaft of the king's chamber pointed toward the culmination of the "pole star" of the time, *Alpha-Draconis*, while the southern shaft pointed toward the culmination of Orion's Belt (Badaway 1964, Trimble 1964).

Before 1964, there had been an important scientific question that remained unsolved: Why had the shafts in the king's chamber been created? In 1964, we had the solution: they were *stellar conduits* oriented toward the two regions of rebirth mentioned in the Pyramid Texts.

The shafts in the queen's chamber were universally considered to be unfinished, and, consequently, Badawy and Trimble did not manage to suggest an interpretation for them. Subsequently, however, Robert Bauval (1990) suggested that the lower northern shaft pointed to an area near the celestial north pole, probably toward the culmination of the star Kochab, while the southern shaft pointed toward the culmination of Sirius at a date around 2500 BC.

As we shall see, we now know that the queen's chamber shafts are indeed

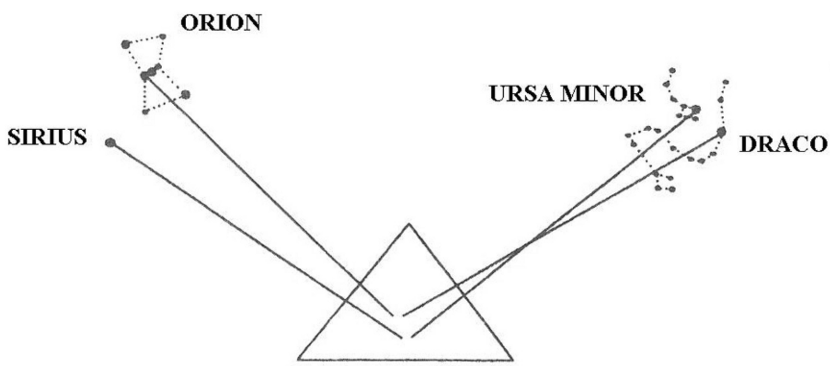


Figure 17.2: Astronomical alignments of the "air" shafts

finished. Thus, I believe this issue is settled. The four shafts had been created with only one purpose in mind: guiding the deceased to the rebirth regions of the sky. It is important to keep in mind that the shafts start off with a horizontal section, and so it would have been impossible to frame the celestial bodies in them; these alignments, then, had a purely symbolic significance.

The stellar interpretation of the four shafts in Khufu's pyramid is, in my view, a shining example of how archaeoastronomy can provide us with a key to understanding some great riddles of the past. Further, it helps in interpreting many *other* structural elements of the pyramids as well. Trimble and Badaway's work answers the question of why the king's chamber was not built on the vertical from the apex. In fact, it is not possible to reconcile these three factors: (1) the stellar, hence fixed, orientation of the shafts; (2) the egress of the shafts at the same height; and (3) the chamber set on the axis. Thus, the building principle that required the exit of the shafts to be at the same height was considered to be fundamental rather than the traditional arrangement of the sepulchral chamber on the axis. Further, the stellar interpretation of the two lower shafts puts an end to a hundred years of ridiculous discussion about the queen's chamber being incomplete. In fact, given that the lower shafts were also astronomically oriented, if the chamber had been an "aborted" sepulchral chamber, its shafts would have been oriented toward the same stars as the real sepulchral chamber (that is, the king's chamber), but this is not the case. The orientations of its shafts, different from those of the burial chamber, prove that the chamber was constructed with a different scope, a point to which we shall return later. (Given their symmetric disposition, one could refute the stellar interpretation and instead propose that the shafts served an aesthetic purpose (Dormion 2004), but such arguments are not justified on historical grounds).

The logic applied in the stellar interpretation agrees with both the humanistic approach (given that it is based on the content of the Pyramid Texts) and a rigorous scientific approach (since the likelihood of all four shafts being arranged randomly is unquestionably low) (Castellani 1998). Also, the stellar interpretation is a simple solution to a decidedly complicated scientific puzzle, and as often happens, it is the simplest, neatest solutions that are the hardest for many to accept; a memorable example is the general theory of relativity, for which Albert Einstein *failed* to win the Nobel Prize (he did receive it, but for his discovery of the photoelectric effect). Similarly, the astronomical orientation of the shafts is rejected even today by many archaeologists: "Of the theories so far proposed, the most probable attributes a ventilating function to them"

(Verner 2001). There are even attempts to debunk the stellar interpretation by using such things as average inclinations instead of angles of exit to show that the shafts did not all point simultaneously to their stellar targets (Wall 2007).

I will make a final comment based on my own experience. As a physicist, I have seen many attempts to debunk theories that seem strange to some people, and one of the most often "debunked" is precisely Einstein's general relativity theory. However, our galaxy (the Milky Way), just like millions of other galaxies, does not care about such debunking: stars continue to rotate slowly and safely around the galactic nucleus, allowing the solar system to exist and all of us to live, only because a supermassive black hole—an object whose existence was predicted by the general relativity theory as far back as 1917—sits quietly at its center.

17.4 Upuaut

At the beginning of the 1990s, a chance event suddenly brought the queen's chamber to the world's attention. Since accretions caused by the solidifying of visitors' breath had built up, the interior of Khufu's pyramid had begun to show signs of degradation. The first thing to be done was improve ventilation, and so it was decided to install air ducts.

It was of course known that unclogging the shafts of thousands of years of debris would not be enough to give them the function of air shafts—a function not attributed to them by the ancient Egyptians builders, but only by some Egyptologists. The idea was to make use of the existing shafts and pump air in, using a forced ventilation system. The work was entrusted to a German engineer, Rudolf Gantenbrinck, who cleaned out the shafts with the use of a rope-tied robot and then installed the ventilators. During the exploration—which was facilitated by using the exits of the shafts on the faces of the pyramid to operate the robot, though to work safely on the side of the pyramid, 80 meters up and with a gradient of over 52 degrees, Gantenbrinck had to rely on his mountaineering skills—a camera fitted on the robot enabled numerous observations to be made of how the building work had progressed; for example, in some cases badly finished blocks were carelessly tossed aside, especially in the northern shaft. Little did they imagine that a German engineer, 4500 years later, would discover their mistakes.

When the task was complete, Gantenbrinck proposed exploring the lower shafts as well. For this venture he devised and created a special climbing robot. He appropriately called it *Upuaut*, from the name of one of the

Egyptian deities who acted as guides in the underworld and, believe me, never was a name more appropriate.

The exploration began with the northern shaft, and the surprises started coming fast. Far from being abandoned, the shaft was usable for 16 meters, but beyond that point Upuaut was unable to pass through; an iron probe—undoubtedly left by Dixon; see below—and a wooden stick that might have dated from the time of the construction were seen via camera at ground level.

Then, at the beginning of March 1993, Upuaut was moved to the lower southern shaft, and began slowly to ascend. At a certain point the robot passed the level corresponding to the beginning of the grand gallery, showing (as if there was still any need) that the queen's chamber project had not been abandoned while work was underway, because work was still being done on the shafts of the lower chamber while the building of the king's chamber was being planned.

The robot penetrated the very core of the most magnificent monument in the world, and on March 22, 1993, at about 60 meters from the entrance in the chamber, Upuaut began to advance along a stretch of shaft built out of

Figure 17.3: The door discovered by R. Gantenbrinck in the lower southern shaft

fine limestone blocks, the same as that used for the outer casing. After proceeding another 5 meters into the bowels of the Great Pyramid, its path was blocked by a slab (also of fine limestone), fitted with two copper handles.

What you would call a slab with two handles that closes off a shaft? I would call it a door, but Gantenbrinck called it an "unidentified stone object" (USO) in his account. Perhaps this humorous touch was related to the fact that the event was something of a clamorous fiasco for the academic world. Consider that the Great Pyramid is the most celebrated monument in history. Volumes have been written about how and when and why it was built. It is the ancient Egyptians' most staggering achievement, together with the Sphinx—the symbol of ancient Egypt. It must be the most dissected and probed monument in the world, and the subject of study by generations of Egyptologists of all nationalities.

Yet nobody except an amateur researcher, Morton Edgar, in the 1920s, had ever thought about passing a flexible cable into the lower shafts to ascertain how long they were.

After Gantenbrinck's discovery no scientific paper or report ever appeared. The only information available is on Gantenbrinck's Website (Gantenbrinck 1999). Otherwise, anyone who wanted to know what lay behind the door (just millions of people) had to be resigned to a long wait. Gantenbrinck's exploration was interrupted and the door had to wait another 10 years until a new robot was able to reach it in an expedition sponsored by the *National Geographic* in September 2002.

But the 2002 exploration suffered a number of setbacks. Once the new robot had been positioned in front of the door, the team tried to open it by pushing it, but without success (actually it is a sliding portcullis). In the efforts to push it, one of the handles broke. Possibly feeling under pressure, since the explorers had announced that they would open the door live on TV on a specific date, with countdowns on their Website, they made the questionable decision to drill into the slab. On the night of September 17, 2002, on a live worldwide broadcast, a fiber-optic camera fitted to the front of the robot was slipped through a hole in the slab, only to reveal, in the dramatic last thirty seconds of the broadcast, that what lurked on the other side of Gantenbrinck's door was … *nothing*.

The shaft continues for a few dozen centimeters before being blocked *again* by what Professor Zahi Hawass, head of Egyptian antiquities, on live TV called a new door; it is actually a limestone slab that looks quite roughcast, more like the back than the front of a door. A few days later, the group announced that it had also explored the northern shaft and revealed images of a door resembling the one discovered by Gantenbrinck, this time

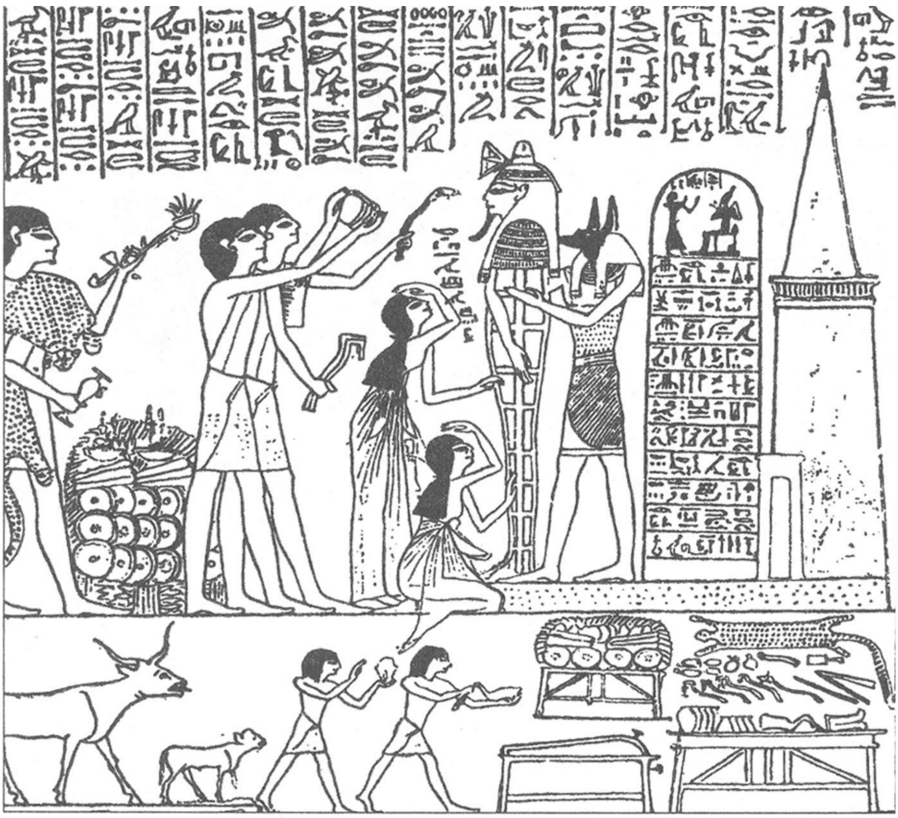


Figure 17.4: The opening of the mouth, from a New Kingdom papyrus. Notice the several ''adzes'' with the form of the Bull's Foreleg constellation

with both its handles intact. It appears to have been found at a distance from the mouth of northern shaft that would match the arrangement in the southern shaft (some blurred marks, possibly hieroglyphics, were noted on the new door).

To date (April 2008), no further details and no scientific report have emerged regarding the second exploration, and we await a third probe of both shafts.

In any case, the presence of copper handles on the doors would seem to indicate that rooms might yet be discovered. We might even chance upon the funerary chamber of the pharaoh, dead before the completion of the pyramid and entombed in this impenetrable lair, as Professor Hawass has suggested. The 2002 exploration showed us the little empty space lying beyond the first south door, but just the front wall, not the ceiling. It might be possible then, that the shaft comes out into a room but that the access to the shaft from the room is located in the ceiling. Let's hope that all the scientific data relating to the 2002 *National Geographic* investigation will be reported. We await the answers to these questions:

1. How are the handles on the other side, *the inside,* of the Gantenbrinck door arranged? Do we really see two handles or could they be the rear part of a *single* handle on the other side?
2. How is the northern shaft structured after the bend that Upuaut was unable to negotiate? Are there interesting conclusions to be drawn from the inner structure of the building, given that the shaft passes extremely close to the grand gallery? What is the gradient of the final part?
3. At what height inside the pyramid's core is the door of the north shaft to be found? At the same height as the other?
4. Have the items (in particular, the wooden stick) of the northern shaft been recovered?

17.4 The Gates of Heaven

Although the idea of chambers yet to be discovered in the Great Pyramid is tantalizing, it may also be the case that the doors at their ends only had a symbolic significance, a concrete representation of those gates that feature so prominently in the Pyramid Texts and have to be crossed by the soul of the deceased. Indeed, the fact that both shafts were terminated shows once again that the queen's chamber fulfilled a precise function within the "machine" that was to ensure the king's rebirth. A sound interpretation of this chamber is that it is the *Serdab* of the tomb of Khufu, that is, the place where the rite of the opening of the mouth took place. In the Ancient Kingdom, as we saw in Chapter 4, this rite was performed on the statue of the deceased, which in this case may have been housed in the niche situated in the chamber. We learned that the rite had profound links with the stars, especially with the Bull's Foreleg constellation to which the lower north shaft points, and we are familiar with another pyramid that was equipped with a Serdab and handed down to us virtually intact: the Step Pyramid of Djoser. Actually, this Serdab too has shafts oriented toward the stars.

Djoser's Serdab is located in a small building on the north side of the pyramid and contains the statue of the pharaoh (today replaced by a copy). The room was completely sealed off, but two little holes, at eye level, had been drilled into the stone slab facing the statue, on the north side. The little structure has its walls sloping toward the top; thus, the holes enabled the statue to look in the direction of the northern sky. The orientation is not

Figure 17.5: The Serdab of Djoser Step Pyramid complex. Notice the holes which correspond to the eyes of the statue inside

Figure 17.6: Two of the three objects found by Dixon in one of the lower shafts (on display at British Museum)

toward true north, however, but 3 degrees 40 minutes east of north. This is clearly not an error (it would be far too much of an error, given the Egyptians' rigorous standards of accuracy), but rather an example of generic orientation towards north, not specifically toward the north pole, and thus similar to what we found in some temples in Chapter 4. One might reasonably think that the building is pointing to a circumpolar star, and this is confirmed by recent measures: the inclination of the room was meant to point toward the star Al Kaid, the hoof of the Bull's Foreleg (Bauval 2006), while the inclinations of the holes through which the statue looks are slightly different, in relation to each other, as well as to the building. One shaft in fact slopes more than the other; hence the eyes most likely looked in the direction of two other circumpolar stars, Dubhe and Kochab, belonging to Ursa Major and Ursa Minor, respectively (Shaltout et al. 2007). In any case, the deliberate orientation of the two shafts—which were certainly not created to give fresh air to the statue—in the direction of the northern stars cannot be questioned.

The symbolic function for which the queen's chamber was devised and built is also backed up by the discovery of three items. The story of this discovery is very curious. As we have seen, the shafts in the queen's chamber were left blocked off by the builders, and were only rediscovered in 1872, by Wyman Dixon. After his discovery, Dixon inserted sounding rods into the shafts, and in his diary he noted the discovery of three objects: a small greenstone ball, a wooden bar 13 centimeters long, and a sort of small forked metal grapnel hook.

These three artifacts are the only things ever found in the pyramid that date with absolute certainty to the time of its construction. It should be remembered that the pyramid has been completely bare since time immemorial; the other unique object found inside is the sarcophagus, which as far as I know has never been moved to see what lies underneath. Despite their evident importance, Dixon's three relics—once mentioned in an article in *Nature* magazine in 1873—were promptly and incredibly forgotten. Two of them, the hook and the ball, are now on display in the British Museum, thanks to the persistence of Robert Bauval, who tenaciously tracked them down. The wooded stick, alas, is lost.

These items were sealed in the shaft by the builders and seem therefore to be a sort of foundation deposit of the Great Pyramid. Yet their true meaning eludes us. It would be more straightforward if they were made of precious materials, or were works of art or bore religious depictions—not just items of everyday use and of seemingly little material value. Their true function is unclear; however, the hook is swallow-tailed in shape, and resembles the *psh-kef*, the forked instrument employed in the ceremony of the opening of the mouth. The ball might be a hand-hammer tool used for smoothing stones; it is similar to some found and documented by Arnold (1991), for instance. It could also be, however, the weight of a plumb line. If it is so, then it may be tempting to interpret the hook as a sighting tool, perhaps originally mounted on the stick.

In this case, the whole set of objects might be the oldest known example of *Merkhet*, the instrument employed by the Egyptians for performing astronomical measurements.

18 On the Paths of the Ancient Stars

> Pyramids should no longer be considered solely as monuments asserting the megalomaniac pride of the theocratic despots who commissioned them, but rather as testaments to the culture, science and advanced technology of the period of their construction.
>
> —Z. Zaba, *L'Orientation Astronomique dans l'Ancienne Egypte e la Precession de l'Axe du Monde,* 1953

18.1 The Rebirth Machine

It would be wonderful if it turned out that the builder of the Great Pyramid had obligingly left an astronomical instrument sealed inside the pyramid for us, just to confirm the monument's close link with the stars. That would enable us to respond to those who stubbornly refuse to accept that the discovery of the stellar orientation of the four shafts, together with the doors at the end of the lower shafts, has changed forever our way of looking at Khufu's pyramid. The last "wonder of the world" would have finally broken free of a century of absurd and harmful speculation, such as unfinished chambers, designs changed halfway through construction, "ventilation" shafts hundreds of feet long but only a few inches wide, and other equally short-sighted conclusions reached by so-called experts.

Today we know that Khufu's pyramid is the fruit of a complex unified design, and that it was devised from the start to be the container for a series of structural elements, whose significance is largely symbolic. We also know that Khufu's pyramid was conceived as an astronomically anchored mechanism, similar to numerous others described in this book, albeit the most sophisticated and complex. The aim of this mechanism was to reconcile the sun cult with the star cult, in order to ensure the king's rebirth, and simultaneously to assert the king's power in the face of death itself.

If the chamber shafts give ample evidence of the link with the stars, so too the aspect of sun worship is reflected in an extraordinary discovery, made in 1954 by the Egyptian archaeologist Kamal el Mallak.

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_18,

Figure 18.1: The Khufu solar Boat.

As we have seen, the sky is represented in the Pyramid Texts as being extremely crowded, with boats whizzing around, and the Sun God accommodating the deceased pharaoh on his boat (or "bark," to use Faulkner's more romantic term). In a large ditch parallel to the pyramid, carefully sealed with enormous limestone slabs still bearing Djedefre's cartouche (and hence, name), Mallak's team unearthed piles of cedar wood planks, neatly laid out in perfect order. It turned out to be a large boat with high broadsides, which had been *dismantled* into 1224 pieces, many of which were numbered and marked so that the boat could be reassembled. The chief restorer, Hag Ahmed Youssef Moustafa, and his team embarked on the exciting adventure of reassembling, after 4500 years, the boat belonging to the greatest pharaoh in history. Today, visitors to Giza have the thrill of seeing Khufu's Sun Bark—43 meters long and weighing approximately 50 tons, housed in a museum alongside the pyramid. The boat was built without the use of nails; instead, ropes of vegetable origin were slotted through holes. It has never been ascertained if the boat ever sailed, such as on the occasion of the pharaoh's funeral.

Apart from the connection of structural elements with the celestial cycles, many other architectural features of the Great Pyramid might have a symbolic rather than a functional purpose. The subterranean chamber, for instance, with its womb-like form, may have been left in the apparently odd state it is found in today (only half-carved out, longitudinally rather than transversely, and with womb-like aspect) for a symbolic reason. As we already noticed, it is curious that (in all fourth dynasty pyramids, not just Khufu's) the descending passage was always partly inside the stonework (that is, passing through the masonry and exiting on the north face), and partly inside the rock, when it would have been much easier to make the whole passage inside the rock and let it come out at the base of the pyramid (as was to be the case with most pyramids henceforth). This raises the suspicion that it was necessary to connect—physically, but also symbolically—access to the subterranean chamber with the very core of the stonework, almost as if wishing to betoken an artificial womb.

The structure of the so-called relieving chambers is also puzzling. As we have seen, these rooms do not fulfill the function attributed to them at all; they do not relieve. On the other hand, the construction of so many apparently useless spaces, one above the other, must have created innumerable problems, not least being the backbreaking task of lifting not one, but five granite slabs ceilings, weighing dozens of tons, up to a height of over 60 meters. Why was that done?

I maintain that the function of the chambers was structural, but that it had nothing to do with "relieving" in the proper sense. The function of

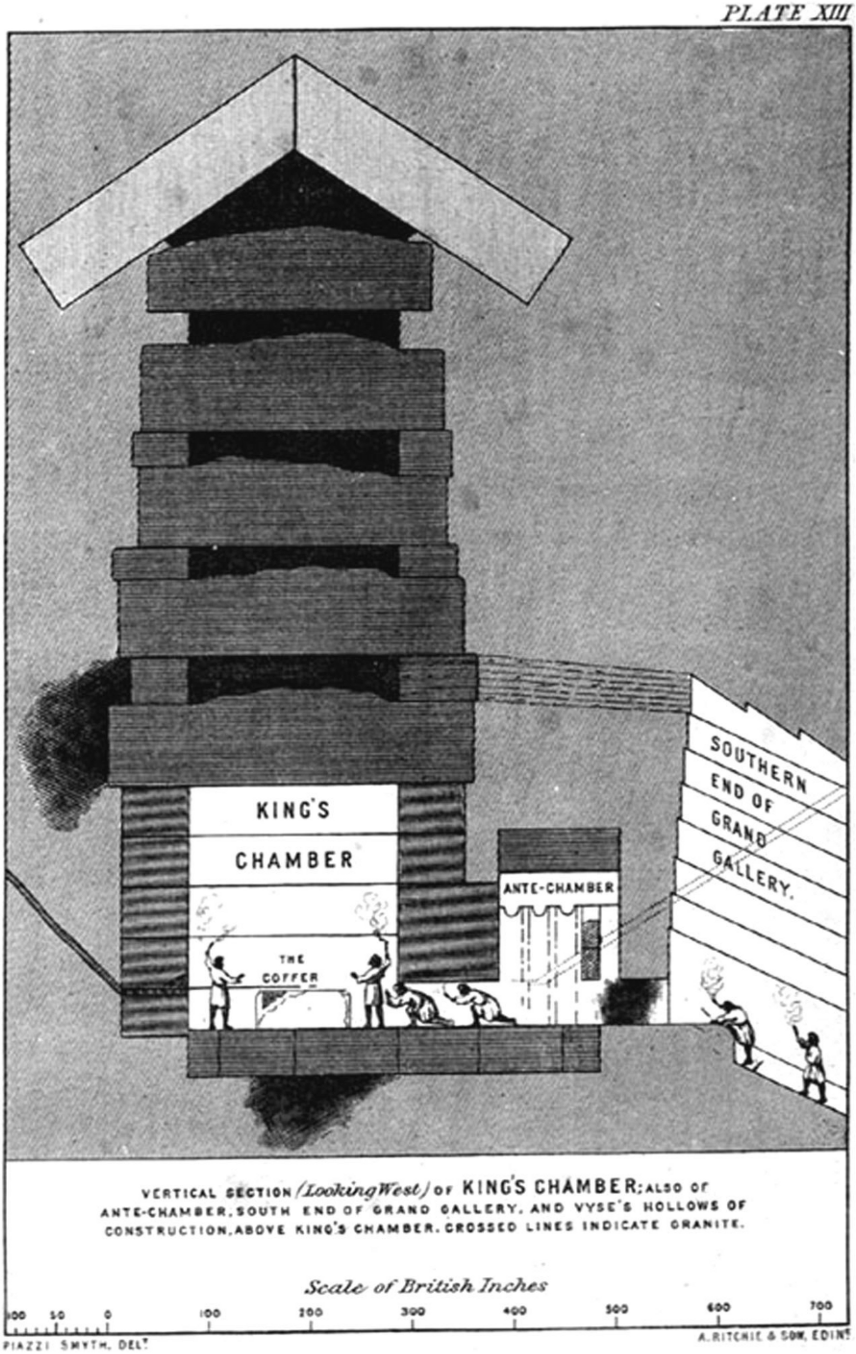


Figure 18.2: Section of the ''relieving chambers'' from a 19th-century survey by Piazzi Smith.

relieving the weight is exerted by the inverted V-vault of the last chamber only. However, if such a structure had been made directly above the king's chamber, the stone slabs on the north side would be leaning dangerously on a part of the pyramid in which few blocks of the core were located, followed by the "vacuum" caused by the presence of the great gallery. Therefore, it was thought advisable to build the relief vault higher, that is, above the level of the great gallery, and for this reason the intermediate chambers were constructed. It is, however, still unclear why the gallery was built so high, and therefore, perhaps the relieving chambers carried a symbolic significance as well. One author has suggested that the chambers may be a symbolic representation of the *Djed Pillar*, 𓊽 the "backbone of Osiris, stabilizer of life," an extremely ancient, possibly predynastic, symbol of Osiris (Pincherle 1980).

18.2 On the Paths of the Ancient Stars

All fourth dynasty pyramids are oriented in such a way that the sides of their bases run parallel to the cardinal directions.

It is natural to commit errors in making physical measurements, and the Egyptians were no exceptions. Consequently, the east and west sides emerge as not having been laid precisely along the north–south axis, and the north and south sides were not laid precisely along the east–west axis. Yet to measure these deviations today, we need to use accurate instruments, given that the errors committed by the Egyptians are truly small. The results vary from side to side, but it would not make any sense to take an average of the errors, since the corresponding directions were probably determined with different methods (the north–south directions by using the stars, the east–west directions by tracing a 90-degree angle to them), so the sides have to be considered separately. For our purposes, it is sufficient to look at, for example, only the east sides, whose data can be summarized as follows (Dorner 1986):

1. Pyramid of Meidum: $-20.6' \pm 1.0'$
2. Bent Pyramid: $-17.3' \pm 0.2'$
3. Red Pyramid: $-8.7' \pm 0.2'$
4. Pyramid of Khufu: $-3.4' \pm 0.2'$
5. Pyramid of Khafre: $-6.0' \pm 0.2'$
6. Pyramid of Menkaure: $+12.4' \pm 1.0'$

I have omitted from the list the pyramid of Djedefre at Abu Roash, which is in a poor state and not, in my opinion, measurable with a comparable degree of accuracy, though recently a archaeological mission did claim to have determined its orientation very precisely, and it would appear to deviate blatantly from true north, about 0.8 degrees west (Mathieu 2001). The orientation of the “Great Pit” at Zawiet el Arian is missing too, because it has never been measured.

The above data indicate that if one compares the direction of the east side of the pyramids with the north direction, the side of the pyramid of Meidum deviates some 21 arc minutes to west, that of the Bent Pyramid deviates 17 arc minutes to west, and so on. The positive sign next to Menkaure’s pyramid means that the side deviates to east instead of the west of north; the uncertainties indicated by the “$\pm$” signs refer to the errors of the modern measurements, as they are of course affected too.

Think for a moment how much 3.4 arc minutes—the deviation of the east side of Khufu’s pyramid from true north—really is. We have to take an angle of 1 degree, divide it by 60, and then “take three and a half little bits”. We can draw in the sand a right-angle triangle with one of its angles equal to 3 arc minutes and making one of the sides 100 meters long. Then, the other leg comes out to be only 8 centimeters. Thus, accuracy to within 3 minutes is excessive for any conceivable practical purposes (for example, planning a modern building). Evidently, however, for fourth dynasty Egyptians it was a matter of paramount importance. How did they go about it?

If we wished to attain the same standards as the fourth dynasty, we would have to use a good theodolite (transit) or GPS, and proceed with much care. No magnetic compass would be able to give such a high degree of precision. Actually, if you go to Egypt today, you can get a pretty good idea of how much your magnetic compass departs from true north, by placing it on the casing block on the north side of Khufu’s pyramid and checking how much the needle deviates in relation to the side of the block . . .

The pharaoh’s technicians did not have theodolites or GPS, but they did have the night’s stars, (it is impossible to attain accuracy to within a few arc minutes by measuring the sun’s shadows) and were extremely motivated and tenacious in their approach to their work. Up to the year 2000, there have been two suggestions made by researchers about how the pharaoh’s technicians worked: the observation of the rising and setting of a bright star on an artificial horizon, and the observation of the circular trajectory of a circumpolar star (Edwards 1952). Yet it is extremely unlikely that the Egyptians used either of these methods, for a somewhat complicated technical reason, which I shall now explain.

If one measures a physical phenomenon that is constant over time, and repeats the measurement several times, the results will be a number of points scattered irregularly in a “band,” which would have the maximum error as its width and would contain the real value of the measurement required. Thus, since the best accuracy obtainable with the naked eye by a very expert astronomer is of some arc minutes, one would expect the errors of the pyramid's orientation to fall randomly into a band some arc minutes wide, centered around true north. But this is not the case; the errors clearly form a pattern that is not random.

Let us first consider the modulus of the errors, that is, how far off they are, without considering whether they err toward the east or toward the west. The modulus drops from 20′ to 3.4′ from Meidum to Khufu, and then rises again from Khufu to Menkaure. So, either we accept that the astronomers became increasingly expert from Sneferu to Khufu and then their skills declined again, all in the space of less than 200 years (a frankly unacceptable hypothesis), or we have to admit that it was the phenomenon being observed that changed. This means that the method used for finding the north did not always indicate the north, but indicated a slightly different direction as time passed, and so it was by a lucky, albeit incredible, coincidence that the period that supplied the most accurate results was when the greatest and most perfect pyramid in history, Khufu's, was constructed.

The first to notice this pattern of systematic errors and identify its cause correctly was Haack (1984). I am sure however that, if you have survived 17 chapters of this book, you have already guessed that it is precession. Since all methods based on the movement of a single star do not depend on precession, naturally none of these methods was used under the fourth dynasty. Just as an umpteenth demonstration that in Giza things always turn out to be more complicated than we expect, it would seem that only recently the actual method, which is a modification of the method based on circumpolar stars, has finally been determined (Spence 2000; see also Rawlins and Pickering 2001).

18.3 Simultaneous Transit

The method, proposed by Kate Spence, is called simultaneous transit and consists of observing two circumpolar stars, Kochab (beta-Ursa Minor) and Mizar (zeta-Ursa Major), keeping track of their relative positions. North is identified as the direction on the ground corresponding to the segment joining the two stars when it is perpendicular to the horizon. Because of precession, this direction shifts slowly around the north, and in fact it passed from left of the pole to right of the pole (i.e., from east to west) at around 2500 BC. Inspired by this fact, Spence plotted the deviation from true north of the segment as a function of time, obtaining a straight line. Then the

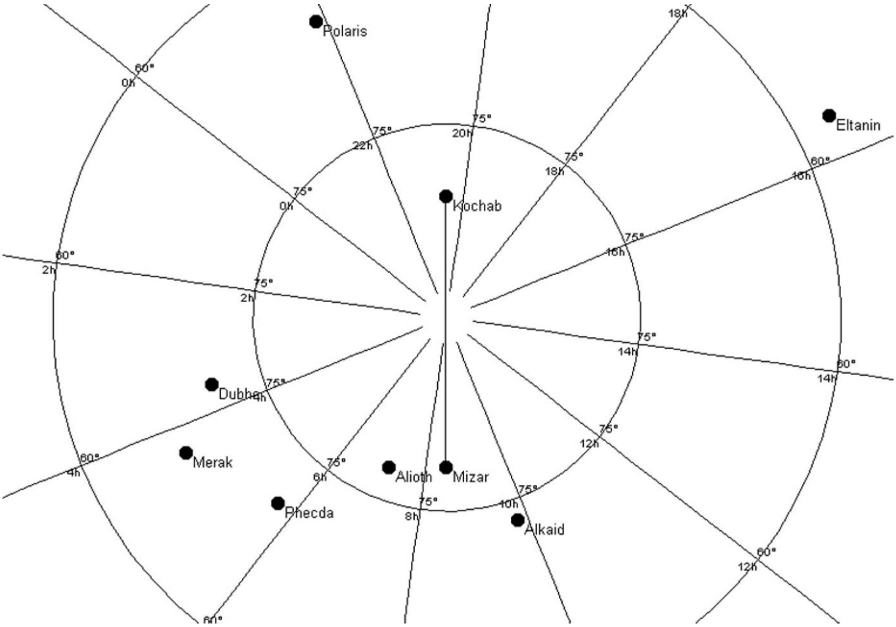


Figure 18.3: The segment used for the orientation of the pyramids according to Spence.

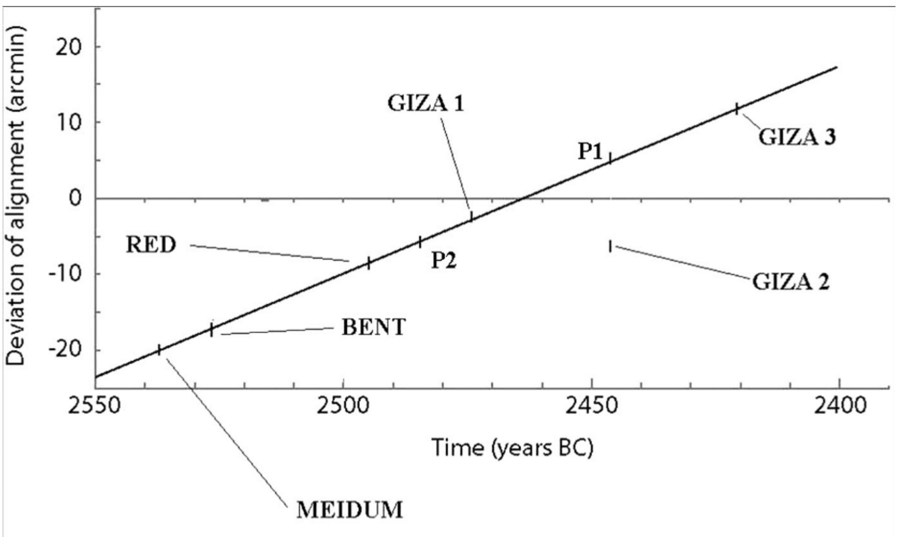


Figure 18.4: Orientation errors of the fourth dynasty pyramids in Spence's chronology. Notice the point P1, proposed by Spence to explain the anomalous orientation of Giza 2 maintaining the same date, and the point P2 proposed by the author with a slightly earlier date. See text for full details.

points corresponding to the orientation errors were positioned on the line, and finally the dates of construction were “read” on the time axis (in the case of Khafre an *ad hoc* assumption has to be introduced; see below), thus suggesting a very accurate chronology for the pyramids of the fourth dynasty.

This procedure, though it might seem foolproof, is completely different from the standard way with which experimental data are treated in physics, and for this reason it is also quite difficult to explain (Spence’s article is written in a rather cryptic, Sibylline fashion). Usually one possesses *given data* chosen by the experimenter, such as the time at which a measure of the radioactivity of a substance is done, and *experimental data*, such as the quantity of a substance present at any given time. Putting the intervals of time on the x-axis and the measurements taken on the y-axis, the curve joining all the points thus obtained corresponds to the physical law underlying the phenomenon and thus provides information about it. Spence, however, did not have access to absolute data on the x-axis. Indeed, we do not know the precise dates of the reigns of the pharaohs of the fourth dynasty (there does not exist an absolute chronology of the Old Kingdom, since the first dating anchored to the Sothic cycle goes back to the Middle Kingdom only). Therefore, Spence is hypothesizing a certain law, and then reasonably adapting the measuring times accordingly. The result is what Spence calls a recalibration of the dates, which leads to the dating of Khufu, for example (or to be precise, the orientation ceremony of Khufu’s pyramid), at 2467 BC.

It is evident that this work does not fit in too well with rigorous scientific method, because if you can adapt the points on the x-axis, you can then force a set of experimental data to follow one law rather than another (in particular, a straight line with a more or less marked gradient). No referee, that is, the person responsible for assessing the validity of a scientific paper for an international journal, would ever accept any work of experimental physics using this data procedure. Nevertheless, as we have learned, there may be occasions when insisting too slavishly on scientific rigor at all costs may be counterproductive, and Spence’s conjecture is quite appealing. Spence’s suggested chronology fits well with the astronomical dating of the shafts of the Great Pyramid; however, it post-dates the chronology habitually acknowledged by many Egyptologists by about 80 years, since they usually place Khufu’s reign in the first half of the 26th century BC. To reconcile the simultaneous transit with this earlier dating, Juan Belmonte (2001a) noted that the orientation might have come about via the same method, but using two different stars, Megrez (*delta-Ursa Major*) and Phecda (*gamma-Ursa Major*), which both transit on the same side in relation to the pole. The graph of the simultaneous transit corresponding to these two stars turns out to match the earlier chronology fairly well.

In both cases, everything works well only if one resorts to a somewhat curious working hypothesis. As one can see immediately, in fact, the value of the error corresponding to Khafre's pyramid is situated correctly on the calibration line *only if it has the opposite sign*. To explain this fact, and therefore the fact that Khafre's pyramid deviates to the same direction as Khufu's, Spence has come up with a clever ruse: she assumes that, for some unknown reason, the orientation ceremony of the second pyramid took place in the summer, rather than in the winter. In winter, the segment between Kochab and Mizar is located to the right of the pole at night; hence, in summer, it is seen to the left, and for this reason the error, which should be toward the west, is actually toward the east. A similar trick has to be applied to Belmonte's method; it must be admitted that in the case of Khafre the orientation was effected with the two stars at their lower culmination, that is, under the pole, while all the other pyramids were oriented using the upper culmination.

Although I do find the simultaneous transit methods extremely convincing, I do not find convincing the explanations given for the "anomaly" of orientation of the Khafre pyramid. The reason is that the orientation of a pyramid must have been an operation—or a ceremony—of great importance, as we know happened with the temples. Therefore, it is likely that it would take place on the same day of the year (maybe at the heliacal rising of Sirius?) and not on a random day. So why was the ceremony for Khafre, and only him, held in the opposite season? The situation grows even more paradoxical with Belmonte's theory, since it is perhaps more natural and simpler to carry out observations on a configuration where the two stars he proposes are low on the horizon, and thus under the pole, something, however, that would have happened only in the case of Khafre. On the other hand, the simultaneous transit method is the only one ever proposed that is able to take into account the effect of precession on the distribution of the orientation errors. Not wishing to forsake this method, and at the same time hoping to solve the dilemma of the anomaly point without an ad hoc hypothesis, I proposed another solution a few years ago (Magli 2003, 2005a). Before discussing it, though, we have to return to a matter that was left standing.

18.4 The Attribution of the Giza Pyramids

Many people, myself included, have been taken in by a lot of twaddle spouted by tour guides while visiting an archaeological site or museum. Tour guides often pad out their spiel with spicy or gory details, adding folksy particulars or even making thing up as they go along, and it was ever thus. For example, Herodotus, the "father of history," born in Halicarnassos in 485 BC, and author of the renowned *Histories*, visited Egypt, in the jolly company of priests, who recounted, among other nonsense, that Khufu had prostituted his own daughter to finish paying for the pyramid. Herodotus describes the Khufu pyramid (with inaccurate measurements) and then says that after the death of the pharaoh, Khafre inherited the kingdom and commissioned the second, slightly smaller, pyramid. The two reigns allegedly lasted a total of 106 years, during which the Egyptians fell on hard times, but the situation was turned around by Menkaure, to whom Herodotus imputes various murky goings-on, apart from the construction of the third pyramid of Giza, that is (Histories II, pp. 126–134).

But I doubt that Herodotus ever went to Giza, because much of the information he imparts is wrong, inexact, or unproven (for example, that Khufu was buried in an underground chamber touched by a branch of the Nile). Besides, how could he not have seen the Sphinx? Even if the enclosure it stands in was covered in sand, concealing most of the body, the head would undoubtedly have been visible.

Once we agree to ignore Herodotus and his guides, the evidence to support the attributions of the pyramids of Khufu, Khafre and Menkaure to their respective pharaohs is shakier than one might think. We are so accustomed to giving them the credit for these pyramids that we take it for granted that these pharaohs created these monuments. For us nothing is more natural than that the creator of a great monument should give it his own name, and once the name has stuck it goes unquestioned.

The presence of these pharaohs at Giza is not open to doubt: inscriptions found in the workmen's quarters mention them, and tombs of their functionaries and priests have been found in the vicinity of the pyramids. There also exists, as we saw, the inscription in the mastaba of Qar bearing the names of the pharaohs who owned the pyramids, written about 200 years after their construction. But a lot can change in 200 years, and lapses of memory about the attribution of a monument can occur, as we shall see. The only evidence that we might consider incontrovertible, in that it is contemporary with the time of construction and written on the building in question, pertains to Khufu's pyramid: the name of Khufu is found in some phrases inscribed on stone blocks in the four upper relieving chambers over the king's chamber (see Chapter 16). These writings appear to have been made by workers when the blocks were being excavated, to indicate their destination.

The first chamber from the bottom, the one already described by

Davidson and from which Vyse started with his gunpowder-assisted exploration, does not contain any such inscription; as a consequence it has been suggested that it was Vyse himself who forged them, thus linking his name with that of Khufu for all eternity. This idea contrasts, however, with philological analyses and with the fact that some of the paintings were clearly made before the arrangement of the blocks in the ceilings; in my opinion a explanation for the lack of quarry marks in the first room might be that they were deleted by the builders during their on-the-spot inspections.

Thus, because we find the name Khufu written on the pyramid ascribed to Khufu, until the day comes when it is proved to be fake, the attribution can be considered sound. Indeed, although an inscription drawn on a monument might have been a way for a king to appropriate a preexisting monument, in the case of the Great Pyramid we can be sure this was not the case, since the relieving chambers were sealed off at the moment of their construction, and one does not pinch something from another monument, writing one's name in an invisible place. Generally speaking, however, we have to take into account the fact that preexisting buildings are sometimes taken over, and we have to consider the *context* in which the clues are found. There are cases where the context helps to exclude a takeover, as in Khufu's, but there are also other cases where it only makes matters worse and more confusing. As confirmation of this, one only has to move from the first to the second pyramid of Giza.

The second pyramid of Giza is glaringly, bleakly, completely anonymous. The name of Khafre or anyone else has never been found on it, and if there ever was a name on it, it must have been rubbed off. It is a possession without an owner. Likewise, the Funerary Temple, the causeway, and the Valley Temple of the second pyramid, as well as the Sphinx and the Temple of the Sphinx, are all glaringly, bleakly, completely anonymous.

So why do books and tour guides say that the pyramid of Khafre was built by Khafre? Have we been conned into buying one of Herodotus's second-hand chariots? Not exactly. Apart from a stele (lying between the Sphinx's legs) which possibly linked the name of Khafre to the statue (the pharaoh's name, however, is today not identifiable due to erosion, and it is uncertain whether it ever was), we have some finds made by the Egyptologist Auguste Mariette, including, from a ditch dug inside the Valley Temple, the splendid diorite statue of Khafre, now in the Museum of Cairo, as well as fragments of numerous other statues of the pharaoh (his name is written explicitly on the bases). Thus, the attribution of Khafre's temple is based on these finds, and the attribution of all the other elements of the complex was made by association. The Valley Temple belongs to the same complex as the causeway, the Funerary Temple, and the pyramid; ergo, everything belongs to Khafre.

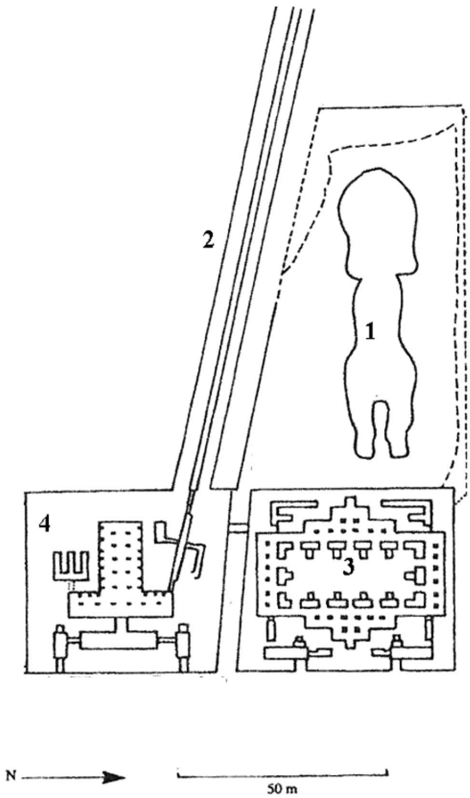


Figure 18.5: Schematic plan of the Sphinx area: 1) The Sphinx, 2) Second pyramid causeway 3) Sphinx temple 4) Valley Temple

Similarly, the association of the body of the Sphinx with the Temple of the Sphinx is sound in that enormous blocks with which it was built definitely come from the ditch dug out for the statue. But we still have to link these two monuments to the rest of the complex; the fact they were built next to each other is no proof that they were contemporary, given that other pyramids have neither Sphinxes nor Sphinxes' temples. What is absolutely certain, however, is that the inner walls of the ditch were not excavated after the fourth dynasty, since they contain tombs dating from that time. To prove that the Sphinx could not have been built earlier, the archaeologist Selim Assan (who appears be the only one who ever really wondered about this) pointed out that, at the point where the causeway of the second pyramid intersects the enclosure, a drainage canal was blocked by pieces of granite to stop it flooding, and so the enclosure around the Sphinx must have been dug after the construction of the road.

To summarize:

1. The fact that the statue of Khafre and fragments of other statues have been found in the temple does not prove that the temple itself was constructed by this pharaoh. Khafre could easily have acquired a preexisting building, maybe refurbishing it for the occasion, or the statues could have been buried in the ditch at some unspecified time. A contextual clue, such as an object found in a building, does not in itself constitute definitive proof of attribution.
2. The attribution to Khafre would be more convincing if it could be ascertained that the Sphinx really represented the pharaoh, as most Egyptologist believe, on the grounds of an alleged similarity between the faces of the sphinx and the pharaoh. To be honest, it takes quite an effort to see such a resemblance, to the point that the German scholar Reiner Stadelman (1985) proposed rather that Khufu was the owner of the statue.
3. Even if we succeeded in identifying the face of the Sphinx, we would still be left with the problem that the Sphinx's head is too small and out of proportion compared to the body. So either the sculptor got the proportions of the head and body wildly wrong, which is unlikely, or Khafre, or whoever it was, had the original, possibly leonine, head remodeled in his image.
4. We do not know whether the second pyramid was built when the Sphinx was constructed or remodeled. The whole effort might even have taken place in the space of a very few years, without being contemporary, however.
5. The blocking off of the drainage canal does not prove a thing. It could have been the builders of the Sphinx who blocked the canal or the builders of the canal who had a reason for making the causeway oriented on that precise direction and hence were forced to block off the canal. In any case, the words "laid by Khafre" are not conveniently inscribed on any of the blocking stones.

Adding to these doubts are several clues, themselves highly debatable and controversial, that allegedly show that the Sphinx had long been in existence by the time of the fourth dynasty.

The first to realize that there was something distinctly odd about the Sphinx, something quite illogical, was René Schwaller de Lubicz (1996), a somewhat quaint figure who studied history of religions and esotericism. Following on his heels came an independent researcher, John Anthony West (1993), closely pursued by Robert Shoch (2001), a geologist at Boston University. What West and Shoch say is that, if you just look at the sides of the enclosure around the statue and some parts of the body that are not covered with restoration bricks, you can see patterns of erosion caused by the flow of water. In Egypt, however, the arid climate prevailing today set in between the fifth and fourth millennia BC, so the body of the Sphinx should have been sculpted prior to this. In fact, Shoch asserts that the erosion on the statue would be consistent with a timeframe of about 5000 BC or earlier, thus solidly in the predynastic era. Shoch's ideas, very debatable but nevertheless based on a scientific approach, have fired the enthusiasm of legions of Atlantis freaks, who are convinced that the monument was built by "the Atlanteans before the Flood".

I do not share the view that Egyptian civilization was imported from somewhere else, as the Atlanteans would have it. To date we have no clue about who would import it, or why or when. As far as the age of the Sphinx is concerned, the hypothesis that the Egyptians could have created these monumental works at Giza in predynastic times cannot be ruled out entirely. There is no doubt that, for instance, the builders of Ggantja in Malta (Chapter 3) were creating megalithic temples one thousand years before the fourth dynasty, and new evidence is emerging that megalithic structures (and perhaps interest in astronomy) also existed in Egypt as far back as the 5th millennium BC. This hinges on discoveries made at Nabta, now in the western desert, a few dozen kilometers from Abu Simbel: a circle of relatively

Figure 18.6: a side-view of the Sphinx and part of its enclosure

small stones and various burials of cows, made with huge blocks carved into mushroom shapes (Malville et al 1998). Besides Nabta, much is already known, but much has certainly to be discovered, about predynastic Egypt (see Grimal 1994); further, although the physical evidence of water erosion in the enclosure of the Sphinx cannot be denied, alternative explanations are available that avoid a strong retro-dating of the monument.

The first attempt to formulate an alternative theory to Shoch's relied on the obvious idea that the water in question may have come from the Nile. Yet the Giza builders were quite familiar with the Nile flood plain and accordingly placed their buildings well above the height reachable by floods, so the river never flooded the statue enclosure. Nowadays in Giza very little rain falls, only an occasional downpour. It is, however, known that the enclosure gets filled with sand very quickly, so one would imagine that it has remained in virtually the same state over the centuries. The geologist John Harrell (1994) takes his cue from this idea, and conjectures that the sand with which the enclosure was filled may have caused the erosion visible today through a process involving humidity. Shoch counters this suggestion by saying that this process, though present to some extent, cannot under any circumstances account for the highly conspicuous erosion we see today (Shoch and McNally 2003). Nor is another geologist, Colin Reader (2001), particularly convinced by Shoch. He puts forward yet another hypothesis to explain the waterless erosion without resorting to a drastic antedating of the monument. According to Reader, the enclosure of the Sphinx may have been created some centuries before Khufu; the morphology of the plain would have caused great quantities of rainwater to be channeled into the enclosure, filling it with water every time there was a rainstorm. Then, however, the excavation of quarries for the great pyramids, placed upstream of the Sphinx, would have interrupted the process, stopping the flow of the waters.

I am not a geologist; however, recently, I was granted permission to visit the interior of the Sphinx's enclosure (usually forbidden to tourists due to the need to safeguard the monument), together with the team of Roberto Giacobbo's program "Voyager" on Italian national television, and I can confirm personally that the walls, especially in the evening with the striking drop in temperature that occurs in the winter in the desert, really look as if they were made the day before out of wet sand.

As far as the symbolism of the monument is concerned, the Sphinx of Giza (whether it was sculpted in the reign of Khafre or previously) is the first known Sphinx. Guidebooks say that the entrance to the temple was guarded by two sphinxes, an assertion based solely on the presence of two statue bases, on which anything could have stood. So we cannot refer to any known stylistic canons here. As we saw in Chapter 4, the Egyptians of the New

Kingdom almost certainly knew the constellation of Leo, so we might suppose that this constellation had already been named in this way by the age of the pyramids, as indeed Orion had. During the age of the pyramids the summer solstice fell in Leo, hence the leonine symbolism may have originated from the sun cult aimed at a "solarization" of the pharaoh (the theory put forward by R. Bauval and G. Hancock (1997), which hangs on the idea that the Sphinx, which is oriented toward true east, did not just represent the constellation of Leo but also the Age of the Lion, that is, the period in which the spring equinox fell in Leo around 12,500 BC, is not backed up by a shred of historical or archaeological evidence, and therefore has to be rejected).

For the sake of completeness, let's look at the attribution of the pyramid of Menkaure. The third pyramid, the Funerary Temple, the causeway, and the Valley Temple are all glaringly, bleakly, completely anonymous. The name of Menkaure or of anyone else has never been found on them, and if the name ever was there, it must have been rubbed off. They are possessions without owners. The attribution to Menkaure derives from the discovery of some beautiful statues of the pharaoh, so the association is *indirect*, exactly as with Khafre. In fact, in 1837 Howard Vyse found an empty stone sarcophagus in the pyramid (unfortunately lost in a shipwreck shortly afterward). Vyse also unearthed fragments of a wooden coffin and the mummified remains of a male. The coffin bore the inscription "King of Upper and Lower Egypt, Menkaure, who lives for all eternity"; the only drawback is that the style of the coffin belongs to a much later period, while the human remains, after being subjected to radiocarbon dating, turn out to be from the Christian epoch.

18.5 A Point to Shift Up, or a Pyramid to Shift Back?

All in all, there is no incontrovertible proof that the second pyramid of Giza was built by Khafre. We only have very clear evidence that this pharaoh quickly became associated (probably while he was still alive) with the architectural complex of the annexes to the pyramid, and it is likely that the buildings were completed during his reign. So, strange as it may seem, there is no incontrovertible proof that the second pyramid was planned and built by one of Khufu's sons, and consequently there is no incontrovertible proof that it was built after the first pyramid.

There is, therefore, another opportunity for placing the point representing the second pyramid on the calibration lines based on simultaneous transit. Instead of reflecting it with respect to the time axis, we can shift it back until it meets the line in the area of the east-deviating errors, the area to which it actually belongs. If we do this, we see that it places the second pyramid at an epoch immediately (some years) before the one marking the time of the construction of Khufu's pyramid.

Following strictly this reasoning, one would infer that the archaeoastronomical data show that the second pyramid was built first, or rather, that the orientation ceremony for this pyramid took place first, while the building itself remains undated. This idea does not disagree with the archaeological data, since, as has been seen, there is no proof that Khafre was the initiator of the project for the second pyramid. Building a pyramid of two million blocks is a very serious business, so if there is already one around, and a king takes it upon himself to build another just a few yards away, maybe he would make it smaller, for financial or other reasons, like Menkaure. But if he wishes to make it more or less the same size as the other, why would he make it slightly smaller? Who has ever made something slightly smaller than that of his predecessors? "*Piu' grande ma non piu' bella,*" which means "Bigger but not more beautiful," commented Michelangelo when he compared his design for the dome of St. Peter's in Rome with Brunelleschi's earlier masterpiece in Florence.

Yet he did make it bigger.

When I first suggested that archaeoastronomical data showed the need to reverse the chronological order in contrast to that traditionally accepted (Magli 2003), I did not really have any adequate historical or archaeological justification to back me up, although the need for a tomb for Khafre could easily be solved with the anonymous pyramid of Zawiet el Arian. But immediately afterward, discussing with my friend and colleague Juan Belmonte, he observed that the data actually allow the two pyramids to have been planned together. Indeed, it is possible to suppose that the original design for Khufu's tomb included *two* buildings, just like that of his father Sneferu at Dashour and like the two tombs in Djoser's complex, in line with the duality of burial place that has prevailed from the time of the earliest dynasties. From the technical point of view, once having shifted the point of the second pyramid back in time, the relative difference between the orientation errors of the two great pyramids is so small (2.6′) as to fall effectively into that band of errors ascribable to the repeated observation of the same phenomenon *at the same time.*

In conclusion, the simpler hypothesis that is compatible with the data is that the bases of the two great pyramids of Giza were traced out together in a common project. Khafre then appropriated the second pyramid, and his original tomb, left unfinished, may really have been initially the great pit of Zawyet el Arian, which is anonymous, but appears to be very similar to the pyramid of Abu Roash. (We could try to improve our knowledge of fourth dynasty pyramid chronology by using dendro-chronology, that is, the dating method based on the examination of the annual growth rings in ancient trees; the sequences of these rings are no longer complete, but the technique would at least allow us to put the wooden finds from the pyramids—for example, Khufu's boat and the wooden beams at Dashour—in chronological order).

As we shall see in the next chapter, highly convincing proofs exists to support the homogeneity of the design of the two main Giza pyramids and to explain the origin of this project, actually the largest architectural project in human history. These proofs have always been in plain view. But to see them one has to acknowledge that the extraordinary "rebirth machines" created by the pharaohs were rooted in a vision that was deeply anchored to the sky and the stars.

19 The Sacred Landscape in the Age of the Pyramids

When the sacred manifests itself in any hierophany, there is not only a break in the homogeneity of space; there is also a revelation of an absolute reality, opposed to the nonreality of the vast surrounding expanse . . . the hierophany reveals an absolute fixed point, a center.
—M. Eliade, *The Sacred and The Profane: The Nature of Religion,* 1959

19.1 An Ordered Landscape

We have come a long way since the idea that the pyramids were nothing but the product of the wildest dreams of megalomaniac sovereigns, monuments created without any overall design and packed with ventilation shafts. But our journey is not yet over.

We have still to tackle the problem of the topographical arrangement of the pyramids themselves, or more precisely of those located in that vast area stretching from Abu Roash to Abu Sir, by way of Giza.

Let us start with a careful look at a map of the plateau. Immediately one gets the impression that the arrangement of the great pyramid complexes on the plain is not random, but quite ordered, following a strict but unfathomable logic.

To remove any lingering doubts, let us suppose that we have one building in a neighborhood, and an architect decides to add another. He will normally build the new one in line with the others, unless there is not enough space, an intervening river, or some other natural obstruction. The other alternative is to break away completely from what already existed, to arrange the new building in as original a way as possible.

In fact, at Giza it did not happen either of these two ways. The designers did not choose to place the two buildings in line, even though they could have done so if they so wished. Aligning the pyramids on the same parallel would not have made sense, since it would involve moving steadily away from the Nile, with the preexisting pyramid plumb in the middle. But placing

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_19,

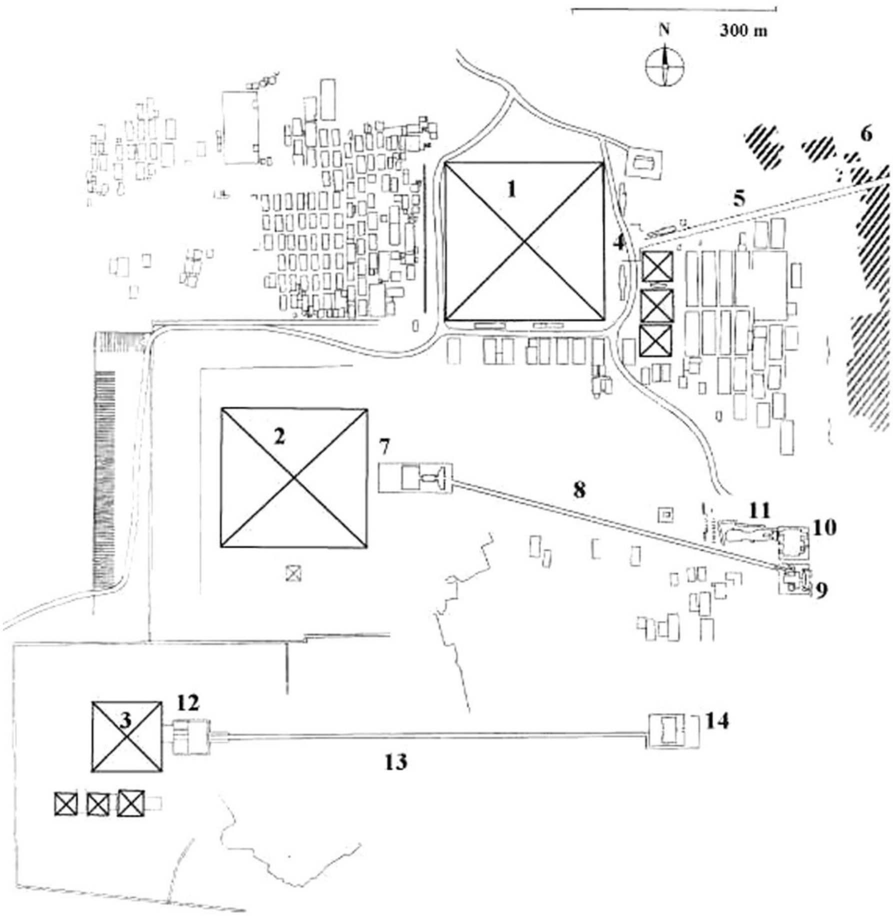


Figure 19.1: Schematic map of the Giza plateau: 1, 2, 3 Main Pyramids; 4, 7, 12 funerary temples; 5, 8, 13 causeways; 6 modern village; 9 Khafre Valley Temple; 10, 11 Sphinx Temple and Sphinx; 14 Menkaure Valley Temple

the new pyramid on or near the same meridian of the preexisting one, facing the Nile, would have been a convenient solution in all respects. That, however, was not done, and not for any reasons relating to the morphology of the land—quite the opposite. Indeed, the geography of the place, if anything, would clearly have deterred the designers from building Khufu's pyramid so close to the rocky ridge running across the northern part of the plateau. As it was, to build the causeway sloping downhill, they had to create hefty structures out of stone blocks, which allowed the monumental path to leapfrog over the abrupt edge of the plateau, more than 20 meters high. Some of the blocks from this great endeavor can still be seen at the point where the Giza archaeological area ends, north west of the Great Pyramid, and the modern village of Naziet starts.

The pyramid of Khafre, in turn, even though it is located in a much more amenable place, in that it is the highest on the western horizon (making it seem taller than Khufu's, though in fact it is not), and the plateau stretches out more gently at the base, is not really situated in what would be the most natural position. The idea—sometimes put forward—that its location may be due to the necessity of having a free view in the north for orientation is easily seen to be unsound, since there was no need for a free horizon in the north to look at the sky in the zone of circumpolar stars; the maximal blocking-sight view of the first pyramid viewing from the parallel of the northern baseline of the second is nearly equal to the height of the pole. The best place of all would actually have been a few dozen meters eastward, avoiding the rocky ridge behind the west side. Yet, to build the monument exactly where they wanted it, the planners needed to cut through the bedrock of this ridge to a length of several hundreds meters. This huge gash is still visible today, running along the west side of the pyramid, and is one of the most spectacular engineering works ever carried out on the Giza plateau. The result, which was clearly planned and wanted, was that the diagonals of the two great pyramids are almost aligned in such a way that, as we shall see in a moment, the lines formed by the their southeast corners point toward a preordained direction.

This puzzling arrangement can be seen quite clearly in the reconstruction, made by Egyptologist Mark Lehner (1985a), of the plateau of Giza before and after the building of the pyramids. The plateau has a funnel shape, which, from the horizon visible from the Nile flood plain, narrows off as it descends gently toward today's sound-and-light-show area, opposite the second pyramid temples, while to the north the rocky ridge rises steeply until it forms the outcrop in front of the east side of the first pyramid. By studying the geology of the area, Lehner also discovered something curious: the main quarry for the first pyramid is situated to its south, a quite natural position, but it stops just at the level of the second pyramid's causeway. Since it is obvious that it would have been preferable to start the quarry as near the pyramid as possible so that the access ramp would be initially low and short, it would appear that the designer had factored in the construction of the second pyramid's causeway right from the start.

Finally, the position of the third pyramid, that of Menkaure, is completely incomprehensible. It is located very, very far, a long way off from everything else, lost in the desert. Thus, enormous extra effort was required to build it; for example, the lower courses of casing, made of heavy granite blocks from Aswan, were transported along the Nile and then laboriously dragged across the desert. No geological or morphological reasons can justify planting a pyramid in such an insignificant, almost hidden location. At first glance, the only conceivable reason might be that placing the pyramid at such a distance enabled the southeast corner to be aligned with those of the other two pyramids…

Thus, there can be no doubt that a scheme with its own internal logic was followed at Giza. The two great pyramids, in particular, show clear signs of constituting a unified project, and the pyramid of Menkaure seems to have been deliberately planned to correlate harmoniously with them. The same can be said of the causeways and temples, as we shall see in the next section. The basic problem, then, is understanding the logic behind it all. And yet it does not appear that Egyptologists ever considered the possibility that the great structures of the Giza plateau were all created according to an overall design or common framework (see e.g. Jordan 1999).

19.2 The Horizon of Khufu

To investigate further the possible existence of an overall plan at Giza, we start with the observation we made with regard to the two great pyramids' orientation on the cardinal points. As we saw in the previous chapter, the pattern of orientation errors of the pyramids of Khufu and Khafre suggest very clearly that both monuments were built, or at least laid out, contemporaneously; accordingly, this suggests that the project was originally conceived as a whole by Khufu, and then Khafre claimed for himself the second pyramid, perhaps completing its construction. Besides the clues coming from the orientation, one only has to observe Giza from a few kilometers' distance, for example from the hill of Abu Rawash (Plate 31), to realize that the two pyramids look like twins and give the impression of having been built to convey a single message, while the third pyramid, Menkaure's, becomes almost invisible, an upstart, an intruder into an already standing, far more ambitious project. One only has to experience this once to appreciate that the effect would be similar from any place in the Cairo valley (except one; see below), if it were possible to see through the modern buildings and air pollution that today are blocking the view of the two pyramids.

Thus, the two monuments dominate the western horizon. Is it really possible that Khufu conceived of, and in part executed, a project that was double the size of that commonly attributed to him? If so, it is highly likely that the temple complexes of the pyramids are also to some extent "twins." Further, as we already know, if a unified design of an architectural complex

Figure 19.2: The two main pyramids as viewed from the area in front of the Sphinx

follows principles of symmetry, its astronomical alignments, granted that they exist, usually would tie in with this symmetry (think of the horseshoe axis of the Stonehenge triliths). To seek further evidence, I have therefore followed an archaeoastronomical approach, once again inspired by the studies of Mark Lehner (1985b), who was the first Egyptologist to highlight the main astronomical references of the monumental complex downhill of the second pyramid:

1. The Sphinx was probably a sun symbol aimed at ensuring the "solarization" of the deceased pharaoh. It looks toward true east, that is, to the rising of the sun at the equinoxes. On such days, if the sun is observed from the area of the Sphinx temple, it sets in the vicinity of the south corner of Khafre's pyramid. Specifically, the southern corner is aligned with the point found at the beginning of the causeway, reachable via a spectacular granite-encased tunnel that starts inside the Valley Temple.
2. At the summer solstice, beginning of the flood season, looking from the same point, the sun sets at the midpoint between the two great pyramids. This image creates a sensational hierophany: a giant replica of the hieroglyph *akhet*  or "sun mountains" made up of the solar disk, which sets—or rises—between two mountains. This hieroglyph also means "horizon" in the sense of the place where the sun sets or rises, and was associated with the Great Pyramid, which was called *Akhet Khufu*, that is, Khufu's horizon. The choice of the symbol was by no means coincidental. There also existed a version without a disk, or

djew, which possibly represented a sort of "primordial mountain," still with two peaks, however, and was linked to the death cult—to the extent that Anubis, guardian of the underworld, is sometimes called "he who is between two mountains" (there also existed a version in which it was Horus who was placed between the two mountains,  so that the hierophany, seen from opposite the Sphinx, might also be referring to this symbol (Shaltout et al. 2007).

The appellation "Khufu's horizon" for the first pyramid is confirmed in several inscriptions dating from after its construction, although the corresponding hieroglyph entered in use in the 5th dynasty. The tomb of Qar also has the name of the second pyramid, "Khafre is great." Nevertheless, though it would appear linked only to the name of the Great Pyramid, the *akhet* hieroglyph only manifests itself if both the great pyramids at Giza exist. We thus have new and compelling evidence that we are dealing with a unified project.

Other evidence of an archaeoastronomical nature comes from the arrangement of the two causeways, which, as we have seen, are symmetrical in relation to the eastwest line. These causeways point toward the sunset in the two points located halfway between the equinoxes and the solstices (winter and summer, respectively, for the first and the second pyramid) (Bauval 1989, Bauval and Gilbert 1994). But as the rate of movement of the sun at the horizon is not constant, these two days do not correspond to the division of the period of time between equinoxes and solstices into two equal halves. What we have is rather a geometric division of the sun's path throughout the year rather than an astronomical or calendrical-type division. At any rate, it is an interrelated arrangement into which, yet again, Menkaure seems to have been inserted harmoniously at a later date, in the best possible way to respect the preexisting symmetries. Indeed, since the two causeways are symmetrical in relation to the eastwest line, he adjusted the ceremonial causeway of the third pyramid along this line.

Naturally, one would think that if the two great pyramid complexes really were designed together, then Khufu's Valley Temple must be linked to a solar phenomenon that is symmetrical to the one the Valley Temple of the second pyramid is linked to (the summer solstice)—that is, the winter solstice (Magli 2008b,c). With this idea in mind, I searched carefully through existing archaeological studies on this temple, which is buried under the modern village that has sprung up at the base of the pyramid. These studies relate to probe digs carried out over the years by the Egyptologists Messiya, Goyon, and Hawass. It can be concluded with reasonable certainty that a monumental building, probably the temple itself, or at least a ceremonial palace associated with the pyramid complex, was situated in an area where the causeway and the ideal extension of the north side of the pyramid intersect, and thus in a special position analogous to the corresponding connection point of the second pyramid's causeway. From this position one could see (and still can) the sun at the equinoxes setting in line with the north side of the first pyramid. Moreover, tracing a line pointing to the sunset during the winter solstice, one sees that this line passes through the center of the funerary temple opposite the second pyramid; therefore, on that day the sun sets, if observed from the same point, behind the second pyramid (this hierophany could perhaps allude to another hieroglyph, 𓇶, the "disk with rays").

It would seem, therefore, that the astronomical alignments of the first pyramid complex mirror that of the second pyramid complex; the symmetry in the astronomical references enables the sun's cycle to be followed throughout the year with eight specific days: the two solstices, the two equinoxes, and the four days at which the sun sets halfway between the equinoxes and the solstices.

Admittedly, we are shortening the odds of all this being part of a unified master plan. It is not uncommon today for outstanding architectural works to be given a name that sums up its contents, and I believe that the same occurred 4500 years ago: *Akhet Khufu* was the original name given to this master plan—the largest architectural project that humanity has ever conceived.

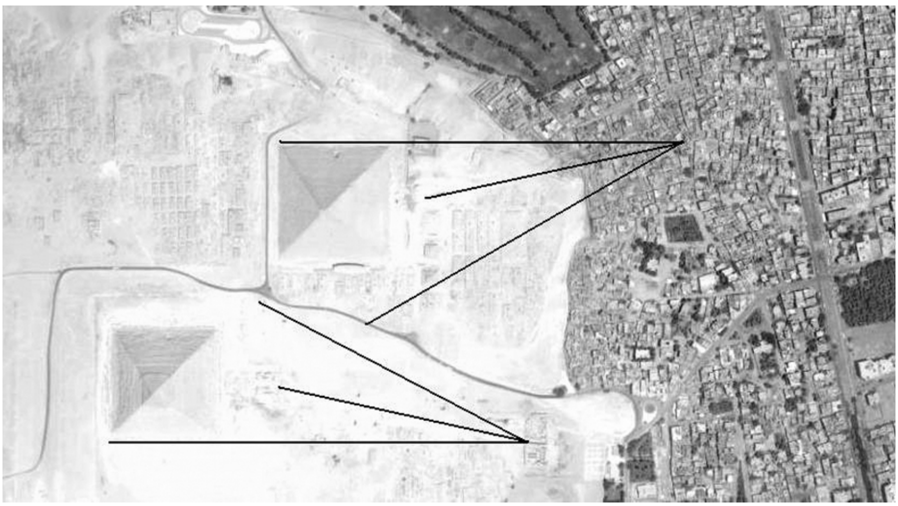


Figure 19.3: The solar alignments of the valley temples with respect to the two main pyramids

19.3 Orion, Sirius, and the Sacred Landscape in the Age of the Pyramids

Still other clues point to a unitary project at Giza. First, however, we have to widen our analysis to the global arrangement of the plateau, and beyond.

As we have learned, interesting discoveries in the realm of archaeotopography are made by applying the methods of archaeoastronomy to landscape (natural or human-made) features when studying alignments. For instance, we have seen that monument builders in the past took great interest in sacred mountains, as in the case of the Incas or of the dolmen of Antequera in Spain (see Chapter 15).

The French Egyptologist Goyon (1994) was probably the first to suspect that two ancient cities located north of Giza, Letopolis and Heliopolis, had an important role to play in the sacred landscape of the Age of the Pyramid.

Letopolis was sacred to Horus and lay on the west bank of the Nile, directly north of Giza. This association with the north, and thus with the constellation of the Bull's Foreleg, was reinforced by the fact that the very shape of the Nile territory as it widens in the delta recalls this constellation, and indeed Letopolis was the capital of the Egyptian province bearing the name "Bull's Leg."

Heliopolis, situated northeast of Giza on the east bank of the Nile, had been a center for sun worship since the earliest dynasties (see Chapter 16). The sun temple of Heliopolis was known as *Iunu*, that is, "column" or "pillar," and was a sort of "umbilicus mundi" of the country; there would appear to be no doubt that the priests there were engaged in astronomy.

Apart from noting that Letopolis lay exactly to the north of Giza, Goyon also noticed that the distances between Giza and Letopolis and between Letopolis and Heliopolis are approximately equal. Further, at Giza there is a clear signal of interest in Heliopolis: the "diagonal," on which the southeast corners of the three pyramids align, points toward this city.

Another aspect that might be significant in the link between Giza and Heliopolis is the position of the capital of the Old Kingdom, Memphis. Memphis stands further to the south of Giza, on the west bank of the Nile, close to the necropolis of Saqquara. The location does not appear to be particularly appealing for the erection of the most important city in the kingdom; it is near the Nile flood plain and criss-crossed (even today) by irrigation canals dating most probably from ancient times. Recently, however, during his survey for the refurbishment of the whole Giza area (the Giza Master Plan Project), architect Tarek Naga (personal communication to the author) noticed that Giza, Heliopolis, and Memphis roughly form the

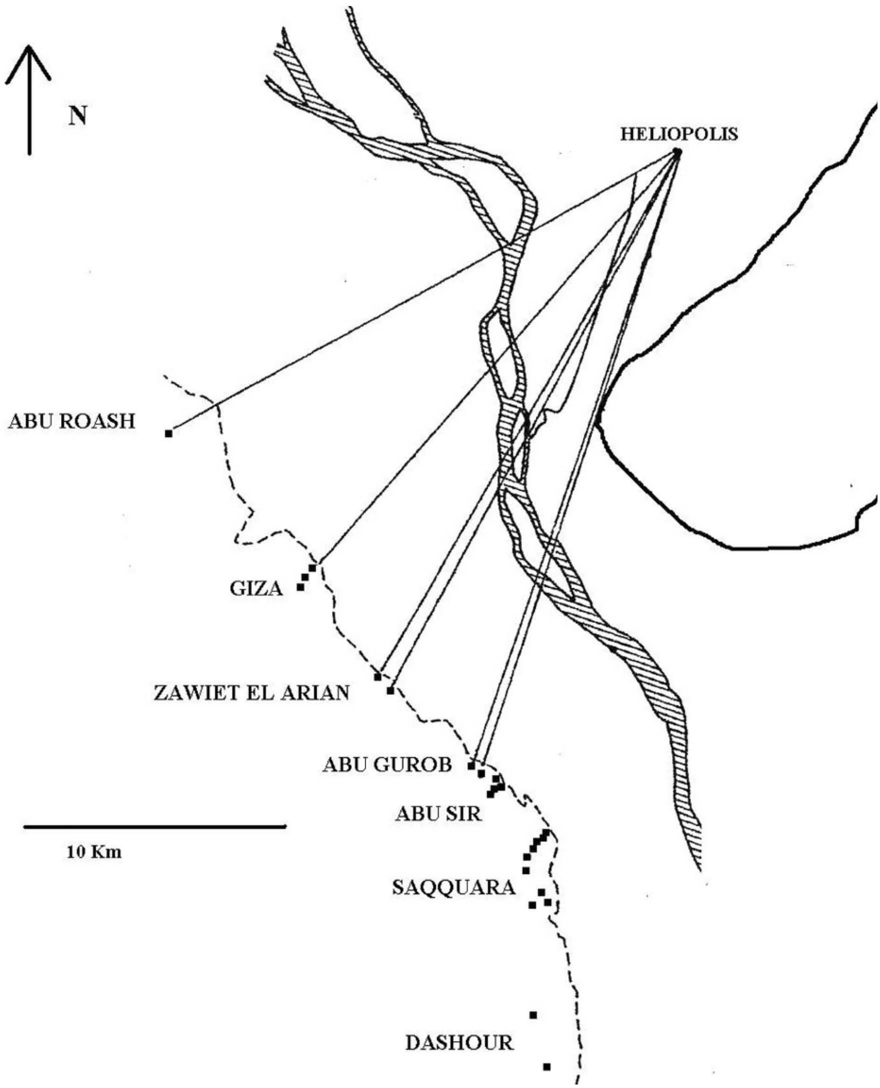


Figure 19.4: Intervisibility of the pyramids of the Memphite area and Heliopolis (adapted from Jeffreys)

three vertices of a "sacred" right-angled triangle (the 3,4,5-sided triangle) of which the Memphis–Heliopolis stretch takes up the hypotenuse.

It is tempting to assume, then, that Heliopolis was somehow the center of attraction for the entire sacred area during the Age of the Pyramids. Could this really be the reason why Menkaure puzzlingly chose to build his own pyramid in an area so far from the ridge of the plateau—the desire to align its corner along the Giza diagonal that indicated Heliopolis? Nevertheless, sliding the corner of a pyramid along a line is obviously not sufficient for fixing its position on the ground. One must also decide where to stop—and Menkaure decided to stop pretty far off. Why?

One possible answer is provided by the controversial but nonetheless fascinating theory called the Orion correlation theory. We imagine ourselves at Giza, watching the sky to the southeast on a clear night, while we await the rising of the stars of Orion's Belt. In the sky twinkles the Winding Waterway of the Milky Way. The first to rise is the constellation of Taurus, with its

Figure 19.5: An old picture of the Giza Plateau from south-west; the line defined by the right corners of the pyramids in the picture points to Heliopolis.

elongated shape, then Orion, and then the Belt, which is unmistakable, as it consists of three stars, two of which (Al Nitak and Al Nilam) have virtually the same brilliance, and the third (Mintaka) is slightly less bright. We can trace out a segment, a main diagonal, between the first two stars. The third star, however, does not lie on the diagonal; it is a little displaced. Now let us look at the ground: to our left flows the stately Nile, and we have three enormous pyramids, two almost identical, with a smaller third one, slightly displaced with respect to the diagonal of the other two. The idea, then, is that the overall arrangement of the three pyramids in relation to each other, and also to the Nile, has been astronomically anchored to create a terrestrial image of the three stars of Orion's Belt and their position in relation to the Milky Way (Bauval 1989, 1995). (Another of Bauval's proposals—that the arrangement of these monuments is linked to the configuration of these stars at a much earlier time than the Age of the Pyramids—is not supported by historical or archaeological evidence, and therefore has to be rejected.)

If this theory is right, Giza is a beautiful example, as well as being one of the first chronologically, of a sacred landscape that has been conceived as a replica of the sky. To test its validity, we first consider the quantitative aspect. This test can be done using a high-resolution photograph of the Belt, and identifying the two points defined by the brightest stars of the Belt with the centers of the Khufu and Khafre pyramids. Using the scale thus obtained and looking for the position of Menkaure, it is seen that the center of this pyramid is located about 30 meters away from the point that would correspond to the third star (this latter point falls therefore within the base of the pyramid).

What are the odds that it is just a coincidence? It is difficult to answer this question since we are not dealing with an astronomical alignment in the strict technical sense of the term (Magli and Belmonte 2008). In fact, the distance of the stars from one another hardly varies at all over time, and so if we carefully choose three points, anywhere, that have the same arrangement and scale (not so difficult to find—for example, three towns conveniently selected from an atlas or three lampposts), we can claim to have discovered a correlation with Orion produced yesterday or a hundred years ago. The sport of seeking stellar correlations in the layouts of cities, cathedrals (or even mountains . . .), often not even visible from one another, has become immensely popular on the Web. Therefore, a rigorous approach is insufficient to prove the validity of the theory. One could even reverse the process and, keeping fixed the pyramids, find three other stars that match. However, the Pyramid Texts (Chapter 17) confirm that the stars of Orion belonged to the Duat realm of stellar rebirth in the Old Kingdom funerary

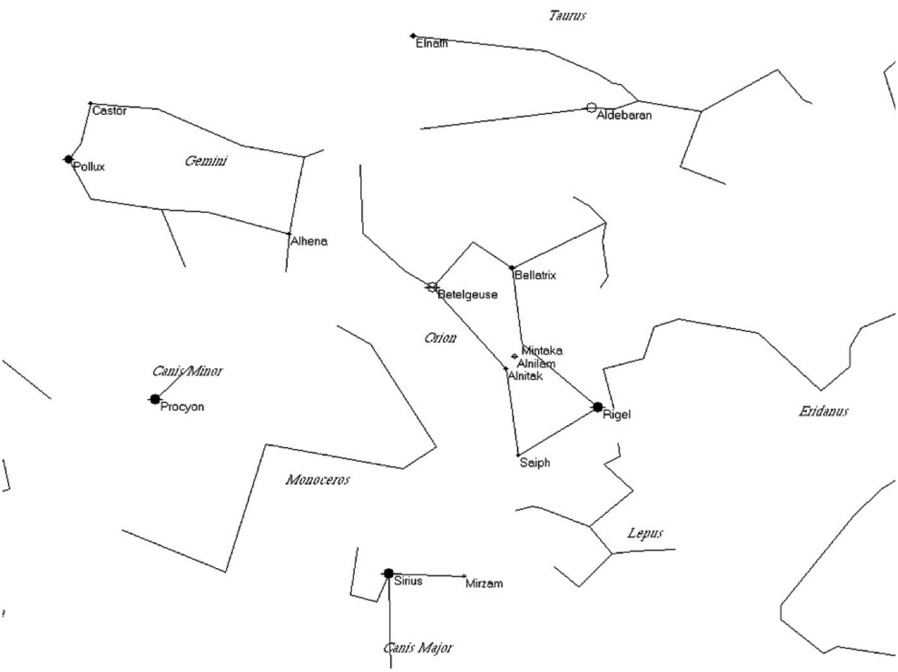


Figure 19.6: The "Duat" region of the sky

cult, and the orientation of the southern shafts of the Khufu pyramid further strengthens this conclusion at Giza; therefore, the proposal of an Orion correlation makes sense.

All in all, I believe that, although we cannot assert that the correlation is "proven," it provides a feasible explanation for the problem of understanding why the third pyramid was located so far away in the desert. I do think, however, that the original layout of the two main pyramids had nothing to do with the correlation with Orion; if the correlation is really there, then it was Menkaure who had the clever idea (since for reasons of shortage of resources, he was forced to build a more modest pyramid than the other two) of taking advantage of the existing ones and adding a new "dimension", the representation of the third star on the ground, thus assuring himself the title of "great," along with his predecessors (the name of the third pyramid was "Menkaure is divine"). Most of the criticisms that have been leveled against the Orion correlation theory actually tend to be somewhat subjective or prejudiced, except perhaps that of the archaeoastronomer Edwin Krupp (1997b), who rejects it observing that, if one looks at the plateau of Giza, from north to south, and compares it with the sky, one sees, in order across the plateau, Khufu, Khafre, and Menkaure, and in order across the sky, Mintaka, Al Nilam, and Al Nitak. So it might be said that the pyramids and stars were "cross-linked" (the cardinal points in the sky and on earth were exchanged) when the image of the sky was brought down to the earth. This objection is a valid one, but there is no absolute recipe for replicating the sky; further, if Menkaure conceived the idea, he had no other way round to realize it.

Another topographical issue that might be possibly assuaged by archaeoastronomy regards the choice of the site of Abu Roash by Khufu's first son, Djedefre. Again, it makes sense that this king did not choose the best available position for building a pyramid—which, as we have repeatedly seen, essentially was that of Khafre—only if one admits that this position was already occupied. However, instead of choosing another building site on the plateau (it is certain that works in Giza were carried out under Djedefre, since the Khufu boat pit brings his cartouches), he moved several kilometers north, to a hill that should have created additional problems for the access of materials from the Nile. Why did he move there?

Whether it is by chance or not, the Abu Roash pyramid is situated at an azimuth, in relation to Heliopolis, equivalent to that of the sun at the winter solstice, which was thus seen from this city as setting on the pyramid (Bauval 2006); Sirius also had a similar azimuth at the time of the construction of the pyramid (Shaltout et al. 2007), and perhaps this was connected to the name of the pyramid, which was "Djedefre is a star *Sehedu*" (we do not know the meaning of the term *Sehedu*). Therefore, the project for Djedefre's pyramid was likely linked to Heliopolis. Actually, in a comprehensive study of the visibility between Heliopolis and the Old Kingdom pyramids, Egyptologist David Jeffreys (1998) has shown that all the pyramids of those pharaohs claiming an "affinity with the sun" were built in areas on the west bank of the Nile that were visible along with Heliopolis—from the north, Abu Roash, Giza, and Zawiet el Aryan. The last site visible with Heliopolis going south is that of the sun temples of Abu Gurob; even further southward, the view is blocked by the rocky formation that stretches out into the medieval citadel of Cairo.

Thus, strong evidence exists that, under the fourth dynasty, the entire area of Memphis was conceived of as a sacred landscape, with isolated monuments that communicated with one another visually during the day and via astronomical alignments at dawn, sunset, and during the night. It is likely that some of these links are yet to be discovered. As far as we are concerned, however, our journey is almost over, except for one very last thing.

19.4 Mirages from Heliopolis

Since I started thinking about the "Giza diagonal" facing Heliopolis, I had the impression that something was eluding me. For a long time I was unable to identify what was actually "wrong" however, until, one day, I stopped "looking without seeing" and then I understood (or at least, *I think* I did).

The fourth-dynasty pyramids were built in places, such as Giza, that were visible from Heliopolis, so they would appear to have been built to be *seen* from Heliopolis. *But that is not the case for the second Giza pyramid.* If we approach Heliopolis and look towards Giza along the famous "diagonal" we can only see one pyramid, Khufu's, because the second is hidden from sight by the gigantic mass of the Great Pyramid.

Today it is utterly impossible to check this "mirage" from the centre of Cairo, owing to the buildings and smog. However, if we extend the diagonal in the opposite direction, towards south-west, we find ourselves in the middle of the desert, where the Fayum highway passes. Here the view is quite clear, and stopping at the roadside, it is possible to see the "opposite" mirage, that is, see the mass of the Great Pyramid vanish behind the second (of course the third pyramid—which would disappear as well if looking from Heliopolis—is in this case in the foreground). Why?

Why would Khafre, who was evidently as well-off as his father and could select a place and/or position anywhere he wanted, decided to build his pyramid in such a way that, although enormous, it was invisible from Heliopolis because his father's pyramid was stuck in the middle?

It seems to me to be far more logical to suppose that it was initially Khufu who wanted to show he was "owner of the horizon" with his double monument, named accordingly "Khufu's Horizon". At that time he also resolved to lay out the pyramids so that they were "reduced to just one", only when seen from a specifically chosen site, Heliopolis, as a sign of respect for the Sun God (Magli 2008).

My hypothesis, actually, can be developed quite beyond than that, and leads to new elements in the interpretation of the whole "sacred topography" of the Memphite area. Indeed, I maintain that Khufu actually inaugurated a way of interpreting and modeling the sacred landscape which ruled *all* the placements of the pyramids up to the end of the V dynasty. This model, which I will call the "symbolic invisibility" model, requires that the funerary monuments of the pharaohs have to be built along what I will continue to call, for simplicity, a "diagonal" but, more precisely, is a straight line of sight which connects a chosen element of the layout of the pyramids of dynastically-related pharaohs, ending in the location of the temple of

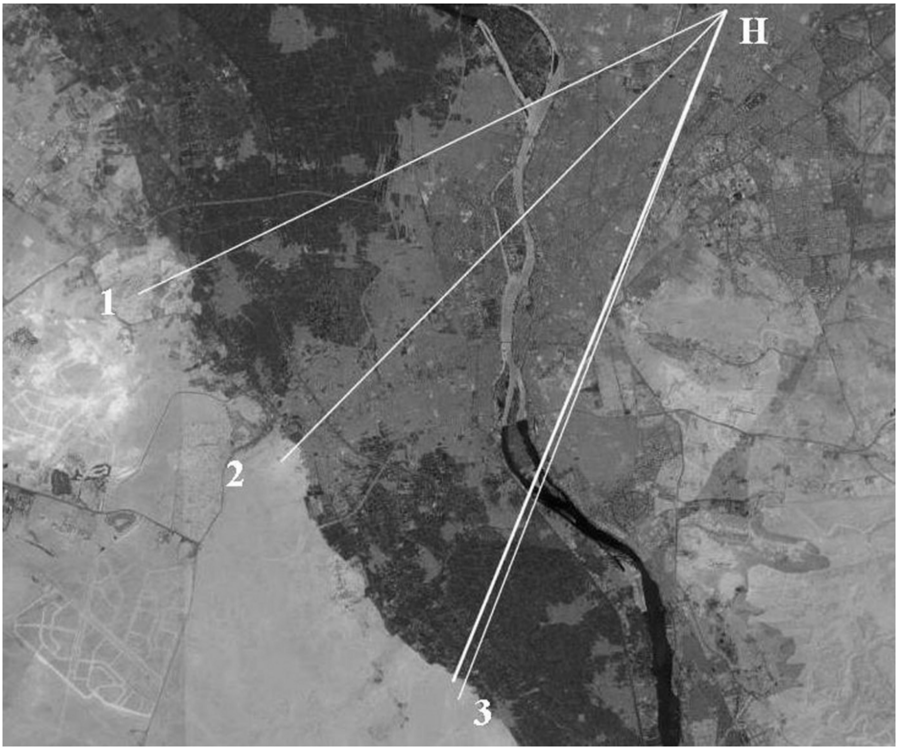


Figure 19.9: A satellite image of the Memphite area: H Heliopolis; 1 Abu Roash diagonal; 2 Giza diagonal; 3 Abusir diagonal. The heaviest solid line close to line 3 is the last (going south) inter-visibility line between the west bank of the Nile and Heliopolis, and corresponds to the Userkaf sun temple.

Heliopolis. Interestingly, although of “topographical” origin, these “diagonals” had *also* to include astronomical significance, as we shall soon see.

The first to conform to the "symbolic invisibility" concept was Djedefre, Khufu’s son. Indeed, when we plot the line which connects Heliopolis with his pyramid’s south-west corner, we see that it crosses near the south-west corner of another pyramid, the so called Lepsius 1, which sits at the easternmost end of the Abu Roash hills. Rather than forming an Akhet sign (as has been recently suggested, see Shaltout at al. 2008) these two pyramids thus form a "Abu Roash diagonal" oriented $\sim 28^{\circ}$ south of west. As we have already seen, this is a astronomically relevant direction which points quite precisely to the winter solstice sunset and, less precisely, to the setting of Sirius (the attribution of Lepsius 1 is unknown and it may even belong to a double project conceived by Djedefre; today, only the inner structure of the monument, excavated in the rocky plateau, remains).

After, Khafre decided to conform himself to the model returning to Giza, so he probably appropriated and finished the construction of the second pyramid (in any case, he attached “modestly” his tomb to a pre-existing project). Next, Menkaure arranged the layout of his funerary complex in order to harmonize with the pre-existing one. The dynastic lineage of Khufu was thus actualized at Giza by the “symbolic invisibility” ; perhaps all this had something to do with a passage of the Pyramid Text (PT 307) where it is said “my father is an Onite, and I myself am an Onite, born in On when Ra was ruler” (*On* stands for Heliopolis in Faulkner’s translation). (Plate 31).

As we have seen, the direction of sight from Heliopolis on the Giza "diagonal" is oriented $\sim 45^\circ$ south of west. Once again, this is an astronomically relevant direction. In the period of the pyramids’ construction this direction was indeed pointing to the setting of the brightest part of the Milky Way. Actually, at those times, an observer looking from Heliopolis would have seen the stars of the Southern Cross, followed by the very bright stars of Centaurus, "flow" together with the great celestial river and disappear from view behind the apex of the Great Pyramid.

Menkaure was succeeded by his son Shepsekaf. For some unknown reasons, to this pharaoh corresponds a break in the tradition consolidated after Khufu. Indeed (as mentioned in chapter 16) he choose to build his tomb as a sort of giant Mastaba at Saqqara; the decision of going far away, and completely out of sight from Heliopolis appears to be reflected also in the pharaoh’s name, which does *not* bring the "solar" suffix.

After him, to the throne ascended Userkaf, probably a grandson of Djedefre. With Userkaf we see something which looks like to a return to the tradition. First, he built a pyramid, not a Mastaba, and his pyramid was located as close as possible to the external wall of the first pyramid ever constructed, the Djoser pyramid in Saqqara. Interestingly, in this way he also initiated a new "diagonal" which was to be continued in much later times, starting from the end of the V dynasty, apparently for pure “imitation” of the Giza one. Indeed, this “Saqqara diagonal” is directed as the Giza diagonal $\sim 45^\circ$ south of west, and therefore of course it does *not* point to Heliopolis (since Saqqara is many kilometers south of Giza). This diagonal connects the north-west corner of the Teti pyramid, the south-west corner of the Userkaf pyramid, the south-west corner of the Djoser pyramid, the diagonal of the Unas pyramid and the north-west corner of the Sekhemkhet pyramid (Lehner 1985b). In any case, as far as what concerns us here, the most interesting point is that the return to the tradition was exemplified by Userkaf *also* with the construction of the first solar temple. Such a temple, as we have seen in Chapter 16, was a monument conceived in a way similar to the pyramid complex, consisting of a building set lower down, a

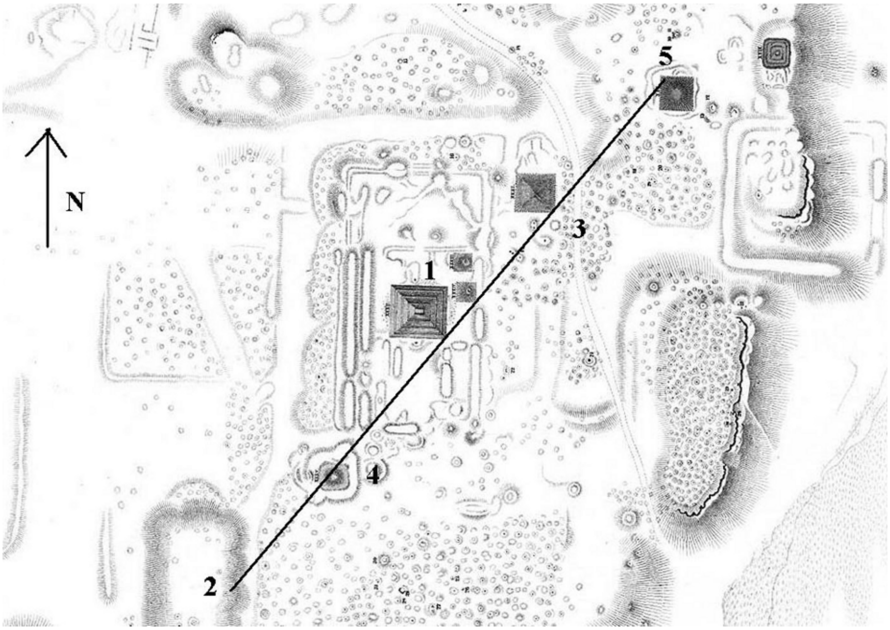


Figure 19.7: The pyramids of the ''Saqqara diagonal'' highlighted in the original Lepsius map (numbering of the monuments is in chronological order): 1 Djoser; 2 Sekhemnet; 3 Userkaf; 4 Unas; 5-Teti.

monumental access ramp sloping upwards, and a monumental area centered in an high obelisk and accessed from the ramp. Curiously, also the ramp of the sun temples is oriented $\sim 45^\circ$ south of west and again, since the temples are located more south than Giza, it does *not* point to Heliopolis; perhaps by chance, its direction indicated the raising of the bright star Deneb (of our constellation Cygnus) during the V dynasty. What concerns most us here is anyway the fact that the Userkaf temple is constructed *in the southernmost available point* of the west bank of the Nile from which Heliopolis *is* visible. Moving a few tens meters more south indeed, the area of Heliopolis becomes invisible due to the presence of the outcrop on which today is situated the Cairo citadel (after having noticed this fact I became aware that the German Egyptologists Werner Kaiser had already suggested that it may have influenced the choice of the site).

The pharaoh thus choose to stress his return to the tradition of the preceding dynasties building his pyramid as close as possible to the III dynasty pyramids of Djoser and Sekhemkhet (and inaugurating a "diagonal" with them) and building a temple dedicated to the Sun god in view from Heliopolis, as the IV dynasty pyramids are.

The successor was his son Sahure, the second king of the 5th Dynasty. With Sahure, whose name means "Close to Re", we definitively return to "solarised" kings. Thus, the natural choice for Sahure's pyramid would have been Giza, with the construction of a fourth monument aligned along the "Giza diagonal". However, building a pyramid complex even farther away in the desert than that of Menkaure's would have been nearly impossible. Thus, at least in my opinion, the Sahure architect had to find a new idea to allow his king to conform to the "symbolic invisibility" model. This idea was to place the pyramid of Sahure in the *first* available location in the south from which Heliopolis is *not* visible: Abu Sir. Immediately after, Neferirkare inaugurated a new "diagonal" in this place (Verner 2002). This "Abusir diagonal" connects the north-west corners of the pyramids built by Sahure, by his brother and successor Neferirkare and by Neferefre, son of Neferirkare (this last pyramid is unfinished) and points to the—invisible—Heliopolis; any person in Heliopolis however would have been aware, looking at the western horizon, that the brilliant obelisk of the Userkaf sun temple indicated the beginning of the sacred area, were the kings of the V dynasty decided to be buried, and that their pyramids were actually disposed along a "diagonal" pointing to Heliopolis although—modestly—in an invisible way. In this case, the obstacle to the view is due to the outcrop of the Cairo citadel which perhaps, in ancient times, may have hosted a temple as well.

Also this "diagonal"—inclined $\sim 71^{\circ}$ south of west— had an astronomical significance, since it was (roughly) pointing to the setting of the very bright star Canopus as seen from Heliopolis. We thus have three "diagonals"—Abu Roash, Giza, Abusir—and three very bright stars or groups of stars—Sirius, Crux-Centaurus, and Canopus—which respectively sat in (approximate) alignment with them. Interestingly, such stars all belong to the lists of the Decanal stars (Chapter 14); the first examples of such lists we are aware of were completed one or two centuries later the construction of these pyramids. After Neferefre reigned Shepseskare (but it should be said that, according to some scholar, Shepseskare reigned before Neferefre). His reign was probably very short, since only the base his pyramid was laid out. In any case, he had to confront to the same problem which faced Sahure, namely, it was impossible to "attach" the pyramid to the pre-existing "diagonal"—in this case the Abusir one—without going very far in the desert. Thus, the architect of the pharaoh planned the pyramid in the small space left between Userkaf's sun temple and Sahure pyramid, remaining in this way not just invisible, but "symbolically invisible" from Heliopolis. The problem of finding an adequate place for a pyramid then became even more difficult for Niuserre. The planners of his monument

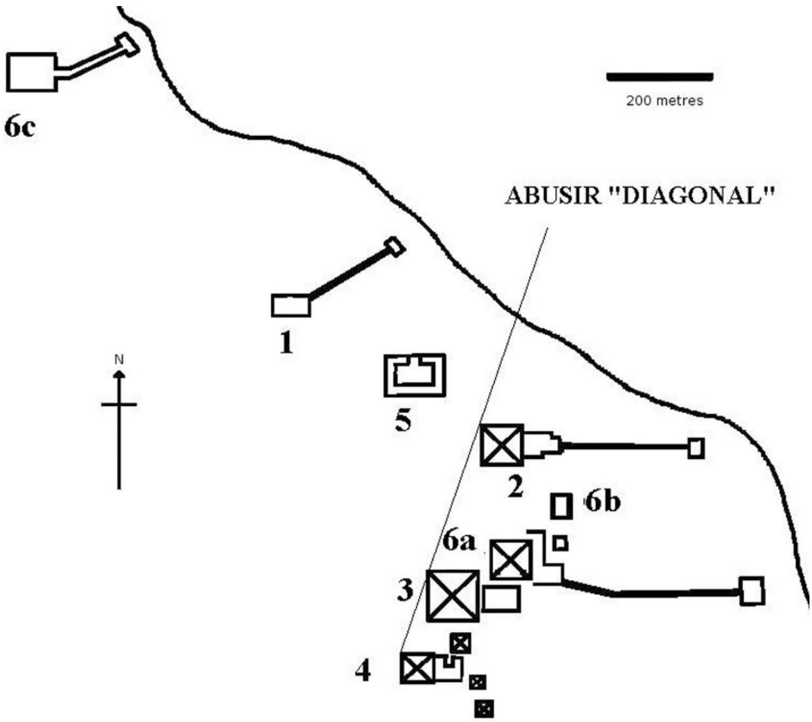


Figure 19.8: Map of the Abusir area (numbering of the monuments is in chronological order): 1 Userkaf Sun temple; 2/3/4 Pyramids of Sahure, Neferirkare, Neferefre; 5 unfinished pyramid of Shepseskare; 6a Niuserre Pyramid, 6b Mastaba of Ptahshepses, 6c Niuserre Sun temple.

found no other way than placing his pyramid to the east side of an existing one, that of Neferirkare, a quite unique example of "intrusive" design for the Old Kingdom. In this way, they also managed to inaugurate a second "Abusir diagonal" which connects the south-east corners of the pyramids of Neferefre, Neferirkare and Niuserre and prolongs also to the corner of the huge Mastaba of Ptahshepses, a very important personage who became a son-in-law of Niuserre. However, clearly such a "new diagonal" was not pointing to Heliopolis, and perhaps for this reason Niuserre ordered the construction of his own sun temple located north of Userkaf's one and therefore in plain view from the sacred city. As we have mentioned in Chapter 17, however, according to existing texts of the epoch also Sahure, Neferefre and Neferirkare constructed a sun temple which have *never* been found. In my view, it is almost impossible that three (or perhaps four, since also a sun temple of the successor of Niuserre may exist) such huge monuments safely escaped to the archaeological investigation of the very restricted area in which they might have been located (since—again—it is obvious that they had to be in view from Heliopolis). Therefore, the present approach strongly supports the idea, already proposed by some scholars, that the abovementioned inscriptions refer to restorations or renewals of the existing temples, and that only the two already known V dynasty sun temples actually existed.

Niuserre was the last king to build his complex in Abu Sir, as the last three kings of the V dynasty will return to Saqqara. The time of the solar kings, the owners of the horizon, was thus, finally, at the end. However, although almost 4600 years have lasted, the relatively short period of the kings who were "close to the Sun God" as the name of Sahure has it, stands as what many, myself included, consider one of the greatest seasons of human civilization. From this epoch, not only wonderful monuments that "frighten the time" remain to us, but also invisible lines that speak about their religion, lineage, and astronomical knowledge. The sacred space they span and design is still so alive, that anyone looking at the western horizon—today just as 4600 years ago—will be in absolutely no doubt.

The horizon belongs to Khufu.

9 The Tree of the World

> While we live in a model of the world that vests our definitions of physical reality in science and spiritual reality in religious principles, the Maya lived in a world that defined the physical world as the material manifestation of the spiritual and the spiritual as the essence of the material. For them the world of experience manifested itself in two complementary dimensions. One dimension was the world in which they lived out their lives and the other was the abode of the gods, ancestors, and other supernatural beings. . .
>
> These two planes of existence were inextricably locked together.
>
> —L. Schele and D. Freidel, *A Forest of Kings: The Untold Story of the Ancient Maya*, 1990

9.1 The Time of the Flower Children

The ancient or preclassical Mayan period stretches far back into the mists of antiquity, to the second millennium BC (Coe 2001). Around 50 BC, almost simultaneously with the Teotihuacan in central Mexico, the period of the Mayan city-state began, among the first city-states being Cerros and Izapa. Between the third and ninth centuries AD—the classical period—the Mayan civilization was to achieve the highest excellence in every sphere, with the development of the great city-states in what is today southwest Mexico, Guatemala, and Honduras.

The classical period ended between the ninth and 10th centuries (Webster 2002), and this collapse has remained so far unexplained. It occurred suddenly and probably dramatically, to the extent that it has even been possible to trace the last date recorded in inscriptions in every single city. This is one of many examples of a collapse of a civilization that is still shrouded in mystery, even though the plethora of data available for the Mayas allows us to use mathematical techniques to attempt to simulate the phenomenon (Hamblin and Pitcher 1980, Lowe 1982). Whatever the cause, at the time of the Spanish conquest, the Mayan civilization had already vanished many years earlier, although pockets of Mayan people lived

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_9,

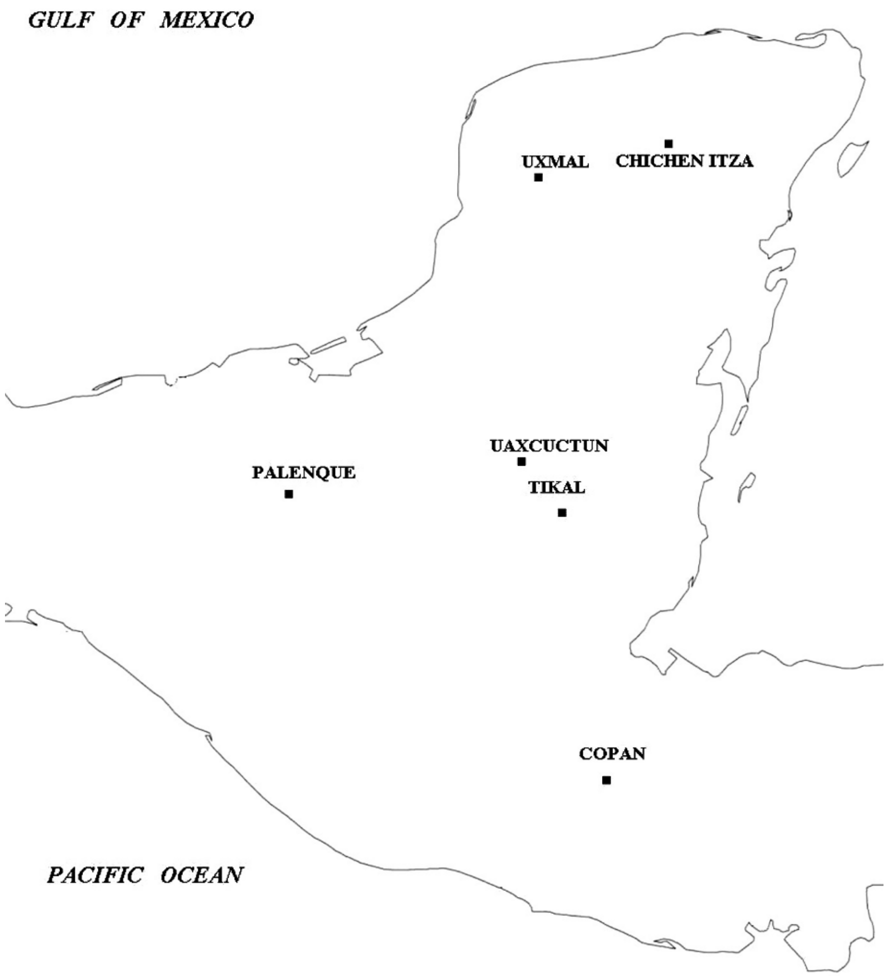


Figure 9.1: Map of the Maya area, with the main sites cited in the text

on, scattered about in little villages. Since then, the population has suffered many hardships, but has managed nevertheless to retain its own identity and traditions.

Mayan city-states were highly complex constructs, politically speaking. They were autonomous, but linked by structured, mutual alliances, which often resulted in conflict between them (Schele and Freidel 1990). This tangle has only begun to be unraveled gradually in the last few decades, due to the deciphering of inscriptions, initially made possible by the brilliant insight of Tatiana Prouskianoff. Up to the 1950s, a rather iniquitous and dangerous archaeological mindset persisted, whereby the Mayas were seen as a sort of "flower people" *ante litteram*. Even though it is sufficient to glance at Mayan art—in which, for instance, human sacrifice is explicitly depicted—to realize how absurd such a conviction is, it really was believed that the Mayas were a calm, pacifist people of docile farmers. This idea was applied also to the inscriptions, resulting in statements like, "The great theme of Maya civilization is the passage of time," as J. Eric Thompson, an authoritative Maya scholar, said in 1954.

We have been able to read Mayan numerals for considerable time, and Prousniakoff came up with the idea that glyphs written between one date and another were the recordings of real events. As so often happens, ingenious things are obvious only when someone points them out. What can be more banal than the fact that in an inscription containing dates, a king or leader should write: "I, X, son of Y, was born, ascended the throne, defeated Z in the city of W" and so on? This discovery led to the opening of archives of Mayan historiography that had remained unstudied, although they were in plain view of everyone. Once our disgraceful shortsightedness was corrected, we rediscovered this wonderful civilization.

The Mayas, in fact, were able to do anything, and were very good at what they did. For example, they knew how to farm using sophisticated systems of terracing and irrigation, they knew how to work with many materials with the highest artistry, and they knew how to construct grandiose, sophisticated buildings. The Mayan world was inextricably linked with the realm of the natural and supernatural, to a degree that was to be surpassed only by the Incas, as we shall see. Their pantheon was extremely complex and ramified, including deities embodying two aspects (old/young, man/animal, good/bad). Itzanma, an old sage, was to a certain extent their main divinity, and by no coincidence the inventor of the arts and sciences. Celestial divinities were associated with the sun, the moon, Venus, and the cardinal points. The four gods associated with the four cardinal points had their own special color and behavior, as in China and Japan. The cosmos was structured in three levels, or "worlds": one subterranean, one terrestrial, and one heavenly. It has often been written that the Mayas therefore considered the world to be flat. But I am extremely dubious that a Mayan astronomer would believe in such nonsense.

The underground world, or Xibalbá, was divided into nine levels, each inhabited by a divinity associated with death. The heavenly world was populated mainly by divinities connected with natural phenomena, for example, Chac, the rain god, the Mayan version of Tlaloc. Venus played a particularly important role; her cycles were studied scrupulously, as we shall see shortly. Generally speaking, the prediction of all heavenly events and the study of their presumed influence on human lives was undoubtedly fundamental for the Mayas, and for this reason they are usually defined "astrologers, not astronomers" (Coe 2001). I shall return to this issue later. For the moment, let me say that establishing what they *were* is a question that need concern us little. What does interest us, rather, is understanding what they *knew*.

9.2 Mayan Astronomy: The Calendar

When we refer to Mayan astronomy we are really referring to *all* astronomy (visible to the naked eye), since their knowledge of heavenly bodies was amazingly complete and accurate. The recording of the movements of the stars was effected using a numerical system based on the number 20 (vigesimal), which employed three symbols: a shell for zero, a dot for one unit, and a bar for five units. Numbers were written, exactly as in our system, with multiples of the base identified by their positions; it is often said that Mayan numerals were more convenient than their contemporary Roman numerals, which did not have the zero, but convenience is largely a question of habit.

The Mayas had three calendars: one of 260 days, the *Tzolkin*, which I mentioned in the previous chapter; a civil one of 365 days, called *Haab;* and a long-term calendar, based on the smallest common multiple between the years of the other two calendars. The smallest common multiple between 260 and 365 is 18,980 (approximately equal to the days of 52 solar years), and this period was considered a sort of "great year," lasting more than the average life span at that time. It may be that at the end of each such great year the Mayas really feared the end of the world, as some chronicles say. What is certain, however, is only that whenever a new great year commenced, special events took place, such as the renovation of temples.

The Tzolkin assigned to each day a number from 1 to 13 and a name from 20 possibilities ($13 \times 20 = 260$). The reason for the choice of a 260-day period is unknown, and in fact this calendar is conventionally called a religious or sacred calendar for the simple reason that we do not know its origin. As we saw in the previous chapter, however, it is likely that it was established in Copan, or even in the preclassical age, in the 4th century BC, in Izapa. In both these places, 260 is the number of days between the two zenith passages of the sun. Other hypotheses put forward seem rather contrived, such as the theory that the 260 days correspond to the average number of days in the human gestation period, that is, a nonastronomical source for a strictly astronomical thing such as a calendar. Whatever the reason, no definitive explanation has emerged to date.

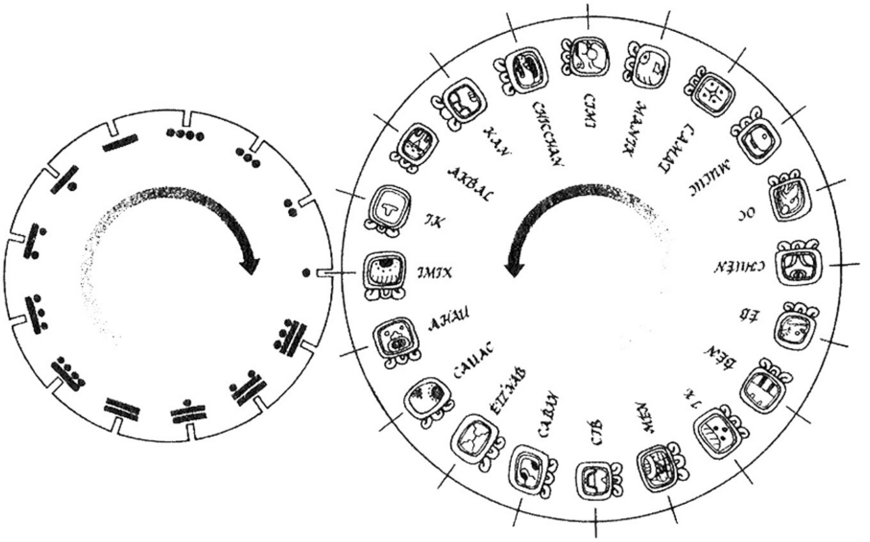


Figure 9.2: The counting of Maya 260-days calendar represented as a double gear, with the 1-13 numerals on the small wheel and the 20 names of the days on the big wheel.

The Haab, designated by scholars as the civil calendar to distinguish it from the sacred one, consisted of 18 months of 20 days each, plus 5 days considered to be inauspicious, making a total of 365 days. Dates were expressed with groups of figures composed in this way: kin (day), unial (20 days), tun (18 unial = 360 days), katun (20 tun = 7200 days), baktun (20 katun = 144,000 days), exactly as our dates are made up of days, months, and years. For us, the days go from 1 to 31, the months from 1 to 12, and the years go on ad infinitum. For the Mayas, kin, tun, and katun went from 0 to 19, the unial went from 0 to 17, and the baktun went from 1 to 13. Thus, possible dates, consisting of five numbers in succession, were finite in number: *the Mayan measure of time was recursive* (not cyclical, as it is the date that was repeated). Every period ended in 13.0.0.0.0., which corresponds to approximately 5,125 years; hence, five periods are the equivalent of 26,625 years, a number of years extremely close to a precessional cycle, perhaps not by chance.

The problem of pegging Mayan chronology with ours, that is, of identifying at least one date with a Gregorian equivalent, is clearly crucial for all Mayan historiography. Without this it is impossible to translate the chronology of events described in inscriptions into our dating system and to know therefore when they occurred. I shall not go into detail with regard to this complex problem, whose solution is based on the identification of astronomic events that can be dated with precision and are recorded by the Mayas, such as eclipses (Bricker and Bricker 1983). It is extremely likely, however, that the starting date of the period the Mayas lived through is August 13, 3114 BC, and thus it can be calculated that the final date falls on December 23, 2012. Of course, the fact that the starting date happens to be August 13—one of the dates on which the sun rises at T-east (and passes to the zenith on the parallel of Copan and Izapa)—is strong evidence in favor of the validity of this chronology.

The recursivity of the Mayan calendar has unfortunately given rise to the most fanciful theories, in particular that the Mayas predicted the end of the world, or at least terrible natural calamities, for December 2012. This type of prediction appears, however, only in the *Books of Chilam Balam*, manuscripts of the 17th and 18th centuries (thus long after the conquest), hand-written in the Maya-Yucatec language but in Roman characters. They contain a tangled web of magic and historical and religious texts in which Mayan traditions and Spanish influence are virtually indistinguishable. Probably the "end of the world" for the *true* Mayas would not have been so very differently lived from what happened on our New Year of 2000. However, there remains the problem of understanding what logic or event governed the choice of the initial date so far in the past (a problem that, as far as I know, has never been seriously addressed) and, more generally, why the Mesoamerican calendar was recursive.

Yet it is also true that Mayan astronomers, eventually studying our civilization, would have had difficulties in understanding why *our* calendars go on indefinitely.

9.3 Mayan Astronomy: The Codexes

It should be stressed that the Mayas knew perfectly well that the Haab calendar of 365 days was not a good measure of the solar cycle. Indeed, they normally measured astronomical cycles with great accuracy and, as far as the calendar is concerned, there is evidence that the value of the solar year calculated by the Mayas at Copan was 365.2420 days, which is actually a *more accurate* value than that of the Gregorian calendar (365.2425 days) we use today. Apart from being interested in the movement of the sun, the Mayas studied assiduously the cycle of the moon (on which they perceived the outline of a rabbit), with the aim of predicting eclipses. They were also interested in the movement of Venus and the other planets. Venus was the planet that preoccupied them the most, with its sometimes evasive behavior, but always somehow alluding to the activities of the sun (see Appendix 1).

Our knowledge of the Mayas' study of Venus is fortunately considerable, as some of their astronomical data have miraculously been conserved.

In 1566, in Izamal, in the Yucatan, a terrible assault on the culture of humanity occurred. Bishop Diego de Landa, convinced that Mayan books were none other than confirmation of the satanic religion prevailing in Mexico before the conquest, ordered them to be rounded up and consigned to flames. In one day, hundreds of volumes of astronomical observations recorded by Mayan scientists over many centuries went up in smoke. However, by a curious and fortunate twist of history, the plan aimed to completely annihilate the scientific knowledge of an entire civilization failed: four volumes survived (and possibly others that may yet be found). These are the so-called Dresden, Paris, and Madrid codices (certainly authentic, and named from the libraries where they are kept), and the Grollier codex (probably authentic). They were written on sheets of bark a few centuries before the conquest, but the data contained in them often refer to earlier times.

It is no easy task to explain what a Mayan codex is (or at least what the codices that have come down to us are; undoubtedly there existed other historical/literary genres that did not survive). Perhaps a better description of them would be "manuals," as they contain extremely accurate astronomical recordings together with pages of descriptions of rituals and predictions, divined from heavenly events. The most analyzed and comprehensible codex is the Dresden codex, which is 3.5 meters long and divided into thirty-nine 8.5- × 20.5-centimeter folios. It discusses the prediction of the eclipses and the cycles of Venus, Mars, and Mercury. The Grollier codex contains a "Venus Chart" comparable to that of the Dresden codex, but simpler (some are of the opinion that the Grollier is false). The significance of the codices of Madrid and Paris has not yet been fully grasped. The Paris contains an astronomical chart that is very important for studying Mayan constellations, as we shall shortly see.

The precision of the astronomers who drew up the table of eclipses in the Dresden codex is quite astounding. The codex contains observations on lunar phases over a span of 11,960 days, that is, about 32 years; 405 new moons were observed, which means that the Dresden codex contains the following estimate of the cycle of lunar phases: 11,960/405 = 29.53086 days—a better estimate than Ptolemy's. Of course, there is nothing astonishing in the fact that the Mayas were better astronomers than Ptolemy. What enabled the drafters of the codex to attain such a high degree of accuracy was the purpose behind it: studying the comparability of various cycles, seeking the smallest common multiple. For example, the period of 11,960 days was not chosen randomly; in fact, 405 lunations are the minimum number required

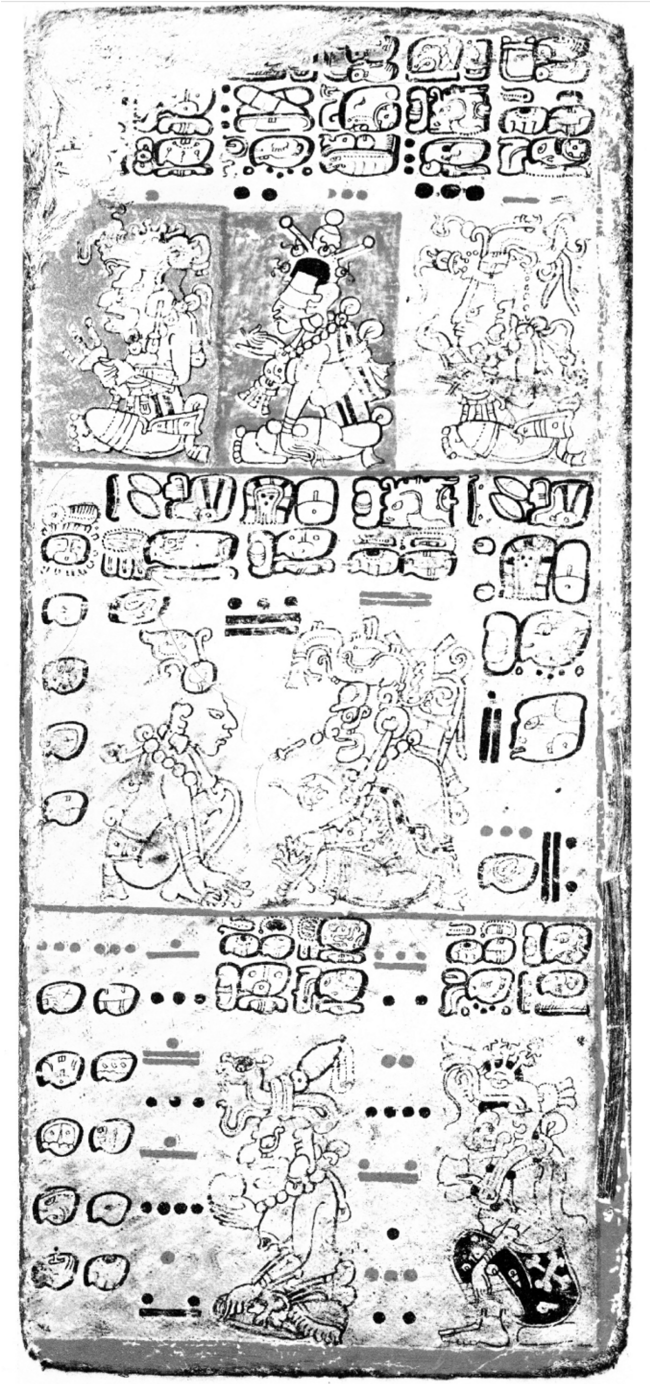


Figure 9.3: A page from the Dresden Codex

to correspond to a integer number of Tzolkin years of 260 days—46 to be exact. In turn, it is often said that this desire for the periods to be commensurate shows that the Mayas did not possess a scientific mentality, thus “rescuing” poor Ptolemy (from what?). I do not agree at all, however.

As I have already said, the question of deciding who performed the most accurate measurements is not of any real concern. Having said that, the idea of estimating different cycles with the same unit of measurement (the day and its decimals, in this case) is typical of our way of reasoning and handling experimental data. Another way—equally valid—is the Mayan one. Actually, I think we might understand the lunar cycle better if we say, as the Mayas did, that there are 405 new moons every 11,960 days rather than if we say that there is a new moon every 29.530836 days.

9.4 The Tree of the World

The Mayas also studied the movements of the stars, especially those of the Milky Way. The Milky Way was seen as a heavenly counterpart of the sacred tree, the *ceiba*, which was thus the *tree of the world*, a veritable path of the spirits that led to the gate of the Kingdom of the Dead. Guarding the gate was a “monster” (the term does not perhaps reflect how the Mayas perceived him), frequently depicted in sculptures and reliefs. The Milky Way and the ecliptic can both be considered as two maximum circles traced in the celestial sphere, which intersect with each other at two points, one in the middle between the Gemini and Taurus constellations, and the other between Scorpion and Sagittarius. The Mayas represented all this by means of a cruciform symbol, in which the ecliptic, arranged horizontally, is portrayed as a two-headed serpent. In some representations, the serpent is shown along with strange figures clambering upon it. These are the constellations of the ecliptic, that is, the Mayan zodiac, which was made up of a division into 13 (not 12 as in ours) constellations (our knowledge of the

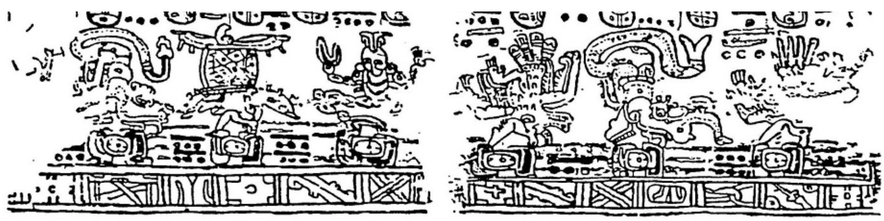


Figure 9.4: Some of the Maya constellations depicted in the Paris codex

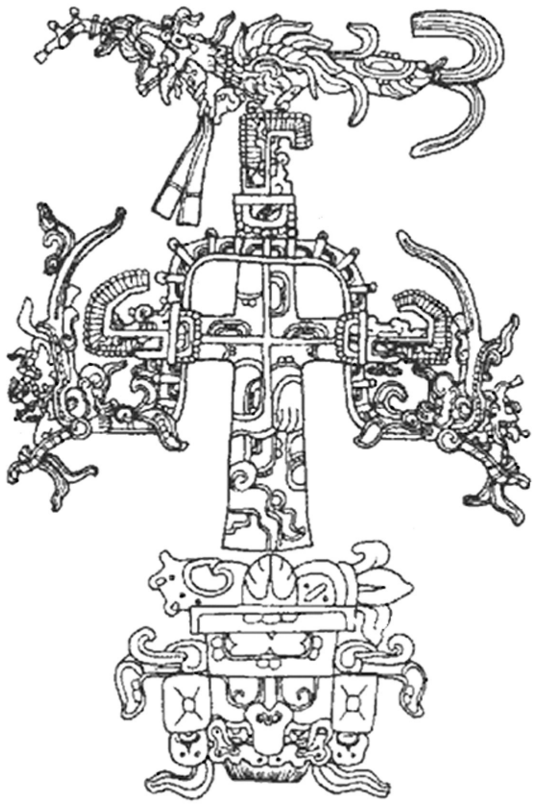


Figure 9.5: The Maya world tree

Mayan zodiac is based chiefly on the Paris codex; see Bricker and Bricker 1992). Among the figures passed down to us, we can identify a couple of peccaries (nocturnal hogs) copulating, to be identified unquestionably with our Gemini, a scorpion (identical to ours and probably made out of the same stars), and then a jaguar, a snake, a bat, and a death's head.

The intersection point between the Milky Way and the ecliptic, which is found in the vicinity of Gemini, slightly above Orion, had special significance for the Mayas. Orion was represented as a turtle with three stars on its carapace, while Gemini corresponded, as stated, to two copulating peccaries. The Milky Way in general and this place in particular were deeply and intimately linked with the Mayan myth of the creation of the world, which we are familiar with thanks to the *Popol Vuh*, the sacred book that someone miraculously made a copy of, in Latin characters but in the Mayan language, just after the conquest, thus saving it from oblivion. The myth is extremely complicated and replete with astronomical meaning, which allegedly, according to Schele et al. (1995), allude to astronomical events that happen in succession on the night of creation, without particular reference to the year they occurred. I think that it might instead refer to specific configurations of the sky occurring on specific dates. To establish which dates, we would have to take precession into consideration. For example, in the key scene of the myth, there occurs the killing of the "cosmic bird," a parrot shown perched on the Tree of the World, at the hands of one of the twins who are main characters in the book. At the foot of the tree is a scorpion, confirming identification of the tree with the Milky Way. However, the bird is usually interpreted as Ursa Major, a dubious labeling, in my opinion, for the simple reason that the stars of the bear are, and have always been, distant from the Milky Way. If, though, the identification of the bird with the region of the celestial north pole is correct (as it seems to be), then one might well deduce that it represents a constellation that has been seen as a bird in many other civilizations—the swan. But the myth of Popol Vuh would then take on an almost embarrassing antiquity, since, as we have already seen, the Milky Way housed the north pole, in the constellation of the swan, as far back as c. 12,000 BC.

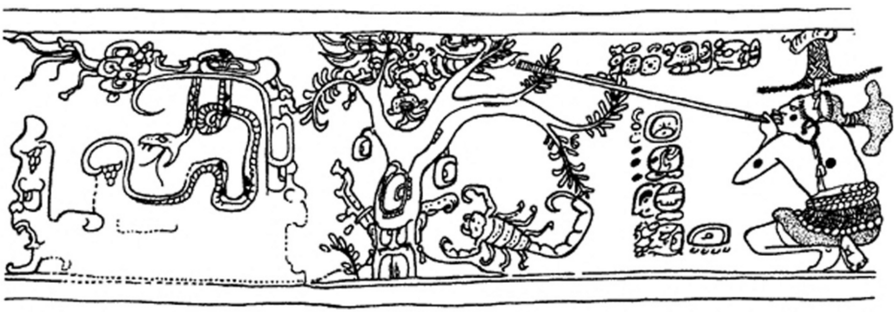


Figure 9.6: Killing the "Cosmic Bird"

9.5 A Building that Turns the Stomach

The Mayan astronomers were enormously precise. But where, and with what instruments, did they work? As we have seen, the only astronomers of ancient times who perhaps used telescopes, as far as we know, were the Babylonians. The observation of the sky was practiced by the Mayas, but also, throughout Mesoamerica generally, with the naked eye aided with a simple instrument that is well documented in the colonial codices. This is essentially a cross that was used to see heavenly bodies and measure angles. In the colonial codices, the astronomer is plainly visible, with his cross-staff, sitting in what appears to be a suitably observatory-like building, with star symbols (like lamps) all around him. Indeed, in almost every Mayan city we find buildings designed for astronomical observations or at least clearly connected with them; listing them all would be outside the scope of this book. I have selected three classic examples, each of which has some interest for us: the first is the so-called Group E of Uaxactun.

Situated a few dozen miles from the city of its great rival, Tikal, Uaxactun was inhabited as far back as the preclassical age, but it sustained maximum growth during the classical age. The most important structure in the city is the pyramid called E-VII-B. The square-based pyramid has staircases on all four sides and dominates a huge square. Aligned to the front of it, in the eastward direction, we find three other buildings—E-1, E-2, and E-3—standing on the same platform. This complex constitutes a stone calendar, totally analogous in conception to the Maltese temple of Mijandra. In fact, from the center of the staircase of E-VII-B, facing east, one can see the sun rise at the winter solstice, at the equinoxes, and at the summer solstice in alignment with the three small platforms E-3, E-2, and E-1, respectively (Aveni and Hartung 1989). This is undoubtedly an extremely old structure. Since, as we have seen, the 260-day calendar was almost certainly based on cycles of zenith passages, the fact that at Uaxactun there was rather evident interest in the solstice and equinox cycles has prompted the suggestion that the Mayas originally had only the standard solar calendar, and that they then reformed the calendar in Teotihuacan style at a later date. The question is still open to debate.

Figure 9.7: The main pyramid at Uaxcuctun

The second building we shall visit is the most famous and most studied Maya observatory, the *Caracol* of Chicen Itzà, in Yucatan (Aveni 2001, Aveni et al. 1975) (Plate 17). The Caracol, which means snail in Spanish, is an enormous structure with a circular layout. From the outside it looks as if it is covered by a domed vault, but the vault has been filled in on the inside, except for a narrow spiral passage that gives the building its name, and some embrasures looking out. The upper section has partially collapsed, but the original structure of the Caracol was different from other roof coverings typical of many Mayan buildings, which have a showy crested or crenellated facade called a *cresteria*. Thus, Caracol's resemblance to *our* observatories is purely coincidental, though many believe (including myself) that it was actually conceived, planned, and built with the very specific aim of carrying out astronomical observations. That this was the real purpose of the structure was already suspected as far back as the 1920s by the archeologist J. Ricketson, who concentrated, however, on sun–moon alignments, which he did not succeed in determining precisely. Consequently, even in the 1950s, there were some who thought that Caracol was the result of a strange taste for the asymmetrically weird—among them Eric Thompson, the foremost Maya scholar, who had the nerve to write the following atrocious passage:

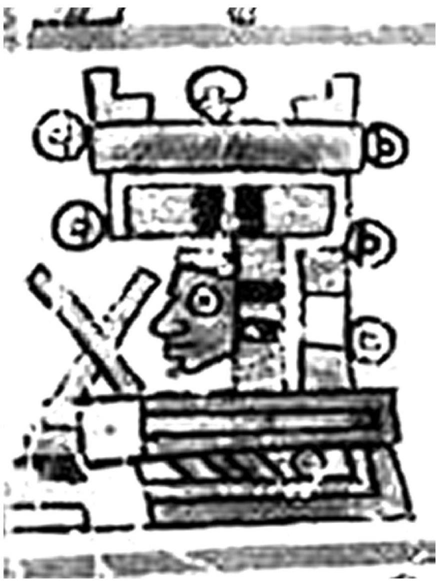


Figure 9.8: An astronomer with a fork-like viewfinder

> Every city sooner or later erects some atrocious building that turns the stomach: London has its Albert Hall; New York, its Grant's Tomb; and Harvard, its Memorial Hall. If one can free oneself of the enchantment which antiquity is likely to induce and contemplate this building in all its horror from a strictly esthetic point of view, one will find that none of these is quite so hideous as the Caracol at Chichen Itza. It stands as a two-decker wedding cake on the square carton in which it came. Something was pretty clearly wrong with the taste of the architects who built it. [J. Eric Thompson, A Survey of the Northern Maya Area, *Amer. Ant.* 11, 1 (1945) page 10]

The "asymmetries" and "bad taste" attributed to Caracol are nothing but the result of a design worked out with a specific aim: the observation—or rather the *control*, see below—of Venus's standstills, as well as other astronomic phenomena. According to Aveni (2001), the Caracol may have had 26 astronomical alignments. For instance, the lower part of the building has a central inset facing the maximum northerly excursion of Venus, while the east–west diagonal is oriented toward the summer solstice sunrise, and various slits in the walls indicate the rising points of particularly bright stars. The upper cupola contained at one time six narrow embrasures of which only the ones on the west side are left (after a collapse during the last century), which define alignments toward the setting of the sun at the equinoxes and toward the setting of Venus at its north and south major standstills. A further window faces generically, but not precisely south; this might have nothing to do with astronomy but it has sometimes been suggested that it may indicate magnetic south, that is, the north–south direction determined by a magnetic compass (which does not usually coincide with the geographical north–south direction; see Appendix 1).

It has indeed often been suspected that the Mayas invented the magnetic compass and used it for identifying the north, which might explain numerous orientations in Mayan buildings that face north "generically." At any rate, it is extremely difficult to check the theory directly since magnetic north changes too rapidly in time to be able to re-create reliably its position at the approximate time of construction of the buildings, and the Mayan compasses, if they ever existed, have never been discovered (so the credit for inventing the compass must stay with the Chinese).

All in all, the Caracol is indubitably one of the Mayas' most intriguing buildings. Maybe the Dresden codex was actually drawn up here, as has been supposed, but the relevant astronomical observations performed must in any case have been decided *before* the construction of the building, since the alignments were created by means of narrow tunnels inside the stonework, which allowed only very limited portions of the horizon to be framed from the inside. Whoever designed the Caracol was well versed in astronomy and already possessed accurate data. It is for this reason that the word *observatory,* in my opinion, does not do justice to the idea of what this building really is. A modern observatory is a place that is "open to phenomena"; the roof slides open and the telescope is pointed wherever one wishes. The Caracol is a "closed" place; significant events must take place within predetermined windows. A good description of the Caracol is a *control tower* from where the astronomers were verifying the regularity, repetitiveness, and measurability of heavenly cycles (a copy of the Caracol, described in the 19th century but today almost completely destroyed, was at Mayapan, a few dozen miles away).

A third interesting building unquestionably linked to the astronomical observation of Venus is to be found at Uxmal, also in the Yucatan. Uxmal is dominated by a pyramid that is quite unique in the world, the Pyramid of the Magician, a huge elliptic-based structure, extremely steep, the top of which looms over the surrounding jungle for many miles. The pyramid was likely used for astronomical observations, too, and many significant alignments depart from it and pass through various other buildings. However, looking at a map of the city, attention is drawn to another construction, the Governor's Palace, which looks out of place. In fact, unlike the other buildings—which display the characteristic orientation slightly

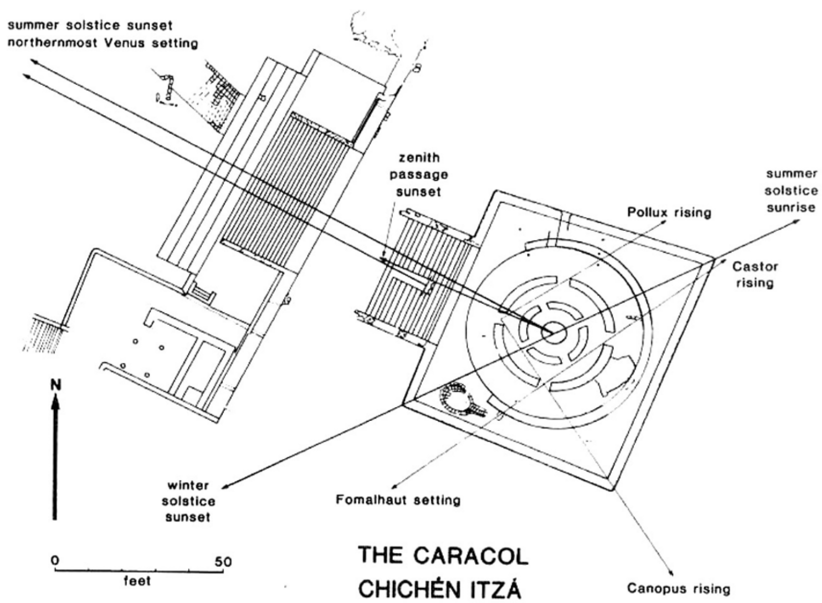


Figure 9.9: Astronomical Alignments of the Caracol (from Aveni 2001, under kind permission)

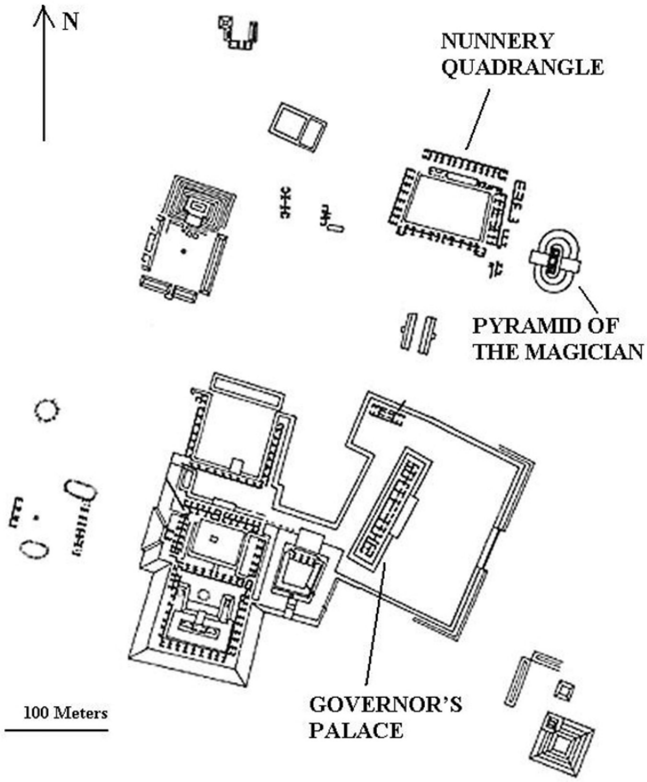


Figure 9.10: A map of the ceremonial center at Uxmal, with the monuments cited in text.

east of north and have their front facing the interior of the city—this monument is directed 28 degrees south of east, and its facade looks onto the jungle (the infelicitous name *Governor's Palace* has no historical justification and can be blamed on the Spanish, as can the name *Pyramid of the Magician* and that of the large buildings arranged in a quadrilateral, dubbed the *Nunnery Quadrangle*).

Glyphs representing Venus, identical to those in the Dresden codex, are to be found on the Palace. This has prompted Aveni (2001) to surmise that the "anomalous" orientation of the structure had something to do with Venus standstills. By tracing a perpendicular line to the facade, Aveni and his colleagues discovered that this direction marked, on the horizon, the southerly extreme of the rising of Venus in its complete 8-year cycle, and, to their amazement, they realized that the alignment passed precisely, on the horizon, through what seemed to be a small natural hill. Beating a path through the jungle, they discovered that it was not a natural formation, but

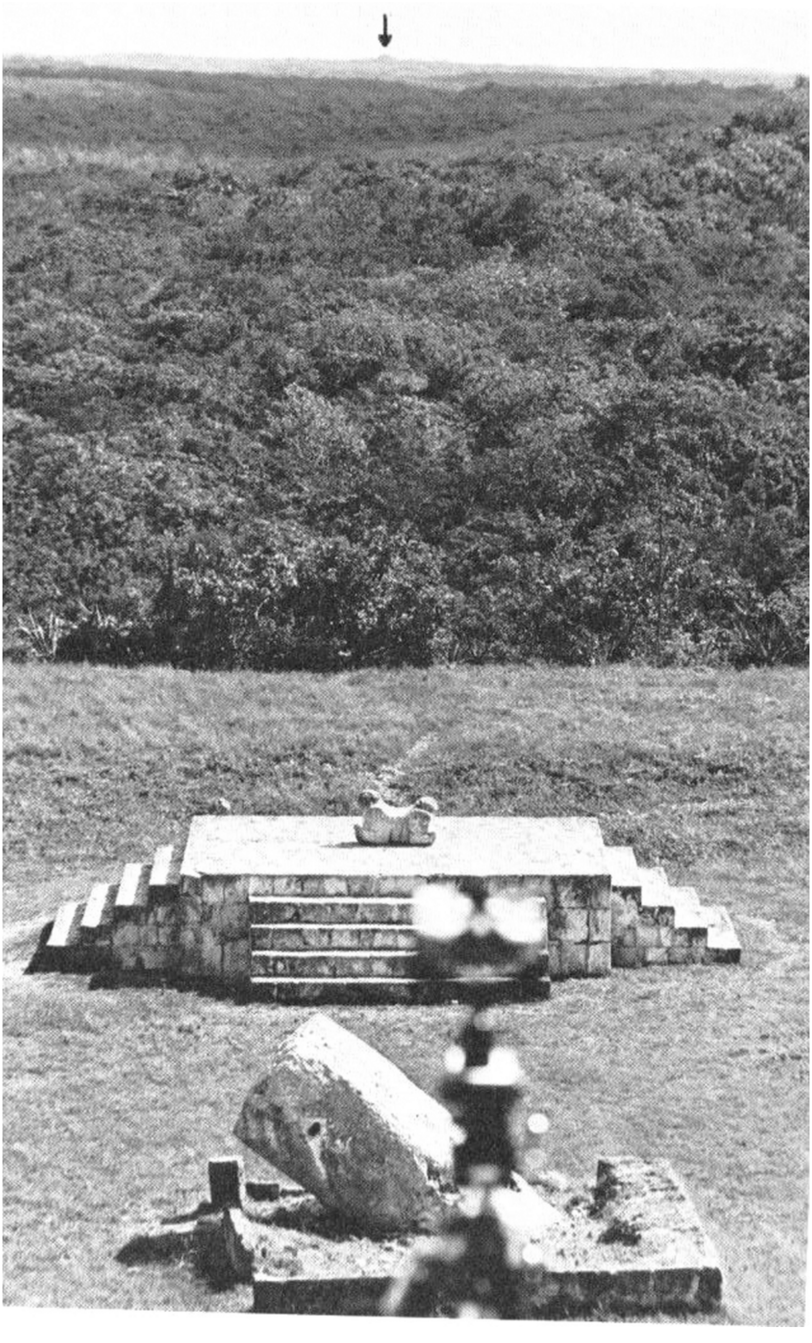


Figure 9.11: The alignment of the Governor's palace at Uxmal with the pyramid of Chectzuc, indicated by an arrow (from Aveni 2001, under kind permission)

rather a 25-meter-high pyramid. Today we know that this pyramid emerging from the jungle is one of the structures of a Mayan site described by the explorer Stephens in the 19th century but then largely forgotten (Aveni 1997, 2001; Sprajc 1993). From its peak one could watch the setting of Venus at its *northerly* major standstill in alignment with Governor's Palace in Uxmal.

9.6 Astronomy and Landscape in Mayan Cities

Apart from following the motion of heavenly bodies with specially made structures, Mayan astronomers were involved in the planning of all main civic buildings. The importance of the celestial cycles was so rooted in Mayan life that sometimes astronomy crops up in the urban fabric of cities in the most unexpected ways and forms, and may be extremely difficult to decipher today (Ashmore 1991, Aveni and Hartung 1986).

One example is Copan, in modern-day Honduras. It is natural to seek evidence of Teotihuacan-type orientation in Copan because, as we have seen, this is one of the sites to be found on the parallel along which the zenith passages of the sun occur on the two dates to which the orientation of the T-axis of Teotihuacan refers. As we shall see, such evidence exists; but at Copan, as at many other places, understanding Mayan astronomical lore is much more complicated than one might expect. Various constructions indeed, including the main temple, are curiously oriented 9 degrees east of north. To grasp the significance of this, we have to note that the axis perpendicular to this direction is identified by a long, precise alignment that crosses the entire valley (and the entire southern part of the city) and is marked with two large stone stelae, about 7 kilometers apart. The alignment coincides with the setting of the sun around April 12 and September 1. I shall call this direction the C-axis, for the sake of convenience.

The second week of April was important because, in a way, it marked the beginning of the annual agricultural cycle. Even today in that very week Mayan farmers employ the *Millpa*, a technique that involves removing old scrub from the fields and burning it. The use of the C-alignment also had a precise symbolic significance, since it allowed the calendar to be divided into *uinal* units (i.e., units—or months—of 20 days). Look, indeed, at what happens to the solar cycle at the latitude of Copan if we introduce, as a "place card," the days corresponding to the setting at C-west and take into account the days on which the sun sets at T-west (it should also be remembered that the Mayan year begins on August 13, the day of the zenith passage in Copan itself and the day on which the sun actually sets at T-west):

1. Sunset at T-west + 1 uinal = sunset at C-west (August 13 to September 1)
2. Sunset at C-west + 1 uinal = autumnal equinox (September 1 to September 20)
3. Autumnal equinox + 9 uinal = vernal equinox (September 20 to March 20)
4. Vernal equinox + 1 uinal = sunset at C-west (March 20 to April 12)
5. Sunset at C-west + 1 uinal = sunset at T-west (April 12 to April 29)
6. Sunset at T-west + 5 uinal + 5 kin (i.e., 5 days) = sunset at T-west (April 29 to August 13)

The C-west alignment of the principal temple in Copan confirms the preoccupation with this way of subdividing the calendar, and the temple accordingly possesses a "window," analogous to the embrasures found in Caracol, oriented on the same axis.

Other examples of astronomically correlated urban planning can be seen in Tikal, the largest Mayan city-state, in modern-day Guatemala. The construction of the six main pyramids in Tikal was probably connected to the representation—the *replica*—of family ties between the rulers who commissioned them (see, e.g., Aveni and Hartung 1988). In particular, the two pyramids facing each other, designated T1 and T2, one tall and slender, the other short and stumpy, are most likely representations of the "male" and the "female," respectively. A second set of constructions, with quadripartite structures and associated with dynastic ties between rulers,

Figure 9.12: The summits of three of Tikal temples emerge from the jungle

Figure 9.12: A lithograph of one of the beautiful stelae of Maya rulers at Copan, drawn in 1844 by Frederick Catherwood.

has two large pyramids on the east–west axis and smaller structures at the other two ends. The complex was conceived of as a terrestrial image, a *replica*, of the world with the northern building symbolizing the celestial plane and the southern building, provided with nine doors, betokening the afterlife.

As a final example of this profound connection between the heavenly cycles and Mayan life, we cannot neglect to mention the presence, in the layout of every Mayan city, of a field on which Mayas played what is usually called a ball game or *pelota*. Despite its name, it was certainly quite unlike any sport that we are familiar with today. Indeed we know little about it, but it seems that the game consisted of getting the ball into one of two stone circles placed at the sides of the pitch, without using the legs or arms, just hitting the ball vigorously with the body, which was protected by rubber padding. Anyway, the game undoubtedly had a deep symbolic element as well; it was a sort of "sacred performance," in which the ball may well have symbolized the sun.

9.7 Palenque

It is difficult to figure out the Mayan relationship with nature. At times it is exceptionally harmonious, and at other times it verges on the wary or suspicious, even superstitious. It was in no way a passive relationship anyway. Institutions, society, and the power of the leaders were all underpinned by this rapport with the heavenly bodies. The very fact of observing the sky was an inseparable part of the structure of the sacred landscape of the Mayas, a place where hierophany was common—that is, the physical manifestation of a divinity via some mechanism, duly linked with a celestial cycle. To learn more about this, we shall visit one of the most fascinating archaeological sites in the world, the Mayan city of Palenque, Chiapas.

Although the place had been inhabited since preclassical times, the monumental center of Palenque was built later, over the course of a century, during the reigns of Pacal (603–683 AD) and his son, Chan Bahlum (635–702 AD). The center of the city is dominated by a large palace, and opposite it, by the Temple of Inscriptions. The temple, one of the masterpieces of Mayan architecture, is a nine-stepped pyramid with a small structure on top. To the north of the temple, facing a square, we find three other pyramidal buildings, known as the Group of the Cross, because one of them houses a relief with an inscription of what looked like a Catholic cross to the Spanish (but that we know represents the intersection of the Milky Way with the ecliptic).

Before elaborating on the pyramidal structures, permit me to digress briefly. The Americas are chock-full of pyramid-type structures. We have already come across many in North America and Mexico and further ones await us in Peru. It will have dawned on many people that it is no coincidence that pyramids crop up all over the place (by the way, also in Italy, at Monte d'Accoddi in Sardinia, and in Greece, at Hellenicon in the Peloponnese), and that there must have been a common origin to the idea of building pyramids (see, for example, Schoch and McNally 2003). I disagree with this "diffusionist" idea, because there is no evidence to support it, and it is known that similar ideas and symbols can come into being independently in different cultures and peoples (see, for example, Boas 1943). We still have a long way to go to understand fully the reasons and symbolisms of single cultures, let alone determine any possible hidden links between them.

Having said this, the answer that archaeologists gave to the question of whether Mesoamerican pyramids had any connection with Egyptian ones or not was brusque and categorical: "The Egyptian pyramids were built as tombs, and nothing but tombs, while the Mesoamerican pyramids were built as temples, and nothing but temples."

We shall see in the last part of the book what great complexity and profundity (of the ancient Egyptians, of course) lies behind the first part of the statement, substantially true though it is, namely that Egyptian pyramids were "nothing but tombs." The second part of the statement, however, is wrong. The first to discover this was the Mexican archaeologist, Alberto Ruiz, who studied the Temple of Inscriptions of Palenque in 1949 (Plate 18). One day, one of the laborers on his team noticed an inconsistency in one of the paving slabs on top of the pyramid. The workers lifted up the slab to reveal a step, and then another. This was in fact a steep staircase that went deep down into the building as far as ground level. The staircase had, however, been filled in with debris by builders, and the work of removing it out took 2 years. At last, on June 15, 1952, Ruiz had the enormous satisfaction of discovering, at the foot of the staircase, in the core of one of the most important "temples, and nothing but temples" of Mesoamerica, a magnificent tomb. The tomb, which had been constructed before the erection of the pyramid and was therefore part of a single integrated architectural design with it, had not been desecrated and the funerary apparatus of the Mayan chief buried therein, Pacal, is today on display at the Anthropology Museum of Mexico City. It is likely that Chan Bahlum, Pacal's son, was also buried in a temple, possibly one of the Group of the Cross structures. Since that time, numerous other Mayan rulers have been unearthed in the temples they commissioned, in Tikal and Copan, for example.

Pacal, a haughty individual with an intelligent and pensive face, as depictions show him, was laid in an enormous stone coffin, sealed with a delicately inscribed lid. The image depicted on the lid, possibly the most famous Mayan work of art, has triggered the most unbelievable and inane idiocies ever written in the already abundant history of pseudo-archaeological garbage, such as that Pacal is depicted at the controls of his spaceship. Actually, the scene carved on the lid is instead a complicated and fascinating representation of deep astronomical-cosmological significance.

The Tree of the World crosses the whole slab in the direction of the longest side, and the figure of Pacal is arranged at the intersection between the Milky Way and the ecliptic. Beneath him there is the entrance to Xibalbà, the Kingdom of the Dead, guarded by the "monster" and represented materially by the nine tiers of the building constructed above the tomb. The king is thus captured, as I see it, at the very moment of death. But the death of the king must also be a rebirth, since there is his son to reign after him and his people, who have to survive. To understand this mechanism, it is crucial to make the following observation. The two zones in which the Milky Way crosses the ecliptic mark the rising of the sun on two days of the year. Due to precession, these two dates vary in the course of the centuries, but during the classical Mayan period these dates coincided with the two solstices. Hence, Pacal is also placed at the solstitial point, so that his death might be identified with rebirth, in an analogy with the resumption of the solar cycle and thus of agricultural activities, particularly the cultivation of maize.

The stone lid, with its complicated symbols, sits on the coffin, and was thus inaccessible after the king's burial and the filling in of the staircase. However, as an explicit reminder of the connection between the deceased and the rebirth of the solar cycle, a hierophany was created in Palenque. On December 21st, in fact, the day of the winter solstice, looking from the building, the setting sun alights on the hill behind the Temple of Inscriptions, indicating the starting point of the staircase leading down to Pacal's tomb. The angle at which the sun sets is more or less the same as that of the staircase; it is thus as though the sun itself were descending into the crypt. On the following day, the sun reverses its path and the life of the city flourishes again, symbolically, under the new sovereign, Chan Bahlum, who ordered the construction of the three temples of the Group of the Cross. Linda Schele (1977) has shown that the arrangement of these temples was also dictated by the desire to create a hierophany, which occurred immediately after that of Pacal. Indeed, once the winter solstice sun has disappeared behind the Temple of Inscriptions, the monumental center of Palenque is enveloped in shadow, apart from the Group of the Cross. In

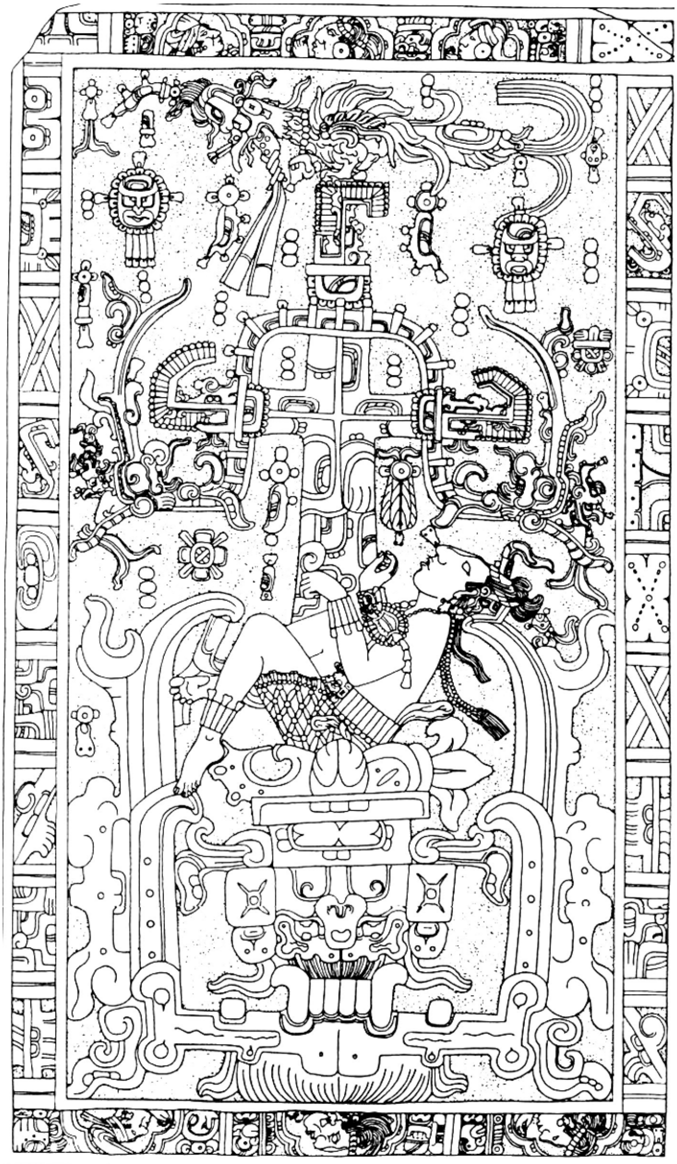


Figure 9.14: Pacal's carved lid.

particular, the facade of the Temple of the Cross is lit up fully only on the day of the winter solstice. When the light fades, a final ray strikes the figure of the "God L" depicted on a panel (the phenomenon is similar to what happens at Abu Simbel; see Chapter 4).

Summarizing, for the Mayas the boundary between the world of humans and the world of the spirits was therefore evanescent, and there existed efficient ways of communication between them. One way, which we shall come back to in the second part of the book, is the vision induced by drugs or self-induced physical suffering, which in the Temple of Inscriptions was aided by the presence of a "psychoduct"—a small shaft that runs parallel to the staircase and was supposed to allow Pacal's spirit to emerge and manifest itself to his son in the mouth of the Vision Serpent, a scene explicitly depicted in the panels of the temples making up the Group of the Cross. Another means of communication is hierophany, the physically tangible manifestation of the supernatural. In a way the temple acts as a sort of theatrical device, whose mechanism is triggered only on the day of the solstice.

Other ways may still be discovered, but in any case I have kept the most famous and spectacular for the conclusion of this chapter.

9.8 A Forgotten Rendezvous

On the day of the vernal equinox, crowds gather in Chicen Itza, in Yucatan. This is a sort of millennial rendezvous, which had long been forgotten, and was only rediscovered in the 1940s by photographer Laura Gilpin (Carlson 1999).

The monumental center of Chicen is dominated by the *Castillo*, a stepped square-based pyramid, about 25 meters wide and inclined at 45 degrees. A flight of stairs, each with 91 steps, climbs up each side, and there is a small structure on top. The building was dedicated to the plumed serpent, its head protruding from the base of the stairs (the pyramid was built in the Toltec-influenced period around the ninth century AD, encompassing a smaller preexisting Mayan building), and is oriented in such a way that one of its diagonals points northwest. This direction (roughly) identifies the rising point of the sun in the days of the zenith passages and consequently on these two days two faces of the pyramid remain in complete darkness until the sun passes the meridian.

The Castillo thus acts as a stone calendar, recalling the duration of the Haab year with its 364 (91 × 4) steps and platform on top, and indicating the zenith passages with its shadow. But the building has a further astronomical function: marking the equinoxes. The way it does this is quite unique. If one examines the outline of the edges of the pyramid, one notes that they are somewhat rounded off, sinuous. The reason for this is that its *shadow* is therefore rendered sinuous, serpent-like. This shadow is normally "lost" in the side of the pyramid. Yet the dimensions of the stairs and of the

Figure 9.15: The plumed serpent descends the stairway of the Castillo pyramid at Chichen Itza

outline of the edges were precisely modeled in such a way that, roughly half an hour before sunset on the days near the equinoxes, the shadow is projected along the stairs. The result is that the shadow is magically seen to *trace* the silhouette of the body of a giant snake, which ingeniously connects with the stone head at the base of the pyramid.

The plumed serpent thus turns up punctually, twice a year, for his millennial rendezvous.

10 The Four Parts of the Earth

> In that part of the sky that the astronomers call the Milky Way, there are dark zones in which they see the entire body of an ewe suckling a lamb. They showed this to me, saying: ''Look there, where the head of the ewe is, look here, and you will see the lamb suckling, and the bodies and the legs of the two animals.'' However, I did not see such figures. It must have been due to my lack of imagination.
>
> —Garcilaso de La Vega, *Com. Reales de los Incas* (1609) (I, 2, 23)
> (Translated from Spanish by the author)

10.1 The Civilizations of the Andes

Humans were present on the South American continent, in Chile and Peru in particular, at least from the 10th millennium BC, and, according to some scholars, possibly earlier. The extremely complex history of the civilizations of the Andes is usually divided into seven periods, each of them very ramified, given the complexity of the geographical borders due to the particular conformation of the territory with its series of adjacent flooding valleys separated by desert zones (Mosley 2001).

The oldest monumental centers that we know of date approximately from the year 2000 BC, among them El Paraíso and Cerro Sechin. The typical structure of these centers, which will remain unchanged through the centuries, is composed of a large truncated pyramid overlooking a court of other buildings, laid in a U-shape. Often the central square of the court is lower than the common ground, but sometimes there is a lower zone in the center of the platform. The meaning of this element, which needed to be accurately planned and built in order to avoid water stagnation, is not clear yet. Another mysterious characteristic common to many centers is the fact that they have been willingly abandoned and destroyed, as in the case of Cerro Sechin, for instance, which disappeared around the year 900 BC.

During the period between the tenth and the second centuries BC, Chavin de Huantar became the most important center, where quite a unique

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_10,

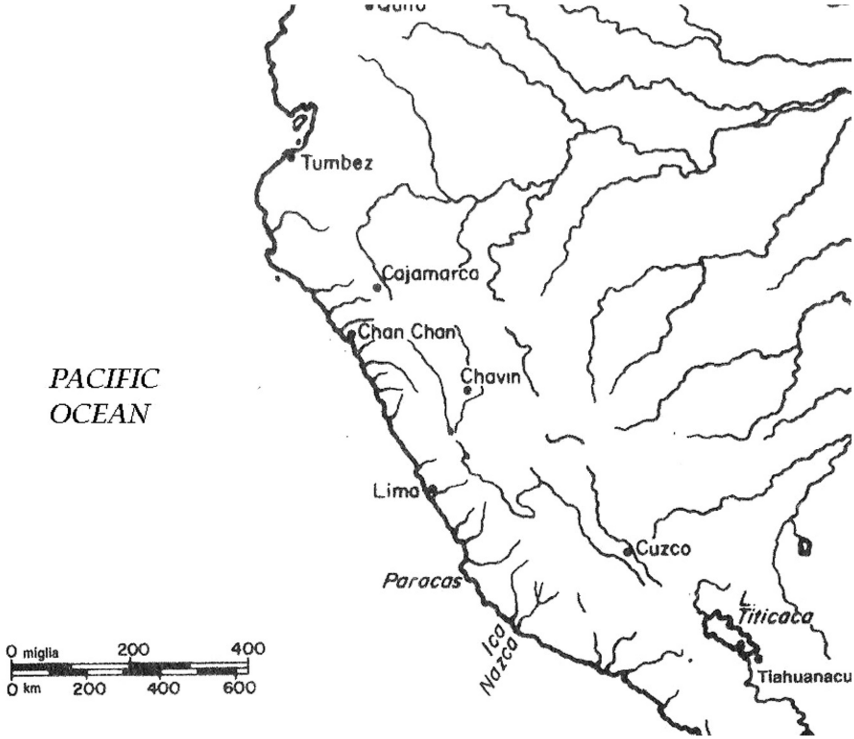


Figure 10.1: Map of Peru', with the sites cited in the text

building today called Castillo, was built as a place for oracular pilgrimage, apparently similar to those of the classic world, and used for many centuries (Rick 2007). In the inner part of the temple, which has a cross-like plan, there is a thing generally known as the "oracle." It is a large monolith in the shape of a knife with a scary face carved on it, placed at the end of a subterranean corridor. A series of ducts and pipelines apparently generated sounds and adequate atmospheres to make even more believable the oracle's "opinions," as the oracle could talk by the means of a priest through a trapdoor in the ceiling.

Chavin was more a center of political-religious influence than a true headquarters of the central power. Later on, however, starting from the third century BC, great civilizations developed with specific characteristics and true capital cities: in the south, the Nascas, which we will talk about in Chapter 11; on the northern coast, the Moche; and in the regions near Lake Titicaca, the culture named after the monumental center of Tiahuanaco. The Moche's artists created wonderful and incredibly realistic portrait-vases, wonderful jewelry, and amazing monumental buildings such as the so-called

Figure 10.2: The Kalasasaya platform at Tiahuanaco

Huaca del Sol, a huge brick pyramid that today is partially destroyed. We know about the Moche, especially since the discovery, in 1987, of the famous royal tombs of Sipan, which "gave back" (as it is generally said, using an arguable verb) the funerary equipment of the chiefs, buried with golden masks and accompanied by sacrificed victims. The Tiahuanaco culture is instead known especially for the extraordinary engineering works that it created. Tiahuanaco was the biggest and most important city in the history of the Andes before Cusco, the capital of the Incas. Many coincidences unite it with Teotihuacan, in Mexico: both cities were abandoned for no apparent reason, and both were considered sacred places by the dominant ethnic group at the moment of the Spanish conquest (the Incas and the Aztecs, respectively).

The monumental center of the city (unfortunately partly rebuilt in an disputable way) is formed by two main elements: a megalithic fence that harbors a lower court, and a platform (Gasparini and Margolies 1997). The fence, called *kalasasaya,* of absolutely shocking dimensions, was constructed using gigantic stone slabs alternating with stone brick sections. It can be accessed via a stairway also made out of gigantic stone slabs with a monolithic statue in front of it. Next to the court lies the platform, gigantic as well, in the shape of a truncated pyramid. Obvious traces of megalithic architecture, both in the form of complex structures and single megaliths, are also scattered around everywhere, as the famous Gate of the Sun. It is a monumental door with various inscriptions of dubious interpretation; in its center there is the image of the Crying God, the main divinity in Tiahuanaco; the God's tears are associated with the rain, according to an iconography that will later percolate into the Incas' religion. It is very difficult to date the monumental complex of the city; usually the megalithic works are attributed to the third–sixth century AD, even though the issue is quite controversial, and some archaeologists attempted to push the dating back in time to the second millennium BC.

The last stage of the Andean civilization before the Incas includes the so called Huari-Tiahuanaco Empire (basically a follow-up of the Tiahuanaco culture under the domain of a warrior people, the Huaris, who adopted the Tiahuanaco style) and, on the coast, the Chimú civilization with Chan Chan as the capital, which is still almost perfectly preserved, with its wonderful mud-brick, finely decorated buildings.

It seems that astronomy played a very important role in all the Andean civilizations before the Incas, as recent and spectacular discoveries confirm, namely the astronomical alignments discovered in the Buena Vista site, dating from the year 2200 BC (Benfer 2007), and a recent study (Ghezzi and Ruggles 2007) that demonstrated that the enigmatic site of Chankillo (c. 300 BC), with its 13 towers laid out on the top of a hill, was definitely a sophisticated solar observatory. The Chankillo astronomers indeed followed the cycle of the sun through the year, framing the sun within the spaces between the various towers (the observatory still works, although it is not as precise as it once was).

Figure 10.3: The gate of the Sun, Tiahuanaco.

It is, instead, very difficult to draw conclusions regarding the possible presence of astronomy in the Tiahuanaco monuments, because the vast majority of the monoliths are not in their original position, as the site has been eagerly "restored." Unfortunately, however, the absurd arguments put forward by Arthur Posnanski (1945) are still believed today and are cited as staggering conclusions. Posnanski claimed that the *kalasasaya* could be dated, on the base of astronomy, as early as the Ice Age. Posnanski made one of the most standard and easily recognizable errors in archaeoastronomy: he found alignments to the solstices (and these alignments were probably true) but also found a relatively small error in them. Instead of concluding that the alignments were not exceedingly precise, he insisted that they were. Then, since solar alignments do not depend on precession, the unique solution was to check for the slow change of the obliquity of the ecliptic, which would have perfectly aligned the monument with the sun, but only some 13,500 years before its probable date of construction.

10.2 The State of the Four Parts

The earliest information regarding the Incas dates back to 1200 AD. They were a bellicose tribe (we do not know its real name, since *Inca* was the word they used to indicate the ruler), native of the Cusco area, which, in less than two centuries, managed to build a very large empire, including the South American territories from today's Colombia to Argentina.

The Inca state—called *Tahuantinsuyu,* or the "Four Parts of the Earth"—was organized according to a centralized framework and was managed through the use of a common language called *Quechua*. The state bureaucracy kept an accurate account of the population, recording the sex, age, and social class of every person of the *Ayllu*, independent farming units formed by groups of families involved in the same type of activities and ruled by a hereditary chief. Every Ayllu had a founding ancestor and kept an accurate record of its genealogical tree; people of the Ayllu was divided into two parts called *haran* (up) and *hurin* (down), mirroring the subdivision of the capital, as we shall see further on.

The management of the country was in the hands of a rigid hierarchy with the noble Incan families on top, residing in the capital. Taxes were paid in nature or by compulsory work in state enterprises. The central archives recorded, therefore, in the same meticulous way, taxes, harvests, and work done by the various villages; the method to record such data was called *quipu.*

A quipu is a cluster of ropes tightened to a main one and laid out as a

Figure 10.4: "Mapa Mundi of the Indies of Peru", showing the quadripartite division of the Inca state (Poma de Ayala)

"tree." The ropes are of different colors, lengths, and dimensions, and have a series of different knots (Urton 2003). Using these knots, it was possible to record numbers (on base 10) and data, which could later be read by the state officer by simply letting the quipu slide between his fingers. Linked to the quipu was the *Yupana*, a kind of abacus made of a board with small boxes (Laurencich Minelli 2007). Despite reports suggesting the existence of special quipu*s* suited to record written texts, they were never found; consequently, it has been stated frequently that the extraordinary civilization of the Incas was illiterate. Recently, however, in the family archive of the Neapolitan researcher Clara Miccinelli, a set of secret Jesuit manuscripts by the mestice Blas Valera and by two of his brothers were found. The manuscripts date from the early 17th century and contain new information on the Peru of the preconquest period; they suggest the existence of a special kind of quipu used to write sentences by the means of a syllabic system (there is a huge debate among specialists on this find; for further information see Laurencich Minelli 2001, 2007; Miccinelli and Animato 1998).

The Incas were amazing builders. First they built hydraulic canals and land terraces, in order to improve the farming system, making it far more

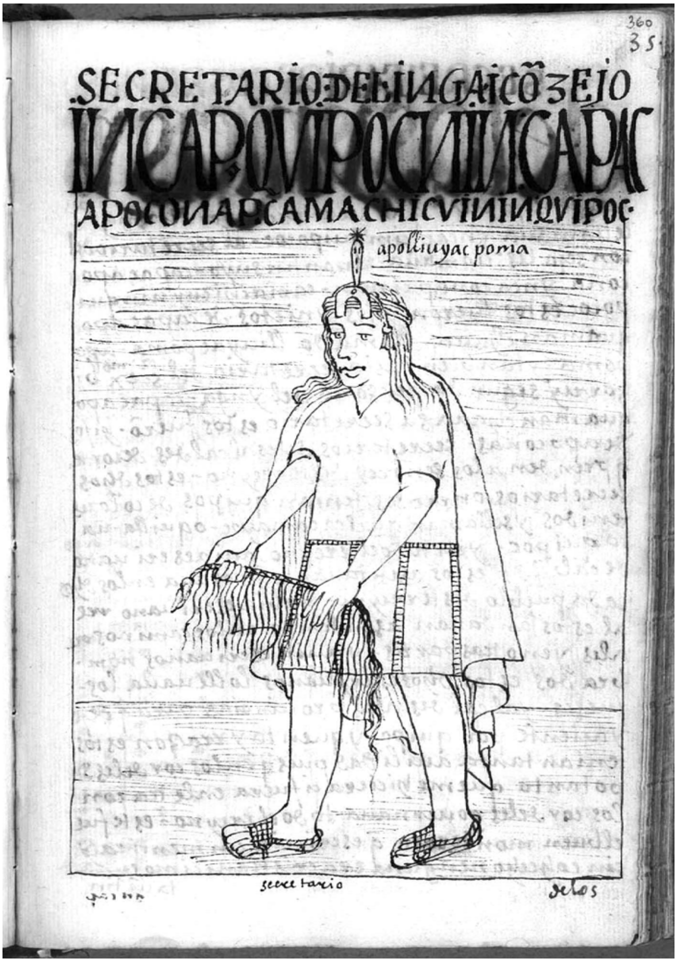


Figure 10.5: An Inca official carrying a Quipu (Poma de Ayala)

efficient and productive. Then, a very efficient storage system enabled accumulating the surplus of production to be used in case of a food shortage. Finally, they built a capillary network of roads thousands of kilometers long, composed by two main roads, one along the coast and the other up in the mountains, connected by numerous bypasses (the roads were not planned to be run by wheeled vehicles because the Andean beasts of burden, the llamas, are not suited to pull carriages; the idea that the Incas did not invent the wheel, which has sometimes been stated, is as nonsensical as it was in the Aztec case, at least in my opinion).

In addition to the language, the centralizing bureaucracy, and the infrastructures, religion was another unifying element of the Inca state. The cosmological vision of the Incas puts their origin in Lake Titicaca. According to the legend, the God-Creator Viracocha created the world: the celestial bodies, the earth (Pachamama), and the sun (Inti), which rose for the first time from a rock in the lake island, consequently called Island of the Sun. On the island there was a complex and very important sanctuary, visited by pilgrims coming from every part of the empire. The pilgrims followed a path that led them to visit the "footprints" of the sun—large marks on the bedrock similar to footprints—and then to the sun rock itself, in front of which there was a huge ceremonial square (Bauer and Stanish 2001). A precise astronomical alignment obtained by using two towers positioned on the top of the hill on the northern edge of the island allowed the pilgrims to watch the sunset at the winter solstice.

The first Inca, Manco Capac, was considered the son of Inti and of Mama Ocllo, daughter of the Moon. The two moved northwest and, after a long subterranean voyage from Lake Titicaca, they reached the Cusco area, where they settled. Thus, the Incas claimed to be direct descendants from the gods; they had a myth prophesying the return of Viracocha, a myth that was probably amplified after the Spanish Conquest however. It is indeed highly improbable, although it has been stated, that the Inca Atahualpa who greeted the arrival of Pizarro at Cajamarca on November 16, 1532, and was that day taken prisoner, believed he was greeting Viracocha in person.

The direct descendance of the Incas from the gods and the close relationship between gods and nature were reflected in the two main aspects of the religious life of the Incas. The first was the worship of the ancestors, whose mummies were carefully preserved (the mummification process is recorded in the Andes starting from the year 4000 BC, and it was practiced by the Chinchorros, in Chile, more than 8000 years ago). The second was the worship of objects, places, and natural phenomena. The entire landscape, with its places (*huaca*), directions (*ceque*), and mountains (*apu*), was considered sacred, and these ideas are still partially alive today (see, for example, Domenici and Orsini 2003). On the mountaintops in particular, on special occasions, the Incas practiced human sacrifice, as the shocking findings of natural mummies of sacrificed children prove (Reinhard 2005).

In addition to the level of the sacred landscape, there was a superior, celestial level, and an inferior one pertaining to the earth. These three levels were connected by the flowing of the rivers from Earth into the great celestial river, the Milky Way or *Mayu*. The three levels of the cosmos and the four parts of the state flew together into the heart of the empire, the navel of the world, the true center of the Incan universe: Cusco, the Puma city.

10.3 The Puma City

Cusco was a splendor, rich in works of art and extraordinary architectural constructions. The Incas' stone buildings were built by fitting together, without any mortar, large blocks of andesite—a very hard and heavy stone similar to granite. The joints between the blocks were polished with bewildering maniacal precision. Within this absolute technical perfection the existence of two completely different styles must be noticed: the *squared blocks* technique, in which the stones are always shaped as parallelepipeds and laid out on strictly horizontal courses, and the *polygonal* technique, in which the blocks are shaped as irregular polygons with several angles and laid out one over the other using apparently crazy, multi-angled, perfect joints. The weight of the squared blocks usually varies between a few quintals and some tons. The Incas' polygonal walls are instead truly megalithic, since the blocks often weigh several tens of tons and can even reach 100, 200, and, in some cases, 300 tons, as in the case, for example, of many blocks of Sacsahuaman, a place that we will discuss shortly (on some of the polygonal blocks the builders left two small protuberances of unknown function and meaning; they look too small to have helped in raising the block with ropes or levers, and look as though they were an aid to wall climbers).

Nobody else in human history attained the Incas' level of perfection in megalithic stonework. There are, however, a few examples of polygonal walls similar to the Incas' in other places of the world, such as Easter Island (see Chapter 13), and Egypt (see Chapter 16). In the Mediterranean area, spectacular megalithic walls were built during the Bronze Age by the Myceneans in Greece (a technique later reused in the polygonal terrace of the temple of Delphi) and by the Hittites in Anatolia. The works most similar to those of the Incas are to be found in Italy, where I have conducted a wide survey (for further details see Magli 2007b,c). Distributed over a vast area in the center of Italy, numerous cities, such as Alatri, Arpino, Ferentino, S. Felice Circeo, Segni, and many others, have polygonal walls made of large stone blocks with sharp edges, joined without mortar. Dating these huge works is a complicated problem not yet satisfactorily solved. Indeed, a disputable archaeological dogma attributes them to the Romans of the Middle-Republican period (between the fifth and the third century BC). The Roman engineers knew very well how to handle heavy stones (just think of the Pantheon columns in Rome, weighing 200 tons each and coming from a quarry in southern Egypt), and they also knew how to build using megalithic stone blocks, as the internal halls of Castel S. Angelo in Rome, made of huge travertine slabs, demonstrate (the castle was originally built as a mausoleum for the Emperor Adrian).

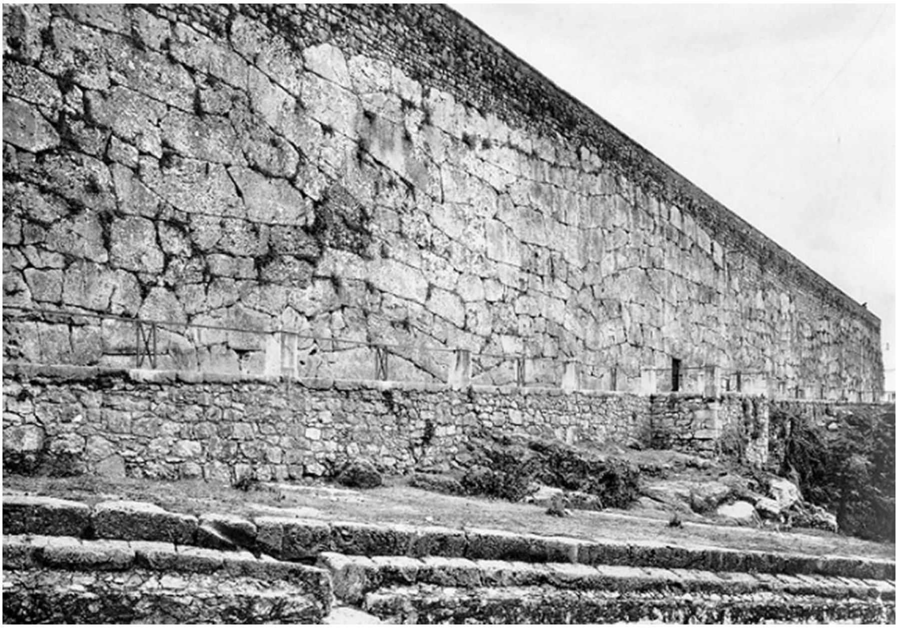


Figure 10.6: Polygonal walls of the Alatri Acropolis, Italy.

Figure 10.7: Polygonal walls on Sacsahuaman

However, except for some rare cases, such as that of the lower wall in the Palestrina sanctuary, inspired by the same building existing in Delphi, the theory attributing the building of the megalithic walls of central Italy to the Romans is difficult to support for many reasons. Indeed, the philosophy of building with polygonal blocks, which entails complicated work on the construction site because the corners of every stone need to be cut with extreme precision, clashes with the practical mentality of the Roman builders, which led to the world-famous structures built in squared blocks, such as the huge foundations of the Coliseum, that can be seen everywhere in Rome and in the Roman provinces.

Polygonal walls in Italy were thus probably made by Italic people, such as the Hernics and the Volsceans, before the Roman conquest, and therefore should be dated around the sixth to fourth centuries BC, if not earlier (Magli 2007b). Many of these works are breathtaking, but none can be compared to the perfection of the acropolis in Alatri, a gigantic megalithic structure (with walls up to 15 meters tall) built with such absolute technical accuracy that it is impossible to insert even a single sheet of paper between its blocks. It is to be hoped that a new method of dating stone will lead to a definitive date of construction (Liritzis 1994, Liritzis et al 1994). The purpose of this building is unclear as well, as we have no written record of it; however, in the 1980s a local scholar, Don Giuseppe Capone, discovered numerous solar alignments between the acropolis and the city gates, and suggested that the trapezoidal plan of the acropolis—a true replica of the polygonal blocks of its walls—was inspired by the shape of the Gemini constellation (Aveni and Capone 1987, Capone 1982; for further details on Alatri, see Magli 2006).

Coincidentally, the Incas' capital had its own particular shape. From some chronicles written after the Spanish conquest we know that the city was planned to make it look, when seen from above, like a puma (the Andean feline also called mountain lion). It is easy to see the profile of the animal when looking at a map of the historical center of Cusco; the main square is the space between the front and the back legs of the animal, while the main temple, the Temple of the Sun or *Coricancha*, corresponds to its genitalia (Gasparini and Margolies 1980, Rowe 1967). The puma's tail is sketched by the confluence of the Tullumayu River and the Vilcanota River, which delimited the ancient borders of the town (today they are covered and correspond to two converging streets). Following the contour of the animal, we see that the head is represented by a hill, called Sacsahuaman, located at the northeast end of the town plan. Indeed, Sarmiento de Gamboa, in his chronicle from 1572 (translated by Clements Markham in 1907), stated:

Figure 10.8: Plan of Cusco drawn by E. Squier in 1860. The profile of a four-legged animal is easily recognizable.

> After Tupac Inca Yupanqui had visited all the empire and had come to Cuzco where he was served and adored, being for the time idle, he remembered that his father Pachacuti had called the city of Cuzco the lion city. He said that the tail was where the two rivers unite which flow through it, that the body was the great square and the houses round it, and that the head was wanting. It would be for some son of his to put it on. The Inca

discussed this question with the orejones [the Inca nobles], who said that the best head would be to make a fortress on a high plateau to the north of the city.

Cusco is therefore, to my knowledge, unique case in the world of a town built on a specific plan conceived to satisfy some purely symbolic criteria. This monumental reassessment of the city happened probably during the first half of the 15th century, over a preexisting site; the conventional date for this event is fixed at 1438. There was no practical need to plan the town between two rivers and with a huge hill on the northwest. The town could have been built some hundred meters south without any problem. As a consequence of the crazy layout of the Incan town, still perfectly recognizable today in the Cusco center, the main roads (created in the last century by covering the rivers) cross the longitudinal streets at different angles, and the blocks of buildings (most of which still exhibit the Incas' marvelous stonework on their foundations) are not rectangular but trapezoidal, because of the need to adjust to the body of the puma defined by the two rivers, getting thinner toward the tail. It should be noted, however, that the scholar Tom Zuidema (1985) refuted the possibility that Cusco was planned in the puma's actual shape. According to him, the first description of the city as a lion—by the chronicler Betanzos—was to be interpreted only as a metaphor for the power of the head of the state, the Inca, living in the town. This metaphor was later misunderstood by Sarmiento as being factual evidence. My opinion is that Zuidema's viewpoint is not alternative but rather complementary; *both* interpretations are likely to be valid. The fact that Cusco was laid out in a puma shape was the counterpart of the metaphoric content of Cusco's phrase "like a puma"; this would not be strange in the Andean world, which was rich with dual aspects. The puma indeed was a sacred animal, and we shall see further on that it might have been connected with another "dual" puma in the sky.

10.4 The Serpent on the Lion's Head

The Sacsahuaman hill was the puma's head. The building, which lies, opposite to the town, in the northern flank of this hill, is, among all the crazy things that we are coming across in this book, definitely the most absurd to us. But the person who planned it and the thousands of people who built it with much effort over several decades knew very well what they were doing, and why (Plate 19).

The building is a series of three parallel, terraced walls over 300 meters

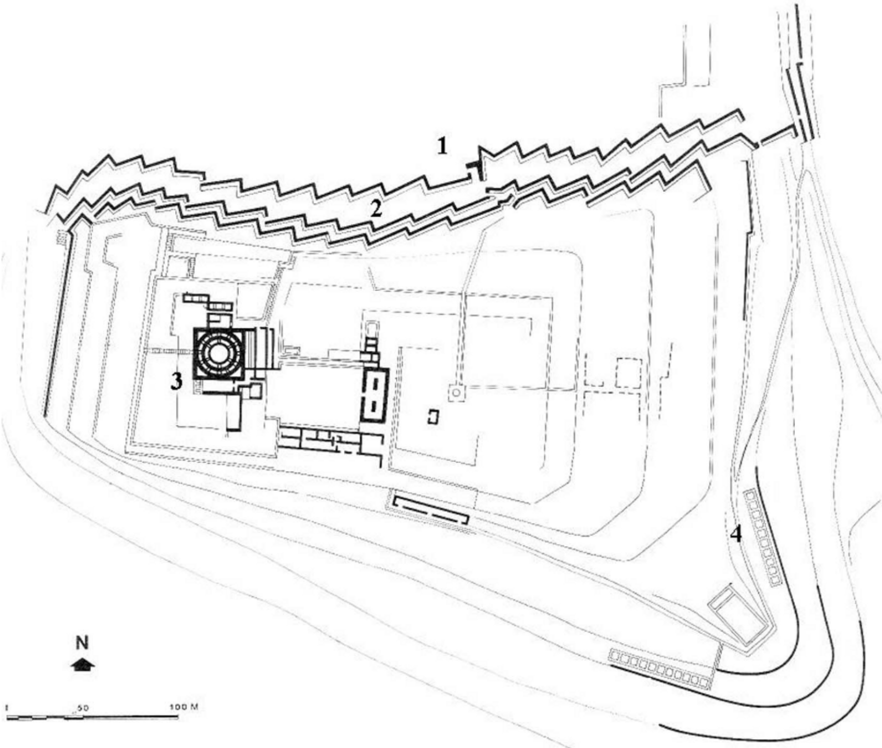


Figure 10.9: Map of Sacsahuaman hill (adapted from Gasparini and Margolies 1997). 1) Main gate 2) Zig zag walls 3) Circular tower 4) Storehouses

long and more than 6 meters tall, made of polygonal stonework. The huge blocks fit together with insuperable precision, and some of them, especially in the corners, weigh over 300 tons. The blocks were quarried on the flanks of a hill that lies some kilometers to the northwest of Cusco (Bauer and Stanish 2001). The walls are laid out in a zigzag line, with regular projections like saw teeth, a feature of even more obscure use than the entire complex (see below). On the hill's top there were various buildings and a round tower, of which only the foundations remain. Important public ceremonies were certainly held in the vast square in front of the walls, and the aristocracy could attend them sitting on the "Inca throne", which is a large rock sprouting characterized by natural "slides" of volcanic origin, finely carved in the shape of a tribune.

Although many archaeologists love to call Sacsahuaman a fortress (which it was during a desperate anti-Spaniards rebellion in 1536), it is ridiculous to think that the structure could have been built for military purposes. The Sacsahuaman "fortress" is totally inadequate for any defensive purpose, for the following reasons:

1. The building is composed by three terraces that form defense lines. However, the width of the first line is too small to allow an effective defense, and the central entrances to subsequent lines are too close together. If the building were to have a defensive purpose, the entrances would have been constructed as far apart as possible, so that if an enemy penetrated the first line, it would have been obliged to move along the line, under the bows of the defenders, to reach the next gate.
2. The defensive function of the saw teeth is totally mysterious. The Spaniards certainly thought that they were used as protruding towers to cross-fire bows or missiles on the enemy. I have estimated, however, that the distance between two such towers is an average of 19 meters. This is much less than twice the maximum shooting distance by a bow or by the hand projectiles that were used by the Incas. This shows that more than one third of the saw teeth built with much effort from enormous stone blocks are superfluous for defense. In comparison, one may notice that the Roman standard for the construction of towers in city walls was to separate them about 33 meters each, a distance that allowed a perfect cross-shot by the defenders.
3. The way in which the gates were closed is unclear, if they were closed at all.
4. The use of the zigzag wall technique is poorly documented among the Incas. A single example can be found in one of the fortification walls of the provincial fort of Inkallakta, Bolivia (Hyslop 1990). But there the distance between the saw teeth is much larger, and the zigzags are probably due to the fact that the wall ascends on the flank of a steep hill.
5. Aesthetics, much more than functionality, seem to have been the inspiring principle of the building. For instance, it was noticed by Gasparini and Margolies (1983) that, at a certain point, the builders first put in place a huge, rectangular megalith and then realized that, instead, two smaller blocks joined together would have been more in harmony with the sinuous turns of the polygonal courses. Thus, they *carved a thin line* on the surface of the megalith to make it look like two joined blocks (yes, quite an efficacious defense trick indeed).
6. The Incas at their apogee had practically no dangerous enemies at all, and certainly none in the heart of their empire.

The only reason why Sacsahuaman has always been called a fortress is that the Conquistadores could not even remotely think that such a structure was built without a military purpose.

But what is the real purpose of this building? And what are its symbolic meanings? It can be read in many tourist guides that the zigzag walls of Sacsahuaman were meant to reproduce the teeth of the puma's head. However, this is nonsense, because the walls are not laid out where the puma's mouth should be, but rather distributed on the upper part of the head's profile. I believe, rather, that the walls were conceived and built in order to represent, on the same hill of the puma's head, another sacred animal of the Incas: the serpent. Clues for this interpretation can be found in the Poma de Ayala chronicle, where a quadripartite Incan coat of arms is depicted, showing a puma and a serpent (and a buzzard and a piece of textile). The iconography of zigzag serpents, connected with that of Illapa, the thunderbolt, can be seen carved on several stones in Incan (or immediately postconquest) buildings in Cusco, and one such carving has been found on Sacsahuaman as well (Trever 2007); furthermore, a long-standing tradition identifies the shape of a running serpent in the polygonal masonry of one of the zigzag terraces (although this might be due to pure chance). Finally, as we shall see, the serpent had a celestial counterpart in the sky, as did the Puma in all probability, in the form of dark constellations located at the two convergences between the branches of the Milky Way.

Another enigmatic place in which Incan stonework reaches perfection is Ollantaytambo, some dozens of kilometers north of Cusco, in the Urubamba valley (Protzen 1985, 1993) (Plate 20).

Ollantaytambo is placed in a strategic position, at the entrance of a canyon, and it is made of a series of artificial terraces with a building on top, erected with the usual extreme precision; as a consequence it is usually described as a stronghold meant to guard the valley. However, some consider it a royal estate belonging to the king. Others consider it a ritual complex; clues for this interpretation come from a sophisticated net of channels that feed a series of wonderful fountains and pools, perhaps meant for ritual ceremonies, and from the observation that the rocks on the hill that faces Ollantaytambo seem to form a gigantic human profile, which the (modern) tradition states is that of Viracocha (curiously enough, a very similar profile can be seen in Pedra de Gavea, a rocky peak not far from Rio de Janeiro, Brazil). As these three different explanations indicate, we really have no clear idea of the purpose of this complex. For instance, the megaliths on the summit could have been part of a building, maybe a temple, but it was never completed, and not because of the arrival of the Conquistadores but because the project was abandoned much earlier. The entire site gives the impression of an ambitious work in progress, a construction site that remained frozen in the state in which it was 600 years ago. The gigantic blocks, dozens of which are still scattered around the site, were quarried from the Kachiqhata hill, some 5 kilometers away on the opposite bank of the Urubamba, and were first carried down to the valley (using a huge rock-cut slide), and then ferried on the river and finally carried up the hill on the opposite side. All in all, I believe that the true meaning of Ollantaytambo has not yet been fully grasped, and the same holds for many other Incan sites in the Urubamba valley. [I discuss in more depth the symbolism of Incan architecture and sacred landscape in a forthcoming book (Magli 2009).] More generally, I do not believe that the origin and meaning of the Inca polygonal stonework have been sufficiently investigated. It is indeed apparent that such a complicated, time-consuming technique was employed—in contrast with the simpler, standardized square-block technique—in specially chosen places with a symbolic, rather than functional, meaning. My friend and colleague Laura Laurencich Minelli (personal communication) proposed the idea that the polygonal, chaotic arrangement of the blocks may symbolize *Pachamama* (the Mother Earth) while the square-block technique might be associated with the cosmic order; in particular, the polygonal masonry of Sacsahuaman might be compared with a symbolic piece of textile, in which the scheme becomes more and more regular. This kind of Incan textile appears to symbolize Pachamama and the progressive ordering of the world. Furthermore, as usual in the Incan world, the two stonework techniques might have been associated with the complementary "haran" and "hurin" concepts: of the two main monuments of Cusco, the Coricancha is built exclusively with square blocks, and the Sacsahuaman is built exclusively with polygonal blocks.

The origin of the technical procedures of stone quarrying and cutting has been traced in part to Tiahuanaco (Protzen and Nair 1997). Sometimes one actually gets the impression that at least part of the huge megalithic constructions (especially those in Machu Picchu; see below) may belong to a period prior to the Incas. As is well known, it is almost impossible to date stone buildings using physical-chemical methods, and the only historical evidence of the building of, for example, Sacsahuaman by the Incas—a construction that should have been carried out in a period very close in time to the conquest—is the recording in some chronicle, particularly that by Garcilaso de La Vega. But even de La Vega, who was born only a few decades after the presumed completion date of the construction and thus could have known an eyewitness to its construction, declares that he does not understand how they could have built such a structure without the help of the Devil.

Perhaps a better understanding of the symbolism underlying the polygonal stonework will help us in better understanding this construction. In any case, works as huge as the Sacsahuaman are only elements in the gigantic sacred landscape of the Incan heartland.

10.5 The City of the Lines

For the Incas, probably more than for any other ancient civilization, celestial bodies and the sacred landscape mirroring them were indistinguishable, as religion, astronomy, architecture, and daily life were linked. The systematic destruction of Incan culture and traditions perpetrated by the Conquistadores makes it more difficult for us to understand the Incas' way of interpreting and studying nature. The only way to do so, is to look at how they modeled the space surrounding them.

A crucial point in how they modeled their space was the idea of *radiality*, the division of space into radial sections starting from a common center. The state itself, called *Tahuantinsuyu*, was the "state of the four parts"—four main directions starting from the main square in Cusco, dividing the town and the state itself into four cantons. Two such cantons, Chinchaysuyu and Antisuyu, were associated with "hanan" ("above"), while the other two, Collasuyu and Cuntisuyu, were associated with "hurin" ("below"). It is not clear whether these four directions were all aligned with the cardinal directions; according to Urton (1978), one of the axes was directed northwest/southeast and aligned with the rising of the Southern Cross as seen from Cusco.

The grid dividing the city in four sections was further subdivided according to a complex and refined mechanism, where human and celestial bodies were mixed in an inextricable way. The Coricancha was the ideal center of a further division of each of the four parts of the city and its surroundings into radial sectors, and the lines dividing such sectors were called *ceques*. Along the ceques there were many *huacas*, "sites worth worshiping," of various kind, including stones, springs, caves, and other places considered sacred. The people living along each ceque were in charge of the maintenance of these huacas, and the maintenance included both administrative tasks, such as checking the correct distribution of the waters, and ritual procedures, such as bringing the offerings on specific days.

The angle between one ceque and the next, and the angle between two subsequent segments of the same ceque, could vary according to various factors, such as the distribution of the waters in that sector, or the desire to direct the line toward prominent hills. Therefore, the ceques were not straight lines, although most of them did not intersect. We know the

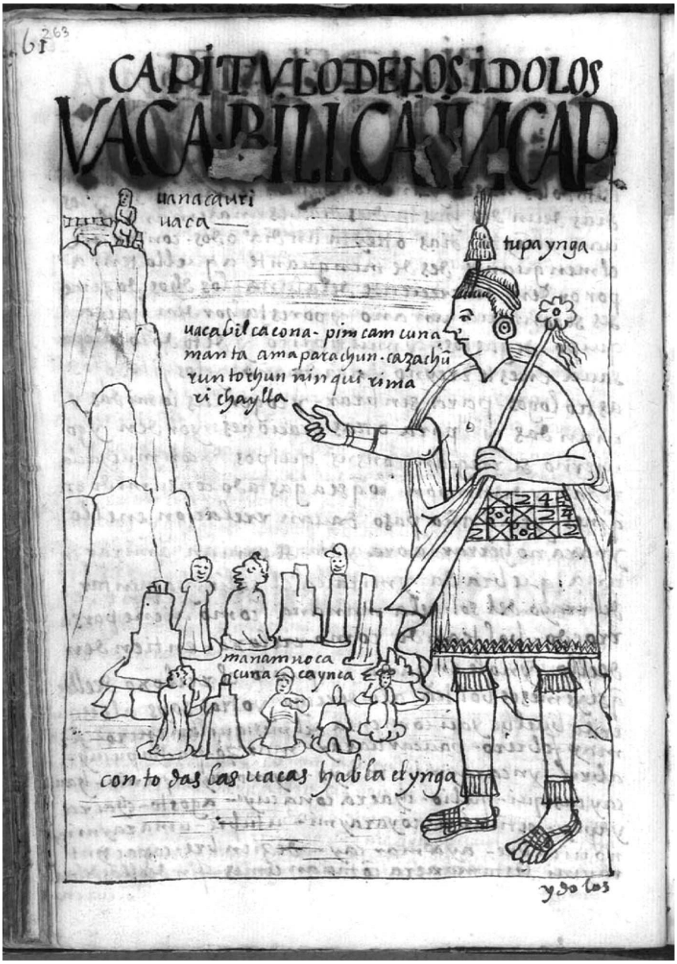


Figure 10.10: The Inca worshipping huacas of various type (Poma de Ayala)

complex structure of the system because of the very detailed report written by the chronicler Bernabè Cobo, who says that 41 ceque lines existed, and that 328 huacas were located along them. However, and despite the fact that in his report Cobo presents a complete list of all the huacas, including for each the name and a brief description, locating the ceque system in the territory has proved to be a difficult task (Aveni 1981, 1996; Rowe 1979, Zuidema 1964, 1988), that was finally completed through Brian Bauer's (1988) fieldwork.

Bauer's book is extraordinary, as it discusses the traces of spirituality and respect for the past that emerge from a landscape tortured by centuries of hatred and contempt expressed by newcomers toward the Indios religion. As an example of this living past, Bauer found a candle that was still lit, having been used in a ceremony the night before his arrival, on the top of a hill called *Huanacauri*—a place that we would consider insignificant, if we did not know that it was the seventh huaca of the sixth ceque of Collasuyu, and therefore one of the elements of a cosmographic system thought to be forgotten for 500 years.

Another exciting aspect of the slow reemerging of the ceque system is that the intrinsic monumentality of every single huaca seems to be casual, or at least unrelated to that of the others. One huaca could be as basic as a stone that no one would notice on a hill, or a humble rock spring, and the next huaca could be as magnificent as the "Throne of the Inca," or a gigantic and puzzling (for us) structure like the Kenko hill, where the Incas built channels, fountains, terraces, and a semicircular amphitheater with a huge monolith that probably represents an animal (a toad or a puma) in its center. (We do not know what the Kenko hill was used for.)

The general idea that one gets by looking at the radial ordering of space within the ceque system is that it is similar to the thinking that lies behind the quipus. Actually, when looked at carefully, a map of the Cusco's ceques is very much alike a quipu spread on the ground, a *gigantic replica* of a quipu , as was noted by the Spanish chroniclers of that period and confirmed in the Miccinelli documents (Laurencich Minelli 2007). It is therefore legitimate to ask what kind of quipu was that. Tom Zuidema (1964, 1977) suggested that the system as a whole was linked to a sidereal lunar calendar of 328 days, in which every huaca represented a day of the year. This theory, though, has not been confirmed by fieldwork research (Ziolkowsky and Sadowsky 1989, Bauer and Dearborn 1995).

I believe that the analogy between the ceque system and a quipu could be raised to a higher level of significance, in that the ceque system is not only similar to a quipu, but may be the replica on the ground of a specific quipu. In other words, I believe that the map of the ceque lines can be read (see Magli 2005a,b for details). According to this idea, it should in future be possible to interpret the typology or the names of the huacas in analogy with the various colors and types of knots of the quipu from which the system was copied on the ground.

10.6 The Pachacuti Yamqui Diagram

It is likely that the recording system based on quipus was used also to keep tracks of scientific observations of the sky, just like with the Mayan codes. Evidence of that is recorded in the Poma de Ayala's chronicle, where an Inca astronomer is depicted with a fork-like observation instrument in one hand and a quipu in the other. Furthermore, we do have convincing evidence from the chronicles that astronomically oriented sight lines radiated from the town's main square, where a large pillar and probably also a tower existed, and from where the movement of the various celestial bodies could be observed. It is, in particular, certain that some special points located on the hills around the town were used as markers for astronomical events. A number of stone pillars (no longer in existence) were laid out with this aim

Figure 10.11: The Inca astronomer, carrying a Quipu and a fork-like viewfinder (Poma de Ayala)

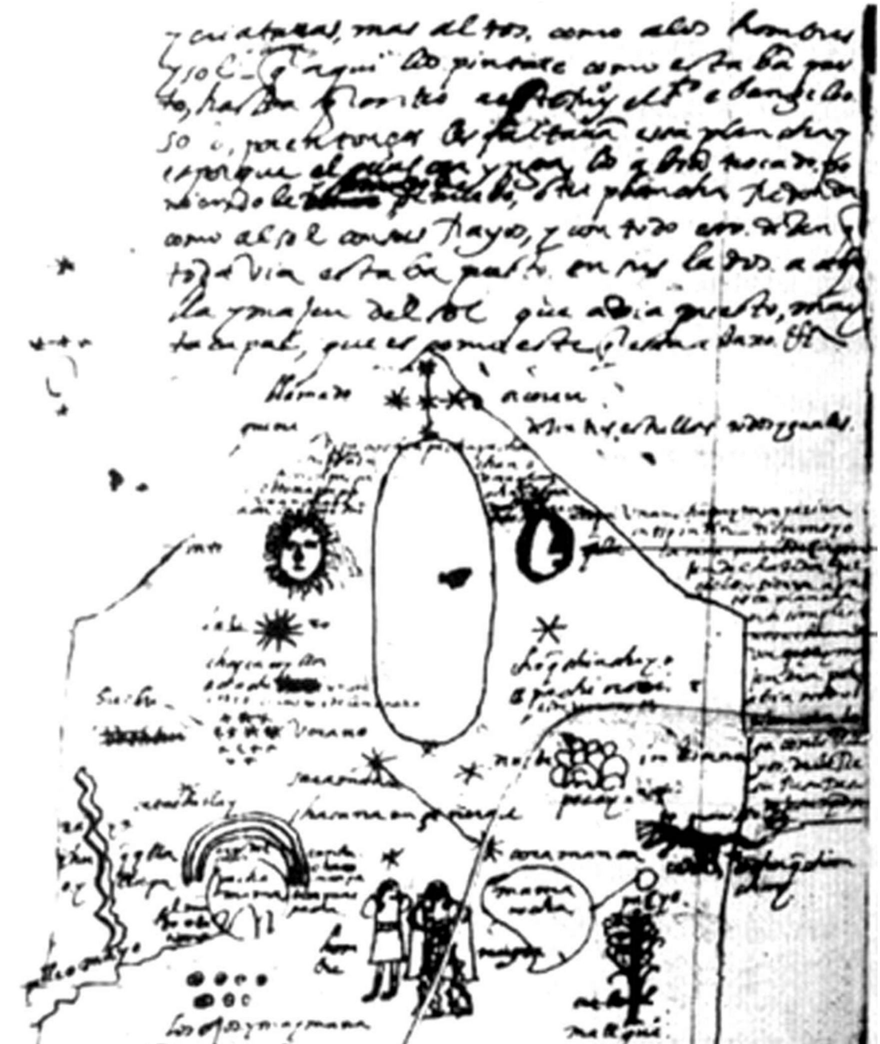


Figure 10.12: Pachacuti Yamqui diagram

on the various hills and were used to locate sunrise and sunset on special days, such as the winter solstice (June 21 in the Southern Hemisphere) and the summer solstice, corresponding to the Incan festivals of Inti Raymi and Capac Raymi, while other pillars probably indicated sunrise during the days in which the sun passes to the zenith. It also has been proposed (Zuidema 1988) that the Incas observed sunrise and sunset at the so-called anti-zenith, that is, when the sun crosses the zenith in the opposite hemisphere (these days correspond to the azimuth symmetrical with respect to due east with that of the zenith). However, no firm evidence has as yet been found for this proposal (Bauer and Dearborn 1995).

Exactly as in Mesoamerica, then, in Peru there was considerable interest in the solar standstills and in the zenith passage of the sun. Various sources confirm this, including the Miccinelli documents, in which there is a picture of a calendar, recording the astronomical events of the Incan year (beginning in our June), which included the day of Conquest (November 16, 1532). Recorded events include moon phases, solstices, equinoxes, zenith passages, Pleiades disappearance and appearance, and a moon eclipse that occurred on February 9, 1533 (for further details see Laurencich Minelli and Magli 2007).

Besides the sun, the Incas thus observed many celestial bodies, such as the moon, on which the Incan calendar (or at least one of the calendars, perhaps a ritual one) was based, and Venus, in its dual aspects of morning and evening star. Furthermore, it is certain that many stars were identified and grouped in star-to-star constellations, such as the *Chacana* group, which was the Incan name for Orion, or the stars called *Collca*, the Pleiades, whose heliacal rising was carefully observed. Almost miraculously, we have a drawing that explicitly proves all of this. It was drawn by the noble Indio Pachacuti Yamqui in 1613. The drawing represents the celestial objects worshiped and studied in the *Coricancha*, the main temple of Cusco. The temple, with its structure still visible today inside the convent of Santo Domingo, is built using the square-block technique, strictly avoiding the use of polygonal joints, a fact which, as mentioned earlier, should have some connection with its symbolic meaning. Here the square-block technique reaches its maximum potential, especially in the exterior boundary wall, which is, for unknown reasons, of elliptical shape.

The interior had only one entrance and was composed of six rooms that overlooked a court; in the center of the court was ideally located the navel of the city and, as a consequence, of the whole Incan world. A room lined with gold was dedicated to the sun. Another lined in silver, was dedicated to the moon. Many other celestial objects were worshiped there, according to the sources and to the depiction of the "celestial pantheon" given by Pachacuti. This depiction mirrors the idea of duality typical of Incan thought, even though some elements are probably added as an apology to the pre-conquest religion, seen as a sort of precognition of Christianity.

The temple is represented as a house or church with the Southern Cross in

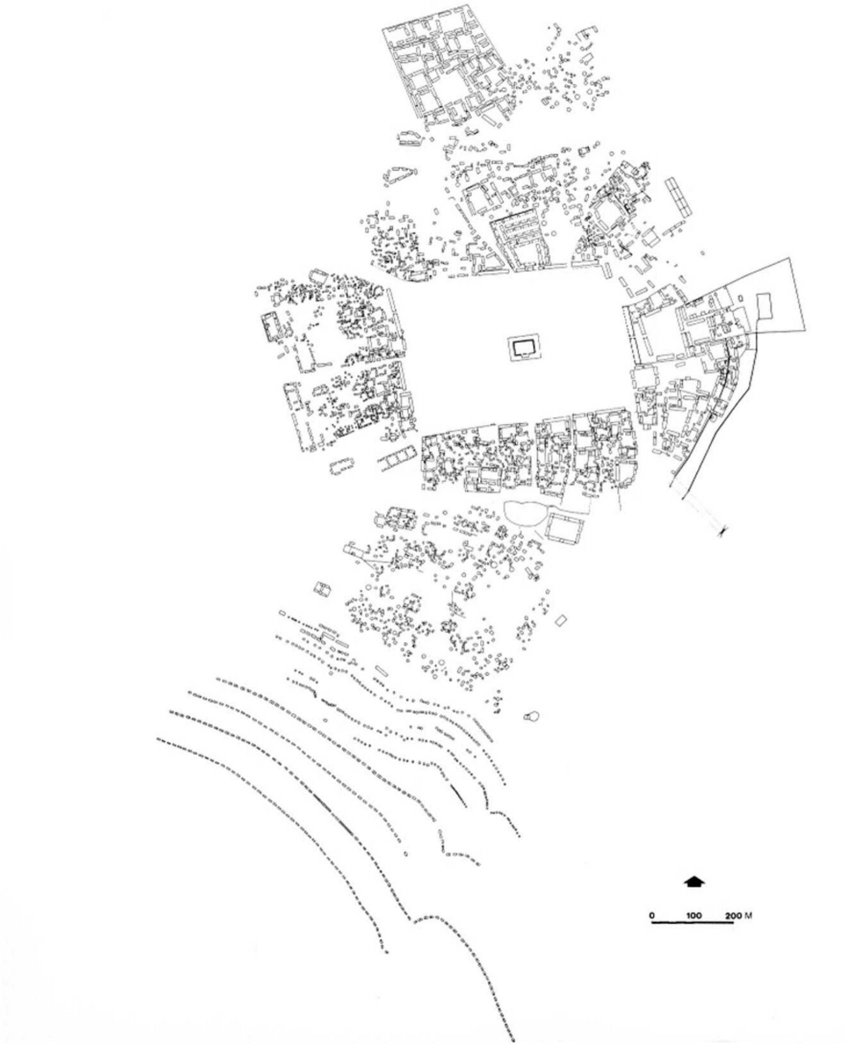


Figure 10.13: Plan of Huanuco Pampa (from Gasparini and Margolies 1997)

its center, so that the cusp of the Coricancha represents the Celestial South Pole with the Southern Cross on top of it. The sacred space below is vertically divided, with an oval (perhaps resembling the boundary wall of the temple) in the center. On the left there are the sun, Venus morning star, a group of 13 stars (maybe the Pleiades), a rainbow, lightning, the earth's surface, the seven main Pleiades indicated as Virarocha's eyes, and a man. In the center there is another starred cross, probably again the Southern Cross, while on the right there is a woman and, top to bottom, the moon, Venus evening star, clouds, a black figure representing a crying feline, the inner part of the earth, and a tree. Finally, on the left, outside the perimeter of the temple, the constellation of Orion is depicted.

It is to be expected that interest in the celestial bodies might be reflected in astronomical alignments of buildings. Research on this aspect of Incan astronomy, however, is still quite incomplete, and only a few examples are known. One is given by the northeast wall of the Coricancha, which is aligned to the rising of the Pleiades, and others have been proposed but not confirmed for some of the lines of the ceque system. Perhaps the most spectacular example of alignment in an Incan building is that visible at the provincial site called Huanuco Pampa (Morris and Thompson 1985). This town is an Incan administrative center, created from scratch in the central highlands of Chinchaysuyu, at an altitude of 3700 meters. It exhibits a very interesting plan, composed of four main quarters surrounding an enormous plaza that is completely empty, except for a severe, square building that was probably used for ceremonial purposes. Although various claims have been made (e.g., Morris and Thompson 1985, Pino 2005), in my view there is no clear evidence that the plan of the town deliberately included a radial organization of the space similar to that of Cusco, aside from the quadripartition of the quarters, which probably corresponded also to a social/functional division. However, the east sector of the town, which is the

Figure 10.14: The east-west alignment at Huanuco Pampa. Notice the stylized feline figures near the lintel of the first door (from Gasparini and Margolies 1997)

unique part built in fine Incan stonework and was thus certainly devoted to the rulers and to ritual activities, exhibits one of the strangest and most spectacular astronomical alignment of which I am aware of.

The buildings of the sector are constructed in a sequence that is not aligned, because each axis bends slightly toward the north; however, the doors of the buildings are aligned in the east–west direction, and therefore from the innermost room of the outermost building one can see the center of the huge plaza and its ceremonial platform, and across to four subsequent doors, each one constructed in fine stonework.

10.7 The Llama in the Sky

The Pachacuti diagram appears to represent the interest of the Incas in any part of nature (rainbows, thunder, trees, celestial objects, and so on). The most enigmatic and unusual element of the drawing is the feline figure, which in the text is called with the quechua name *chuqui chincay* and with the Spanish term *granizo*. The puma, especially a female one, was often associated with the moon in the Incas' mythology; there is, for instance, a legend regarding a puma-grandmother who gets killed and torn apart into crescent-like pieces, and another one in which a serpent and a puma (again together) eat the moon. It may even be that the ceque division of the puma-town is connected with this association as well. In any case, the puma is often present in the iconography; for example, stylized pumas are sculpted on stone lintels at Huanuco Pampa, and many pumas are carved on the so-called *Pedra de Sayhuite*, a gigantic granite monolith on which a map of a city, perhaps an imaginary one, or even a symbolic map of the whole empire is represented (the ability of the Incas in making models of buildings is well documented in the chronicles).

A counterpart to the crying feline was the dark cloud, bringer of rain (Tom Zuidema, personal communication) but also, in my opinion, a *dark nebula constellation* of the Milky Way.

The dark nebula, or *dark clouds*, constellations are a way of representing regions of the Milky Way that is alien to Western astronomy. The Milky Way crosses the sky as a belt of soft lights, and it is therefore hard to see it when artificial light and pollution are present. For instance, on the night of January 17, 1994, when a strong earthquake shook Southern California, causing a blackout, many people fled their homes and spent the night in the open air. The Griffith Observatory in Los Angeles received many calls inquiring about those fascinating lights in the sky. The callers were referring to the Milky Way, which finally had became visible due to the complete absence of artificial light (Krupp 1995). When it is possible to observe our galaxy in optimum visibility conditions, the dark zones inside it can be perceived as figures. The Incas (and also the Australian aborigines) saw animal shapes in them, and organized the figures into a band of dark constellations that cross the sky in a way similar to our zodiac, the band of the constellations of the ecliptic. In commentaries, such dark "animals" in the sky are mentioned, for instance by Garcilaso de la Vega, who was unable to recognize them. The Western conception of the sky is so different from the dark cloud conception that such constellations were definitively identified only at the end of the 20th century, when Gary Urton (1982) published his key anthropological work. Urton found traces of the Incas' vision of the sky within the astronomical lore of the Misminay, a people living today in a village a few kilometers from Cusco. From Urton's work it appears clear that the following constellations are to be found, displayed in a line, among our Sagittarius, Scorpio, Southern Cross, Vela, and Puppis constellations (Plates 21, 22):

1. Two *Tinamou* (ground-dwelling birds similar to grouse), one near Scutum, the other under the Southern Cross
2. A fox
3. A llama (in order to see it is necessary to imagine a llama lying on its side) between Scorpio and Centaurus; the two bright stars alpha and beta Centauri were seen as the "eyes" of the llama
4. A little llama, lying under his "mother" llama
5. A toad, west of the Southern Cross
6. A serpent, between Vela and Puppis

All the above-mentioned animals were both common and important in Incan times, either for practical reasons (such as the llamas) or for reasons connected to myths and beliefs (such as the fox and the serpent). A connection with water and sacred mountains can also be supposed (Reinhard 2007). For instance, the toad rises heliacally during the rain season, and toads are commonly utilized in rituals for rain. Among the sacred animals, however, both the condor and the puma appear to be lacking a celestial counterpart. The existence of a puma constellation has been proposed as well. According to Urton (1982, table 7) it could be located, therefore, in the tail of Scorpio, but I have instead proposed that it lies much further north than that, to be precise between Cygnus and Vulpecula (Magli 2005b). Here, indeed, the two branches of the Milky Way converge, as do the rivers of Cusco near the puma's tail, and there is little doubt regarding the fact that the Incas considered *Mayu*, the Milky Way, to be a celestial river formed by the same water that would later fall on Earth as rain. In addition, at least according to one of Urton's (1982, p. 59) informants:

> The Milky Way is actually made up of two rivers, not one. The two Mayus originate at a common point in the north, flow in opposite directions from north to south, and collide head on in the southern Milky Way.... These data indicate that the celestial river has a second center, a "center of origin," in the north.

Perhaps, therefore, Cusco was built in the shape of a puma in order to represent the terrestrial counterpart—the replica—of the celestial puma located as the town at the confluence of two "rivers".

It may also be that the celestial llama, just like the puma, had its own terrestrial counterpart. It is the Paramonga "fortress," built on the top of a hill north of Lima. Paramonga amazed the Spaniards because of its similarity, at least from a distance, to a European castle. It is actually a great pyramid made of raw bricks, created by four subsequent terraces. Its present shape dates back to the Chimú period (around the year 1200 AD), and its purpose is still unclear, although it was probably more of a sanctuary than a fortress. What is certain, instead, is that the main platform extends toward the east to create a smaller bastion and, as a consequence of that, when looked at from above, the complex recalls the profile of a four-legged animal.

Maybe there are celestial counterparts to other dark constellations as well, like the fox, for example, and they still have to be identified. With the Incas, in any case, and perhaps in the most inextricable and complex way so far, we see a close relationship between the sacred landscape and the cosmos. In a sense, the separation between the two did not exist at all: the human level was part of the celestial landscape, and vice versa. Not only Cusco itself, the navel of the world, had been planned and built in the shape of the celestial puma, and not only in the celestial river, the Milky Way, ran the same water that was used for farming, but in a sense the entire landscape was like a complex machine. Whenever some of the gears got in the right position, for instance when the sun passed between two towers at the horizon, a communication channel between the two levels opened up.

How were the observations performed? How did the Incan astronomers work? to answer these questions we need to set aside the false information, the imprecise and foolish ideas that the postconquest chroniclers used to mask their ignorance regarding their predecessors. Luckily, there is a place where it is possible to do this.

10.8 An Old Town on an Old Mountain

It takes your breath away, and not for the rarefied oxygen at high altitudes. It takes your breath away because it is one of the most beautiful and enigmatic places on earth (Plate 23). We do not know what the Incas called it; we only know that it lies between two paired peaks, and that a peak was called *Machu Picchu*, the old Picchu, in contrast with the other, *Huanya Picchu,* the young one. These names were reported in 1911 to the archaeologist Hiram Bingham by people living in the area, and he named the town as the peak, Machu Picchu, a name that today is incorrectly assumed to be Incan.

Machu Picchu stands on the ridge below the top of the rocky peaks, in a position of extraordinary beauty, overlooking the Urubamba valley; according to some, the profile of its twin mountain Huayna Picchu recalls a gigantic crouching puma protecting the town (Salazar and Salazar 1996), but maybe it is just an illusion. Incredibly foolish things have been written about Machu Picchu, so let's look first at available information that is accurate.

The town is invisible from the valley below and, although it may seem incredible, there is no proof whatsoever that it was ever visited by the Spaniards. It is not even certain that the existence of such a town was ever mentioned in postconquest documents, although it should be mentioned that a city called Picho, which may have been what we call Machu Picchu, is cited in a few writings of the second half of the 16th century (Rowe 1990). Perhaps the town disappeared from history because it had been abandoned for a number of years *before* the conquest, maybe due to the arrival of virus

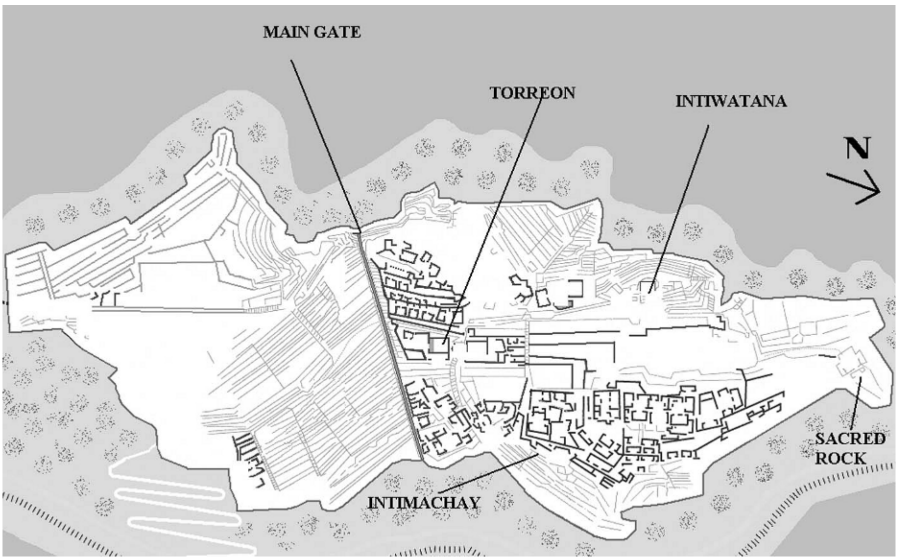


Figure 10.15: A schematic map of Machu Picchu with the sites cited in text

diseases (measles and smallpox) brought to the Americas by the Spaniards that spread in the Incan empire, decimating the population a few years before Pizarro's arrival. Machu Picchu was then invaded by vegetation and was known only to some farmers who lived in the area, until 1911, when the American explorer and archaeologist Hiram Bingham left the first Western footprint on its ground.

Everything else that has been written on the history of this town is speculation, if not fantasy. For instance, we do not know when it was constructed and we do not even know if the city was entirely built by the Incas or not. There are in fact several parts of gigantic walls built with huge stone blocks that were integrated with walls built with smaller blocks, in the typical Inca's squared style. In spite of this, it may be read in many scholarly sources that Machu Picchu was constructed as a royal estate of the Incan ruler Pachacuti. This idea comes from the same paper cited above (Rowe 1990). However, I think that not many people did read it, since it does not contain any evidence whatsoever. Indeed, Rowe states, "*we can suppose* (*podemos suponer* in the original Spanish) that the Inca ruler choose Machu Picchu as a personal estate and as a memorial of war campaigns in the zone of Vitcos."

Debatable assertions do not stop there. For example, it is known that a thousand people or so lived in Machu Picchu, and their survival was based on high-altitude agriculture on terraced fields and from springs that provided the city with water through a sophisticated system of aqueducts. When the burial grounds of these people were discovered, the bones were, however, considered to be mostly of females, which raised the suspicion that Machu Picchu could have been a sanctuary of the "Virgins of the Sun" or, according to others, a gigantic brothel. The abandonment of the town engendered foolish legends of a priest running away with a "virgin," dishonoring the town, or of syphilis (traces of which appeared to be found in the "virgin's" bones, sic), which allegedly destroyed the entire population. Fortunately, a reexamination of the bones has shown that the number of females was overestimated, so that at least the virgin theory is now debunked (Burger and Salazar 2004).

All in all, we do not have many clues regarding what such a beautiful town, built according to a strict urban plan and with wonderful megalithic walls, lost under the top of a mountain, was used for. However, we do know that it is perfectly and wonderfully integrated into the nature around it, so much so that the masonry structures mix with the natural rocks in bewildering harmony, and the city is most naturally identified as a sacred place, perhaps a pilgrimage site. Its relationship with the landscape is probably by design; for example, the peak of the highest mountain of the

Figure 10.16: The Torreon at Machu Picchu

region, Salcantay, lies directly due south of the city (see Reinhard 2007 for a complete discussion).

There is another thing we can be sure of: the Machu Picchu people had a deep interest in astronomy. For instance, a building in the shape of the letter P, today known as *Torreon*, was probably used as an astronomical observatory. The building, similar to a large tower, is lighted through three trapezoidal windows, two of which point to sunrise on the June solstice and to the rising of the Scorpio constellation, respectively. An observer inside the Torreon, on the day of the winter solstice, would have been able to see the sun rising in the morning through a window and, in the evening, the Pleiades rising in the same window, while the Scorpio constellation was rising aligned to the southeast window (Dearborn and White 1983, 1989). A third window of the Torreon is oriented northwest and its probable astronomical purpose is still to be determined.

Another important structure of Machu Picchu, called Intimachay, was linked to the summer solstice (Dearborn et al. 1987). It is a cave located on the eastern side of the terraces below the city, famous because, near its entrance, the natural boulders of rocks seem to form two open wings of a bird; on the ground, a sculpted stone helps the eye to imagine a huge condor, just landing to watch the hillside of the city. The natural cave was modified internally by adding to it some refined masonry works and creating a "window" (or a tunnel, to be more precise) on its facade which is 44 by 56 centimeters wide and 2.2 meters long, carefully cut into the rock. At the end of the tunnel a polished slab blocks the view from inside, except for a small portion of the horizon, where the midsummer sun rises. The section of visible horizon is very small, about 10 arc minutes, and allows the sun beams to reach the end of the cave only for a very short period (about 20 days) around the solstice.

Those two monuments certainly do not exhaust the subject of astronomy in Machu Picchu, and we still need to understand a lot more about it. Recently, for example, on the side of the mountain directly overlooking the town from the west, the buildings of Llactapata (already described by Bingham) have been closely reexamined, and it was discovered that the two sites are tightly linked to astronomical alignments (Malville et al. 2004). Machu Picchu itself is still full of enigmas, such as the Intihuatana, or Sun Stone. Despite the name, the purpose of this monolith, carved in granite on a terraced rocky peak, is not clear at all; maybe it was used as a gnomon, or as a viewfinder to observe the sun. Similar stones probably existed in many towns, and are usually called *ushnu*, a term that is applied also to stepped pyramids or huge platforms of ritual use. Most were destroyed by the iconoclastic fury of the Conquistadores, together with many other items of

Figure 10.17: The Intiwatana at Machu Picchu.

the Andean culture; there is, however, another Intihuatana in the Incan complex of Pisac, 10 kilometers from Cusco. An intact example of an Incan ritual platform remains in the center of the huge plaza at Huanuco Pampa, and a unique example of an Incan stepped pyramid also remains, in Vilcashuaman.

Machu Picchu, despite all the unanswered question, is one of those few places where the level of humans and the level of cosmos still meet and mix in an extraordinary way. To underline this special character of the place, while the astronomers were keeping track of the movement of the sun and of the stars, in the most northern point of the complex an artist sculpted a large rock—today called Sacred Rock—as a replica of the profile of the mountains visible on the background, setting forever, in that way, the inextricable link between the town and the stone from which the town itself was born (Plate 24).

11 The People of the Lines

> There can be no doubt that with this enormous amount of work, continuing through hundreds of years, ancient Peruvians pursued a definite aim, which lay in the center of their interest.
>
> —Maria Reiche, *Mystery on the Desert*, 1980

11.1 The Nascas

The Nasca drainage plain is a vast, somewhat desert-like area called a *pampa* in the southern part of Peru. Although in Nasca it rains very little, the ground is relatively fertile, and there are seasonal rivers, subterranean folds, and springs. Nasca was thus the cradle of a civilization, contemporary to the Moche's civilization, that can be dated between II BC and VI AD, thus many centuries before the Incas.

The Nascas lived in villages and had an impressive ceremonial center, Cahuachi, formed by huge structures and, in particular, dominated by a large brick pyramid (Orefici 2003, Sullivan 1988). The site was abandoned for unknown reasons, perhaps an invasion or climatic changes, around the sixth century AD, and it is suspected that the town was deliberately flooded in order to bury it under a layer of mud. Through various archaeological studies, we have a fairly clear idea of the Nascas' way of life. They were expert farmers, and they skillfully used the underwater available through open air and underground canals. They loved music, so much so that in Cahuachi a large number of musical instruments were found, especially wind instruments similar to multiple-cane flutes, obtained by tying together canes of different sizes and length, which are still in use today; they also had ceramic trumpets, ocarinas, and various types of drums. They also loved to collect human heads, called "trophy heads," which were dried using a special technique.

Through the excavation of burial sites, we have learned about the Nascas' arts, especially involving ceramics and fabrics. On the ceramic pieces,

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_11,

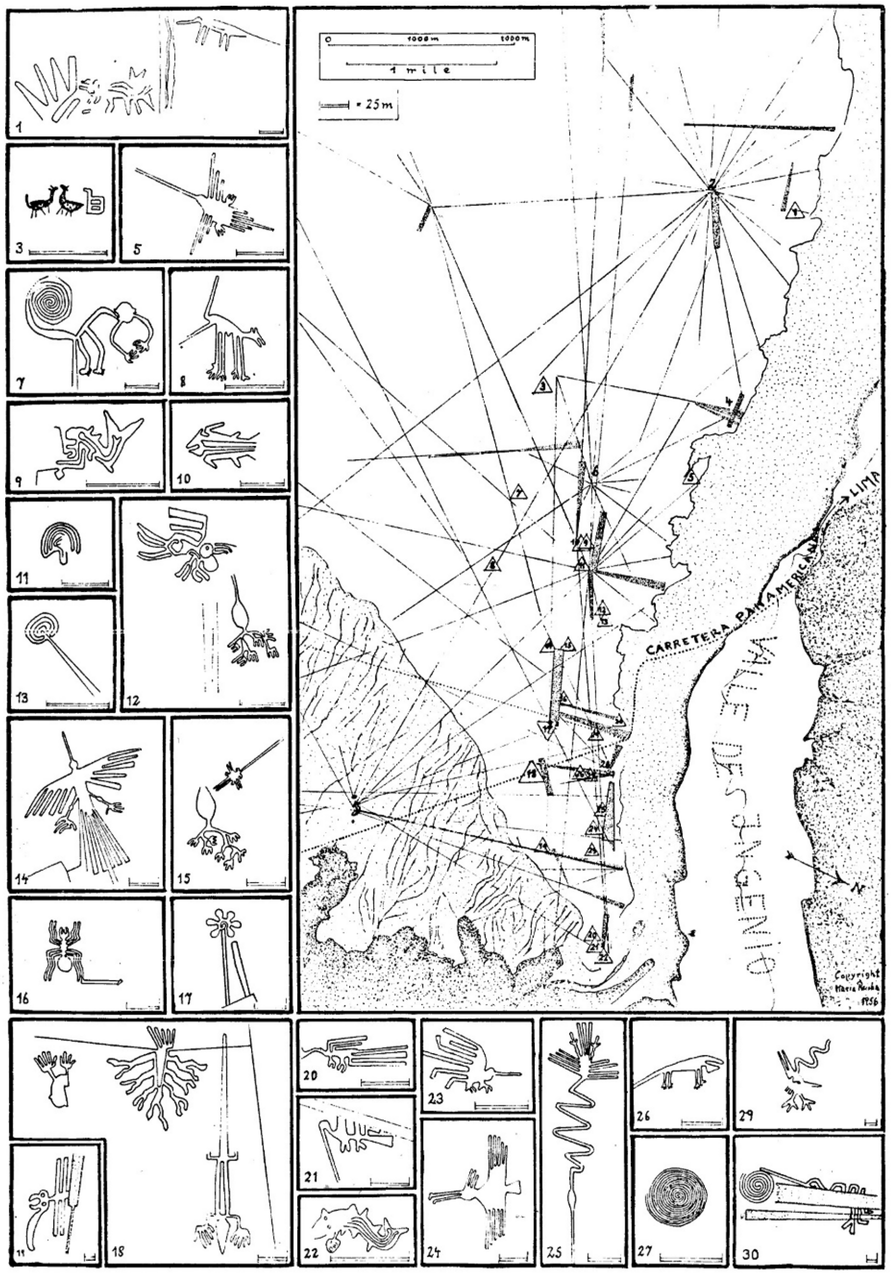


Figure 11.1: The Nasca geogliphys in a drawing by M. Reiche

zoomorphic beings are often represented, or beings that are half men and half animals, as evidence, probably, of a cult based on these type of divinities. The decorative motifs of Nasca textiles are instead typically geometric lines. Indeed, the Nascas seemed to love lines.

In 1920 the pilot of an airplane flying over the Pampas suddenly realized that the plateau was crossed by a large number of artificial lines. He thus unveiled one of the most intriguing mysteries of pre-Columbian archaeology. On the Nasca desert-like surface, somebody drew thousands of kilometers of lines by digging superficial tracks on the ground and removing the pebbles. Most of these "etchings" on the desert surface run straight; others create huge geometric figures (mostly trapezoids). Some groups of lines form gigantic drawings of living beings, tens or even hundreds of meters long (*zoomorphic geoglyphs*). Thus Nasca is a gigantic work of art, constructed over many centuries.

To describe the Nasca lines, it is crucial to distinguish the geometrical lines from the geoglyphs. The latter include dozens of figures placed in a relatively restricted area of the pampas. They represent living beings, so it is common practice to refer to them by the name of the animals they resemble. I reluctantly follow this practice, and the reason for my reluctance will soon be clear. The animals include a spider, a condor, a monkey, a pelican, a cormorant, a chick, a dog, and a killer whale. (There is also a so-called "astronaut", but this figure could have been added at a much later time.) The resemblance of these very stylized creatures to the corresponding animal is vague at best, for these reasons:

1. One of the spider's legs is too long, which has led some to speculate that it could represent the reproduction apparatus of a particular species that lives only in Amazonia.
2. The condor has too small a head.
3. The monkey sports a wonderful but unrealistic spiral tail, and one of his paws has five fingers and the other only four.
4. The pelican has a rectangular body.
5. The cormorant has a very long zigzag neck.
6. The chick has two enormous "hands", one with five fingers, the other with four; some believe that this figure is a toad.
7. The dog seems to have just suffered an electric shock, and one of his paws has four fingers.
8. The killer whale image is the most similar to the true living being. However, there is another "whale" that strangely has a round burden hanging on its neck, possibly a human head.

In general, the Nascas' zoomorphic creatures are different also from

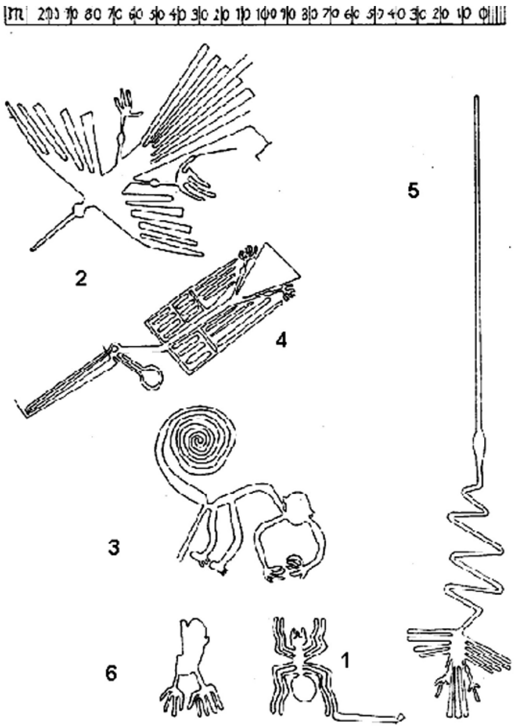


Figure 11.2: Some of the zoomorphic geogliphys: 1 "Spider" 2 "Condor" 3 "Monkey" 4 ''Pelican'' 5 ''Cormorant'' 6 ''Chick''

known Nasca depictions of these animals, with a few exceptions, such as the killer whale, as noted above, and the long-neck bird (Proulx 1990). These two figures are also portrayed on ceramic vases, but it may be that the vases were inspired by the lines, and so we are back to where we started.

All the other Nasca lines are straight paths (often dozens of kilometers long) or huge geometric figures. Among them there are triangles, spirals, and especially trapezoidal shapes, sometimes very large (the largest has an area of about 130,000 square meters).

It is certain that the two classes of lines— zoomorphic and geometric— belong to two different periods. The zoomorphic class is the oldest (or the one that ended first) because some of the geometrical lines cross the figures. It is impossible to date the lines by themselves, and therefore any dating is indirect and based on ceramic findings. There are a large quantity of fragments of ceramic vases near the tracks; most of the ceramic shards are thick and undecorated, suggesting a practical rather than a ritual use (Clarkson 1991), but ceremonial drinking vessels were also found.

The fascinating mystery surrounding the Nasca lines has unfortunately engendered numerous debatable, incorrect, and even foolish ideas. Among the foolish ideas is that the lines are runways for alien spaceships or messages for aliens. But there are a few things we know for certain, and I will discuss those facts. I will also mention some of the incorrect ideas that are still given credence in some quarters.

It often has been said that it is impossible to trace the pampas lines without viewing them from above, but this is incorrect. All that is required is a well-designed plan and the ability to trace precise geometric lines with the aid of poles and ropes. What is fascinating here is that there seem to be no traces of mistakes in the drawings or changes in the figures, and a view from above certainly would have made the line makers' work much simpler. For this reason, and also on the basis of some depictions on ceramic findings, somebody suggested that the Nascas invented the hot-air balloon. In 1975 this theory was put to the test by Bill Spohrer and Jim Woodman, who managed to fly over the pampas for a few minutes in a hot-air balloon prototype built using only materials and techniques that would have been available at the time of the Nascas. However, the experiment, although successful, does not prove that hot-air balloons existed at the time of the Nascas.

Another theory that has a few adherents is that the Nascas' lines were made by a huge number of workers. This, too, is not true. The tracks can be made by removing the pebbles on the surface and baring the ground underneath them. During the 1980s an experiment proved that building a standard Nascan trapezoid (with an area of around 16,000 square meters) requires a team of some 20 people working for 1 week (Aveni 2000). But the work of tracing thousands of kilometers of lines must have been carried out over the course of several decades or even centuries anyway.

Another theory considers the Nascas' geoglyphs to be unique in the world, but in fact there are many others in South America. For instance, the Paracas' famous "candlestick" on the Peruvian coast, 200 kilometers from Nasca, which is thought by some to be a representation of the Southern Cross (but we know little about who made it or when or why). There are also some beautiful and enigmatic figures in the Acatama deserts in Chile, and a huge system of geometrical lines is reported to exist in the Sajama region of Bolivia's western highlands. The Effigy Mounds in Ohio (see Chapter 7) could themselves be considered geoglyphs, and in England there are some huge images created on chalky hills; these images are difficult to date, although it is possible that some date from the megalithic civilization. The most famous are the beautiful Uffington Horse, probably of Celtic origin; the Cerne's Giant, which perhaps represented Hercules; and Wilmington's Long

Man. These three figures, like the Effigy Mounds, might have astronomical associations; for example, it has been suggested that the Uffington Horse might be associated with the Pleiades.

Thus, based on what we know so far, we can say that the Nasca lines are "simply" the product of ingenious people who were capable of doing things with extreme accuracy and seriousness. But we need to return to the assertion, mentioned earlier, that the *meaning* of the Nascas' zoomorphic figures can be understood only by viewing them from high above, as from an airplane. This assertion is incorrect, for the following reasons:

1. Many lines can be seen from the surrounding hills.
2. An observation point a few meters high provides sufficient perspective to appreciate the complete shape of the designs.
3. A drawing of a figure can be done by just walking on it.

However, it *is* true that the *global complexity* of the zoomorphic geoglyphs can be appreciated only when looking at them from above, at a distance of a few hundred meters. Therefore, I believe that the crucial question to be answered about the zoomorphic figures is whether the Nascas followed predetermined plans for a global project, even if they were aware that the complexity of the project itself would be appreciated only by people who were aware of its existence.

11.2 The Lady of the Lines

By looking at the Nasca plan, one immediately suspects that the straight lines can be astronomically oriented, and that the zoomorphic figures could represent constellations. However, in the 1930s, when the lines were discovered, the interest of ancient peoples for the sky was unknown, and only Lockyer and a few other scholars dared to suggest that places like Stonehenge were linked to astronomy or that the ancient Egyptians knew astronomy. From this point of view, the explorer-archaeologist Paul Kosok, who was the first to understand the importance of the lines and to suggest an astronomical explanation, is to be considered a pioneer. Kosok discovered by chance that some of the lines were oriented toward the setting sun at the solstices (and, rightly, he had himself photographed triumphantly near one of them). Unfortunately, though, he consequently offered a half-baked explanation of the whole system—that the Nasca lines were a gigantic astronomy treaty written on the pampa.

In 1930, a young German mathematician, Maria Reiche, moved to Peru and started working as a restorer for the National Museum in Lima. Then

Figure 11.3: Paul Kosok in front of a solstitial alignment at Nasca

she learned about the lines, and she moved to Nasca, where she lived the rest of her life exploring the pampas and dedicating herself to the preservation of the geoglyphs (Maria died there on June 6, 1988). She deserves enormous credit for the preservation of the Nasca lines, and was the first person to embark on the titanic enterprise of mapping all the lines. She also discovered the probable unit of measurement used by the Nascas, and proposed a reasonable hypothesis regarding the way the drawings were made.

According to Reiche the drawings were first traced in chalk on large pieces of rough fabric. The designs were then enlarged to the scale chosen for the ground drawings, with the aid of ropes, sticks, and wooden calipers.

Reiche also carried on Kosok's research about the interpretation of the lines and was herself convinced that the key to understand Nasca was astronomy; for instance, she suggested that the monkey and the spider were representations of two Nasca constellations, corresponding to our Orion and Big Dipper (Reiche 1980). Reiche's idea, later explored by Phylliss Pitluga, was that the Nasca plain hosted a global project with a specific, single astronomical aim. However, she was never able to find the key to such a project.

11.3 The Enigma of the Lines

The astronomical hypothesis of Kosok and Reiche was reconsidered in 1968 by Gerald Hawkins, who performed an archaeoastronomical study of the site on behalf of the National Geographic Society. Unfortunately, he divulged the results of his research only in an internal report to the Smithsonian Institution, the report was never published and now is almost impossible to find. What *is* easy to find, in various places in the archaeological literature, is that Hawkins debunked the Kosok–Reiche astronomical hypothesis. For instance, in the authoritative book on Nasca written by H. Silverman and D.A. Proulx (2002), the astronomical interpretation is dismissed in this way: "Basically, an alignment between a celestial object and a ground marking is statistically insignificant because countless stars are visible in the clear night sky at Nasca." But this is, of course, an atrocious nonsense that Hawkins could not possibly have stated. Thus, I have concluded that his work on Nasca is usually quoted by people who have not read it. So I tried to find a copy of the original report, a task only recently accomplished thanks to the kindness of the Smithsonian's librarians.

Hawkins report is somewhat rough. But it clearly states that his team measured only a small number of lines and geometrical figures on the pampa—21 triangles and 72 straight lines, for a total of 186 (93 × 2) directions. Hawkins did not do an archaeoastronomical study of any of the zoomorphic geoglyphs, so his conclusions, if correct, are valid only for the geometric lines.

After having collected the data, Hawkins programmed a computer to compare the directions of the lines with those of the solar and lunar stations, obtaining 39 significant results. Through an analysis that I will not discuss in detail here, he concluded that the astronomical hypothesis was statistically significant, and he then proceeded to compare the same line directions with the rising and setting of the brightest stars, concluding once again that there is no evidence, from a statistical point of view, that the lines he chose were

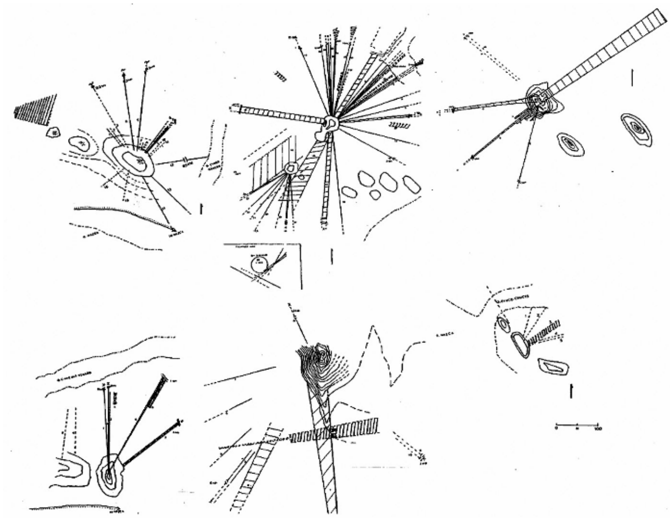


Figure 11.4: Examples of line centers in a drawing by M. Reiche

used by the Nascas to indicate astronomical events, even though he found a large number of single astronomical alignments. On the base of these data he concluded: "The ancient lines in the desert near Nasca show no preference for the directions of the sun, moon, planets, or brighter stars.. . . The pattern of lines as a whole cannot be explained as astronomical, nor are they calendric."

The key to these conclusions lies in the expression "as a whole." What Hawkins really proved is only that based on the few lines he studied, (but the result is likely to be valid in general, see below), a *global* interpretation in terms of astronomical or a calendrical purposes was not statistically supported.

After Hawkins, another authoritative archaeoastronomer, Antony Aveni, tackled the problem. The book on the Nasca Lines he edited (Aveni 1991) contains many important contributions by various authors; Aveni in particular proposes a hypothesis (further developed later, see Aveni 2000) that most of the straight lines radiate from common centers formed by natural or artificial hills should be connected with the flow of subterranean water (see also Johnson et al. 2002). The trapezoidal figures also tend to be oriented toward water springs. As far as the symbolic interpretation is concerned, Aveni suggests that the Nasca lines are to be considered as forerunners of (and similar to) the Incas' *ceque* lines. Indeed, as we already know, the ceque lines had an extremely complex symbolic content, including astronomical alignments but also stations that were considered sacred for other reasons; many of them were associated with springs and water distribution. Therefore, the Nasca lines should be considered "cosmographic lines" connecting a series of phenomena and elements considered sacred, such as hills, and perhaps solar and lunar astronomical alignments, but especially water flows and springs. The lines were efficiently maintained and were walked on during ceremonies or rituals, as the many ceramic findings prove.

I find the parallel between the Nasca lines and the ceque lines, even though interesting and worth considering, a bit suspicious from a methodological point of view. The parallel is based on a model that is 1000 years younger and not fully understood. Further, one of the unsolved problems of the Incas' history is that of finding the sources of their complex and fascinating cosmological view, but it is difficult to connect the Incas with the Nascas in any way (as a curiosity, let me mention also that the Incas did not care at all about the Nasca lines, since the Inca royal road that crosses the pampa goes straight, crossing without any worry all the lines it encounters by chance). Finally, the ceque lines were part of a system based on the concept of radiality from a single center regarded as the true center of the universe, while the Nascas had dozens and dozens of centers.

In any case, the problem of the zoomorphic geoglyphs is fully distinct from that of the geometrical lines and remains fully unsolved.

11.4 A Lesson Left on the Chalkboard

The zoomorphic geoglyphs, as we have already seen, predate the geometric phase; it is difficult to be precise, but they were probably drawn between the second century BC and the first century AD. It may even be that the two phases correspond to two different systems of beliefs; to be cautious, one could follow Persis Clarkson (1991), who says that "certain areas of the Pampa look like a chalkboard used for many different lessons but never erased between each lesson." But what was the argument of the zoomorphic lesson?

According to the archaeologist Johan Reinhard (1996), the worship of mountains might have been strongly connected with the Nasca religion and, in turn, with the making of the lines and of the figures. This worship would be connected with water as well, as will happen many centuries later with the Incas, so that the connection with springs and water flow is not excluded by this hypothesis, although it has to be reconciled with Ruggles's (1991) observation that radial-line azimuths tend to avoid orientations on prominent peaks. In any case, according to Reinhard, the zoomorphic figures were drawn to invoke the aid of gods; for instance, the spider might have been a fertility symbol. The figures could have been used also as ceremonial paths, related to specific gods and ritually walked on specific occasions.

Clearly, if the Nasca divinities to whom the figures were supposedly dedicated were mountain gods, then such divinities had a very good chance of enjoying the figures by viewing them from above. However, although I do not dismiss this interpretation, I persist in thinking that the zoomorphic geoglyphs have to be related *also* to a representation of the Nasca constellations, and therefore that their layout on the ground should be connected with the sky in Nascan times. Of course, as usual in the Andean world, different symbolic patterns of interpretation are not mutually exclusive, and that is why the purely astronomical Kosok-Reiche interpretation has proved to be blatantly wrong.

The reason why I insist in searching for an astronomical interpretation of the zoomorphic figures is, first of all, that the symmetry axis of many of them clearly points to the solstice sunrise, as if the beings were looking at the rising sun. This may indicate the will of representing the sky on a specific day. To check the validity of this hypothesis is quite a difficult task, however, because we do not know how the projection of the sky on earth was done, and the problem is thus similar to that of finding the ancient Egyptian's constellations on the basis of their pictorial representations, a problem that, as we discovered in Chapter 4, is very hard to solve.

There is another, very simple reason for my firm belief that an astronomical interpretation is needed for a complete understanding of the Nasca zoomorphic geoglyphs. As we saw, it is not necessary to be in an airplane to appreciate the shape of the figures, but the complexity of the layout of the figures as a whole and their extension on the plain can be wholly evaluated only by looking at them from a few hundred meters above. On the other hand, when one actually does this, the whole group of figures gives the strong impression of being part of a single system, developed in time according to a global plan, carried on for many years. Thus, we are led to accept that rituals were performed and cyclically repeated on different geoglyphs according to this or that particular day or occasion. In my view, a further confirmation of this relies on the fact that there are no copies of the figures scattered in the pampa; therefore, the repeated rituals did not consist of making the drawings, but rather going to the area, seeking the already existing figure for the desired ritual, and performing it again, perhaps by walking, or praying, or drinking, or who knows. It was therefore necessary to have a map of the drawings, or at least it was necessary to have someone in charge who kept in mind the position and meaning of the various geoglyphs, in order to be able to choose the correct image for specific occasions and to pass on this knowledge.

It may be that the catalogue of the drawings was kept on textiles. However, there is another, very simple solution for the place were this map might have been located, a place where the map could be read, at night, by anybody aware of its existence.

Yes, the sky.

The Last of the Lands

12

> The statues were polysemic symbols utilized within a multi-dimensional social context, and were central to the functioning of a cult which centered upon ancestor worship, fertility and rites of passage.
>
> —J. Anne Van Tilburg and Georgia Lee, ''Symbolic Stratigraphy: Rock Art and the Megalithic Statues of Easter Island,'' 1987

12.1 Easter Island

On some unknown date in the first half of the first millennium AD, a flotilla of Polynesian pirogues, probably coming from the Marquese Islands, landed on a very small island lost in the immensity of the Pacific Ocean, formed a million years earlier by volcanic eruptions and never before inhabited.

According to a legend the discoverers called the island Te-Pito-te-Henua: the last of the lands. (Today it is called Rapa Nui by its inhabitants.) Some 1300 years later, on Easter's Monday 1722, the Dutch captain Jacob Roggeveen was the first European to leave his footprint on that same island, which was therefore known, from then on, as Easter Island.

It is a triangle of land 160 square kilometers large, spotted with dead volcanoes and incredibly far away from anything and anybody. The closest land (besides the Sala-y-Gomez rock; see below) on the west side is the Pitcairn Island, 2000 kilometers away (famous because it was the last destination of the *Bounty* mutineers); the Chile coast, on the east side, is 3600 kilometers away.

The history of the island was carefully reconstructed—not without difficulty—using local legends, archaeological data, and most of all genetic and paleobotanical analysis (Barthel 1978, Fisher 2002). On the island a form of writing called *Rongo-Rongo* was used, but unfortunately very few texts, written on small wooden tables, survived the destruction of the indigenous culture by the Europeans. In any case, all the linguistic, archaeological, botanical, and genetic data show that the Polynesians reached Easter Island, as said above, in the first centuries AD, probably around the fourth century.

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_12,

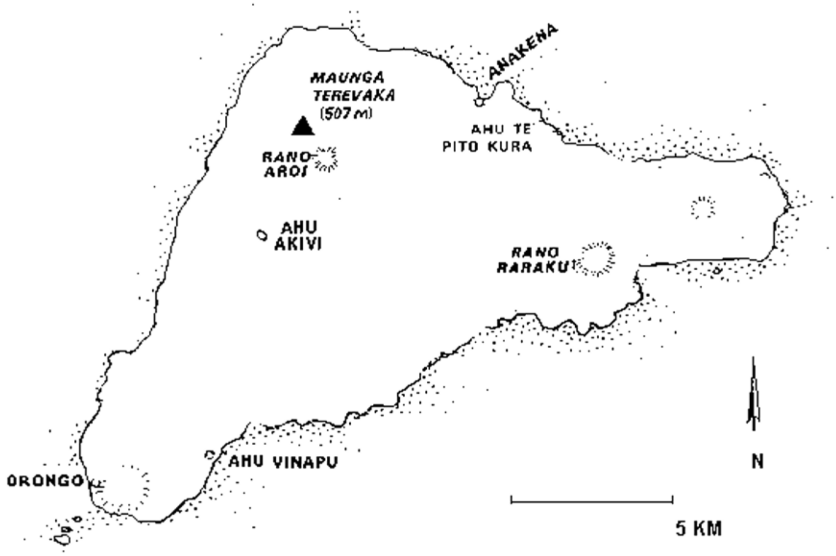


Figure 12.1: Map of Easter Island

The Easter Island colonization happened within that amazing expansion that, starting in remote times, brought the Polynesians to colonize Tahiti, the Marquese Islands, and eventually Hawaii and New Zealand. On Easter Island there is basically a unique landfall, the Anakena Beach; legend has it that Hoto Matua, the first king of the island, landed there. On Anakena Beach the newcomers built a village with oval-shaped huts, and it is believed that they used their canoes to make the roofs. Easter Island, which today is completely bare, was at the time rich with palm trees and inhabited by a vast population of birds. The newcomers brought other plants with them, such as banana trees, and thus were able to build a prosperous and self-sufficient economy. The population grew to the incredible number of 10,000 people, divided into clans and living in different villages.

In the meanwhile, for unknown reasons, a cult was born, about which we know very little. This cult was based on the worshiping of the large stone statues that have made Easter Island famous: the *Moai*. Doubtlessly the collective effort required to build the Moai was huge, and it is believed that it started or at least accelerated the destruction of the island's resources, since the palm wood was certainly used in abundance in the process of moving and placing the statues. The civilization of the island collapsed around the year 1600 AD. The production of the statues stopped, the forests disappeared, and the soil eroded because of the lack of trees and became barren.

Perhaps the idea that the island residents thoughtlessly destroyed the island's resources is too similar to our fears about what we are doing to our environment, and it may be that other concomitant causes facilitated the process. Whatever the reason, the archaeological evidence points to a collapse of the entire social structure, with fights between the various clans. Possibly many of the statues were intentionally knocked down in these fights, but one thing is certain: the population was drastically reduced. The Moai religion was then gradually replaced by a cult of the "bird-man" which is interpreted by some as the awareness of the fact that, having depleted the place of all its vegetation, it had become impossible for the islanders to leave the island. This bird-man cult is also historically documented in the European chronicles, and had its headquarters in Orongo, the southwest point of the island, were annually a competition was held to find the eggs of a bird that nests on a rock near the coast. In Orongo it is still possible to admire many petroglyphs depicting this bird-man, or possibly the winners of the race. Finally, in 1722, the Europeans triumphantly entered the Easter Island history, starting their usual destruction of the history and culture of the indigenous people, which ended in 1862 when the few remaining islanders were captured, enslaved, and taken to Peru.

12.2 The Stone Ancestors

Easter Island is *populated* by Moai. Today on the island there are more Moai than people; at the moment of maximum demographic expansion, there was a Moai for every one hundred people. A Moai is a monolithic anthropomorphic statue with stylized and oblong traits, probably (but not certainly) representing a being of male sex, with the body merely sketched. Usually the statues are embellished by reliefs representing ears with elongated lobes, clothes, and other objects. The monoliths are made of rock from one of the dead volcanos of the island, known as *Rano Raraku*, which was used as a huge open-air quarry. As we shall see in more detail later, many statues remained in the quarry, or on the slopes of the volcano; among the latter is the so-called *Tukuturi*, the sole Moai that seems to represent a human being kneeling down.

The huge boulders of rock destined to become statues were patiently quarried using hand-hammers of hard stone; while the bottom part of the block was still not completely detached, the top part was already being carved. Thus, the statues were shaped on the spot and then carried to their appointed site already finished or nearly finished. To many statues, or possibly to all of them, a sort of cylindrical hat was then added, probably representing the hair of the figure, made out of a heavy red coral stone block.

Figure 12.2: The Moais at Ahu Akivi

On the island there are about nine hundred Moai (to be precise, 887 of them have been counted). Among these, 397 are still in the quarries; of the remaining ones, at least 288 were successfully carried to their final destination (Van Tilburg 1994). The standard Moai is about 4 meters tall and weighs 12 tons. The largest Moai was never finished and lies, as a sort of puzzle for visitors, in the Rano Raraku quarry. It is over 20 meters long and it weighs at least 170 tons, so it is hard to believe that it could have carried elsewhere (I believe that it was meant to stay there, in the womb of his quarry-mother). It is not clear what method was used to move the Moai and lift them into an erect position. Were they carried directly in the erect position, as suggested by accounts reported in the first Europeans chronicles? In any case, moving the standard-size Moai would not have been a problem for a motivated team of some hundreds of men (see Appendix 2).

The final destination of the stone giants were stone platforms, called *Ahu*, hosting a collection of statues positioned one next to the other. Having to sustain a weigh of several tens of tons, the *Ahu* were themselves sturdy and extremely solid buildings made of stone blocks. Some of the platforms show signs of various restorations or reuse, and it is even possible to notice the presence of Moai *recycled* as construction materials. Other platforms, however, were built with exceptional skill, joining with extreme precision huge polygonal blocks in a manner that closely resembles Inca's stonework (for example, Ahu Vinapu, Ahu Tepeu, and Ahu Vai Mata). It is possible that

Figure 12.3: The Moais at Ahu Vai Uri

not all of the platforms were intended to support the Moai, but their precise function is unknown (some are called *seawalls*, even though this was obviously not their purpose). The presence on the island of these Inca-like walls fueled the idea that Eastern Island was reached also by people coming from South America (see, e.g., Heyerdahl 1961), but up to now no clear evidence has been found to support this view.

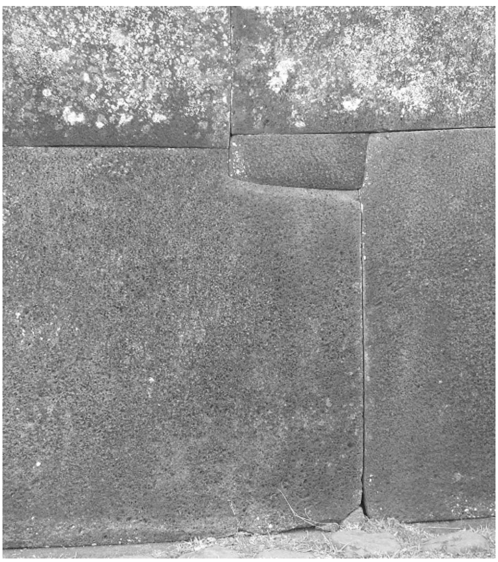


Figure 12.4: Ahu Vinapu, detail of polygonal joints and keystone

The most important Moai platforms are the following:

1. *Ahu Tongariki* lies on the south coast, close to the slope of Rano Raraku. The platform (restored) holds 15 huge Moai.
2. *Ahu Vinapu* is located in the west end, near the island's airport. It is considered one of the older Ahu. The quality of the stonework of the platform is impressive, very similar to the Incas' polygonal masonry.
3. *Ahu Akivi*, probably one of the last to be built, is the only large Ahu that is built on the interior of the island, on the western slopes of the central volcano. It holds seven Moai, all very similar to one another in their dimensions, shape, and expression. They are good examples of the standard size: 4 meters tall, weighing 12 tons. The platform is carbon-dated around the year 1440 AD, and it is thought to have been used up to the end of the Moai period, around the year 1600 AD. If this is the case, then the seven statues may represent subsequent rulers of this part of the island.
4. *Ahu Naunau* is on the northeast coast of the island near the place were the first settlers are thought to have landed, Anakena Beach. The platform was changed and rebuilt several times. The statues have recently been restored, including the original red-rock hats, and each one shows detailed, although enigmatic, carvings on the back (Plate 25).

Figure 12.5: Moais on the slopes of Rano Raraku.

5. *Ahu Vai Uri* is on the western shore, near Akapu. It is the only platform that holds statues that are appreciably different from one another. In its center stands a prominent character flanked, on its left, by two figures of similar size. On its right stands a smaller figure and, further ahead, still on the right, the remnants of an even smaller Moai. It is very difficult to interpret these differences, although one may consider them monuments dedicated to special people, perhaps a royal family.

What is the meaning of these extraordinary works? The vast majority of scholars believe that the Moai were part of a cult that worshiped ancestors, represented by the statues (Van Tilburg and Lee 1987). However, despite the fact that they are not all perfectly similar, the statues are too standardized to be portraits of different people. Rather, I believe that they conform to a style, with rigid canons, that has little resemblance to known images from Polynesia or South America. The stylized, oblong traits have little to do with the somatic characteristics of the inhabitants of Easter Island as well. On the other hand, we must recognize that the megalithism on Easter Island was a autochthonous phenomenon. Indeed, although several megalithic monuments do exist in Oceania—such as the spectacular site of Nan Madol on the Pohnpei island, composed of tens of artificial islands of rectangular shape separated by canals and built using huge basalt boulders, or the Tonga gigantic trilithon, which is over 5 meters tall—they all belong to a much later period than the Easter Island colonization, since all the radiocarbon dates related to these stone monuments fall within the last millennium.

This is why I believe that, even though the interpretation of the Moai as representations of the ancestors may contain a kernel of truth, it is not enough to explain the obsessive, maniacal presence of the statues on the island. To gain further insight, we must consider the distribution of the Ahu on the territory and the relationship between the statues and the landscape. The general impression that one gets from these monuments is that of a "frontier", except for *Ahu Akivi*, which looks like a late stylistic exercise or an attempt to reaffirm a changing tradition whose meaning is no longer fully understood; all the other Ahu are in fact located near the coast, and all the statues face the interior of the island. (Maybe they are looking at the villages or the horizon and the sky, as we shall see below.) Thus, they form a sort of ideal border, needed to indicate and therefore to legitimate the presence of humans. Consequently, the whole island is a *sacred landscape* similar to that of the Sardinia island, where, as we mentioned in Chapter 3, thousands of huge towers are used to establish the presence of people (see also Chapter 15). This special place where humanity lives is visited by the Moai; they indeed look like newcomers who, as soon as they disembarked from their canoes, start walking inland. But where are they going?

Figure 12.6: The profile of Rano Raraku

Figure 12.7: The profile of a Moai (picture rotated 90 degrees to facilitate comparison)

A very plausible possibility, in my opinion, is that they wish to go back to their rocky mother. Indeed, and this has been noticed by many others before me, the thing that a Moai's profile resembles the most is the profile of the volcano Ranu Raraku, the quarry where all the statues come from. Ranu Raraku is, after all, a real Moai *nursery*. Statues of different dimensions and at different stages of their sculpting emerge for the rock, some abandoned for unknown reasons, others because the stone was cracked, and still others ready to be transported or simply standing there and left in place on the slopes of the volcano, looking outward. It looks like the mountain is peeling off, reproducing itself in smaller scale and in an obsessive way with little variation and at different levels of definition, in a succession that reminds many of M.C. Escher's famous lithographs.

12.3 A Perplexed Captain

The Easter Island civilization is enigmatic, but the biggest enigma of all is understanding how the Polynesians found an island as small as the head of a nail in the middle of the Pacific Ocean. To understand this we can rely both on ethnoastronomy, that is, on astronomical lore passed down by Polynesian traditions, and on archaeoastronomy as well.

The progressive colonization of the Polynesian islands by the Asians started around the year 1000 BC. It is commonly believed that when an island became overcrowded, groups of its inhabitants moved further and further east, colonizing new islands. It is actually unclear if these social reasons were really sufficient to motivate people to embark upon journeys toward the unknown, but it is possible to leave without a precise destination only if one has good orientation techniques, so that at least the risk of going around a circle can be avoided. Moreover, such techniques were required also for navigation between the various islands already colonized, because most of them, separated by very large distances, required open-sea voyages.

To get a sense of the ability of Polynesian sailors, it is important to read the ethnographic reports. Yet from the very first reports by the European navigators one can guess how extraordinary these abilities must have been. For example, in 1768 Captain James Cook, preparing to leave Tahiti, let on board a Polynesian pilot named Tupaia who, under the bewildered eyes of the captain, easily navigated the ship in the open sea until the Rurutu Island, many hundreds of kilometers south from were they started. Unfortunately, Tupaia caught an infectious disease shortly after and died, taking with him his navigational secrets, certainly linked to astronomical knowledge. It is indeed known that within the Polynesian communities there were some special individual called *Tohungas* whose job was the observation of the sky.

Their main task was that of associating the navigation targets (chosen directions, or sea lanes leading to already colonized islands) with the rising or setting of specific stars. In particular, when the pirogues had to go from one island to another, the pilot tried to associate a star with their final destination. The voyage would then always start at night, as soon as the desired direction was identified by using the corresponding star; near the equator the star's trajectory is close to perpendicular to the horizon, and that makes such operations easier to perform. During the day the pilot relied on the sun and, when possible, on currents and winds, calibrating again the ship's position at night (Esteban 2000). Navigating toward the unknown looking for new lands, the pilot found some aid also in little traces such as floating pieces of wood or the flight of birds, in order to locate the closest land.

In the case of "the last of the lands," it could not have been easy to find a lilliputian island in the middle of the ocean by navigating this way, and therefore it is reasonable to believe that many embarked on this type of journey but that only a few lucky ones survived and reached Easter Island. Interestingly, the islanders did not give up completely the idea of moving further east. It is probable that they discovered and regularly visited the only other available piece of emerged land (calling it "island" would be stretching things a bit) between them and South America, which is Sala-y-Gomez, some 400 kilometers northeast of Easter Island. This place is inhabited by colonies of marine birds, and it has a name in the native language of Easter Island: *Motu Motiro Hiva,* which allegedly means "land of the birds coming from very far away."

It is reasonable to expect that at least part of the islanders' astronomical knowledge was incorporated in the monuments of the island. Archaeoastronomy studies on Easter Island were first carried out by Mulloy (1970) and later widely extended by Liller (1980); recently, a full reassessment has been given by Belmonte and Edwards (2004).

The ethnographical evidence shows, as expected, that the islanders had accurate knowledge of the celestial cycles; in particular, a number of stars and asterisms had traditional names, several of them being common to other islands of Polynesia. Among them, we can mention bright stars such as Vega, Sirius, Canopus, Antares, and many others, and also some asterisms. The two most important ones were *Matariki* (the Pleiades), and *Tautoru* (Orion's Belt), used as markers of important activities through the year. In particular, the heliacal rising of Matariki, followed almost immediately by that of Tautoru, marked the beginning of the year, while the fishing season closed with its disappearance from the sky in mid-April. Thus, accurate observations of the Pleiades were crucial for the islanders, and the informants reported that there were special places from where the astronomer-priests watched the sky. In particular, the informants mentioned a cave that "was an observatory where priests observed the stars, and a school where candidates for priesthood where instructed in the science of the stars." Moreover, they mentioned an outcrop in the Poike Peninsula that was a "rock for looking at the stars." In this place, some 200 meters from the outcrop, an etched rock boulder has 10 cupules, which are likely to represent the Pleiades. There is also an astronomical connection between the ceremonial center of Orongo and the Poike outcrop, since the sun rises over Poike peak on winter (June) solstice as seen from Orongo. On the island there are also the so-called *tupa*, conical towers of unknown scope and age, which might have been used as observatories as well.

From the archaeoastronomical point of view, the main goal is to establish the possible astronomical orientation of the Ahu platforms. Many of them are just parallel to the shoreline since, as we have already seen, the Moai are supposed to have landed and "walked" toward the interior of the island. Many others, however, do show a clear tendency to be aligned with astronomical phenomena. This is true, for instance, of Tongariki, which shows a solstitial alignment, and Ahu Akivi, which shows an equinoctial alignment (Liller 1980).

Interestingly, around the probable dates of construction of such sites, the asterism of the Pleiades was setting very close to the azimuth of the setting sun on winter solstice, and Orion's belt was setting very close to due east. Since there is no significant evidence of solar alignments of any monuments in Polynesia, or evidence of equinoctial alignments (an east–west alignment found in Nan Dawas might be interpreted as an orientation toward the rising of Orion' s Belt; see Esteban 2000, 2002), most of the solstitial and equinoctial alignments on Easter Island could perhaps be reinterpreted as pointing toward the Pleiades and toward Orion's Belt, respectively (see Belmonte and Edwards (2004) for more details).

Life on this tiny island was thus deeply connected with the celestial cycles. I have the impression that there are still unknown aspects of such connections, and that perhaps a clue lies in a 1979 archaeological discovery: archaeologist Sergio Rapu and his team uncovered some fragments of white coral and red scoria that, when assembled, turned out to be the eyes that were originally placed in the elliptical eye sockets of the Moai (Plate 26). Now that we can fully appreciate their faces, it looks very likely that the giant sentinels of the island where looking at the stars.

A Picnic on the Side of the Road 13

So does that mean they never even noticed us?
—Arkady and Boris Strugatsky, *Roadside Picnic*

13.1 Instructions Not Included

The novel *Roadside Picnic* by Arkadi and Boris Strugatsky is, in my opinion, one of the best works of science fiction ever written. The story (which inspired the movie *Stalker* by Andrei Tarkovsky) is simple: extraterrestrials with technology much more advanced than ours pay a visit to Earth, take not the slightest notice of us, and then leave. The place where they landed becomes known as "The Zone."

Imagine being an ant that lives near a road. A human family stops and enjoys a picnic, completely oblivious to your presence. When they leave, a number of traces remain behind: scraps, broken things, parts of other things, a failed attempt at a sand castle, a dollop of jam. You, as an ant, have not the vaguest clue as to the origin, composition, or function of these things. You only know that some may be useful to you, others useless, and still others dangerous. The humans in *Roadside Picnic* rummaging through The Zone are exactly like you those ants; they find useful things (such as what appear to be inexhaustible batteries), useless but puzzling things (such as two disks that seem to have no other purpose than to always remain at the exact same distance from one another, despite there being nothing visible connecting them), and very dangerous things (such as a jam-like substance that can trap a man like flypaper). What is certain is that the aliens did not care at all about humans. *They never even noticed us*.

Our predecessors were not extraterrestrials, but humans who lived and suffered and loved and thought. But to a builder of Stonehenge, a Mayan astronomer, an Anasazi engineer, an Incan architect, or to the designer of the Great Pyramid, our technology, our little conceit of considering ourselves to be evolved, our way of counting, reasoning, recording data, our way of constructing theoretical schemas would be about as useful as a

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_13,

chocolate teapot. Our way is not absolute. It is not *the* way, it is but *one* way.

We are like those ants at the aftermath of the picnic. The picnickers did not leave instructions explaining in ant language what had happened or why. We have fragments and traces of evidence. We have what has been left behind, which is at best partial and mostly just mute. But it is not only that. It is that they would not have been interested in how we saw them anyway. They had their own way of thinking, reasoning, and studying that was not like ours, but that was just as effective. If we want to understand their ways, we must give up our schemes and embrace theirs; through respect comes understanding. But this is not easy to do.

13.2 The Similaun Man

At 3:30 on the afternoon of September 19, 1991, two German mountaineers hiking the edge of the Similaun glacier in Italy's Val Senales, near the Austrian border, spotted the mummified remains of a human body protruding from the ice. The men who arrived to rescue him thought they were dealing with a lost fellow hiker, or at most a soldier killed during World War I.

They were off by 5000 years. It turned out indeed to be the body of a man who had lived between 3350 and 3100 BC. The story of the Similaun Man and his discovery is still fraught with problems. First there was the problem of establishing whether the body had been found in Italy or Austria, an argument that the Italians eventually won by a matter of a few dozen meters (the mummy is presently conserved at the Bolzano Archaeological Museum). Then came the customary exercise in absolute foolishness as archaeologists veritably elbowed one another to come up with the most patronizing and ridiculous conjectures to explain the man's death: a shepherd who ventured too far and froze to death; a hunter lost in a blizzard; a shaman who climbed the glacier to die in communion with nature.

Not long ago, more in-depth analysis of the mummy demonstrated that the real cause of the Similaun Man's death was a wound inflicted by an arrow. He did not die, therefore, of natural causes, or because he got lost. Nor was he a hunter-gatherer, shepherd, or shaman. He was a warrior, and apparently an active one insofar as traces of the blood of at least four different individuals were found on various parts of his gear.

What interests us here is that the discovery allows us to learn about a contemporary of the megalithic builders, the famous "howling barbarians," quite literally frozen in a moment of everyday existence, his clothing and equipment completely intact.

The Similaun Man was dressed expertly against the cold. He was wearing the following garments:

1. A cloak of woven grass
2. A bearskin cap with chin straps
3. An overgarment in goatskin sewn with thread made from animal tendons
4. A wide loincloth, also in goatskin
5. Goatskin trousers with footstraps in deerskin
6. Shoes with leather soles and uppers covered in netting that could be stuffed with hay for extra insulation

At his waist he wore a sort of calfskin haversack with laces that contained a few objects made of flint and bone as well as some dried mushrooms, which probably served as an antibiotic (the man had a number of tattoos on his skin, which were also perhaps made for therapeutic reasons). His hunting or, rather, combat gear consisted of the following:

1. An ax made of nearly pure copper (99.7% copper, 0.22% arsenic, and 0.08% silver), the yew wood handle of which is still attached. The blade is fastened to a fork in the handle with birch tar and then wrapped tightly with strips of hide. This is the only integral prehistoric ax that has come down to us, and seeing it up close gives one the strange impression that it was used just yesterday.
2. A longbow of 1.82 meters, also in yew wood, on which the Similaun Man was still working when he died. The quiver, made of chamois and stiffened by hazelnut rods, held two finished arrows with flint points and triple fletching (meaning the familiar three stabilizing "fins" we still use today). There were an additional 12 arrows still to be finished, each about 84 centimeters long, with a number of arrowheads carved from deerhorn. Though there was no bowstring on the bow itself, the rope made of raffia (i.e., cane fiber) found in the quiver was probably intended for that purpose.
3. A dagger about 13 centimeters long, with a triangular flint blade and a scabbard of raffia.

He was also carrying two birch bark containers and a woven grass net, probably for catching birds. Additionally, he was equipped with a curious deerhorn tool resembling a jeweler's hammer that was perhaps used to sharpen flint. Archaeologists called the tool a "retoucher," although and not surprisingly it is the only example of a "retoucher" as yet known to science.

In 2004, using digital imaging, the facial features of the Similaun Man were inferentially reconstructed, resulting in a visage remarkably similar to that of a world-famous (recently dead) Italian opera singer, to such an alarming degree that I suspect that this was somehow intentional. At the very least we should remind ourselves that a computer cannot do anything without a program that tells it what to do; thus, so-called computer reconstructions depend on the programs that generate them, which in turn depend on what the programmer was thinking when he wrote the code. So these virtual portrait reconstructions are only sometimes plausible and *never* absolute, a fact that often goes unmentioned.

Debatable recent reconstructions aside, I am sure that the Similaun Man would not be at all pleased with the way we habitually imagine primitive stone-age man. We need only note that the clothing and equipment of a single individual encompassed the hides of five different animals (deer, chamois, bear, calf, goat) as well as wood and fiber from 18 trees and plants, none of them used haphazardly but chosen so that their properties best suited the resulting object's function. Actually, although there's absolutely nothing objectively anachronistic about him (for example, he comes from the Copper Age and is not carrying a bronze sword), in a certain sense there is something in the man himself, in his perfect coherency, that seems anachronistic. The reason? Creeping evolution.

13.3 Creeping Evolution

If we are going to free ourselves from our mental schemas, the first task is to understand what they are. Since we're talking about history and the past, the first thing to do is take a look at how we conceive of the passage of time over the course of human history. Well, it is quite obvious how we tend to see our history: we see evolution as being a process of improvement.

However, a biological phenomenon is a physical phenomenon, like everything else in the universe. Biological evolution is the change over time of a physical system, and it has nothing at all to do with improvement. Giraffes with longer necks are neither better nor worse than the shorter-necked giraffes that came before them. The trees that giraffes eat grew taller, provoking change.

Such a system interacts with itself, and maybe the trees will eventually develop thorns so as to be less appetizing. But the resulting new trees will not be better. When something evolves over time, which in physics means it simply changes, if the original state is known, it is in principle possible to calculate the new state at a later time. This does not mean improvement; nor does it mean decline. All it means is *change*, by virtue of the forces to which something is subjected. Does this also hold true for human beings? Yes, because evolution does not in itself entail the concept of improvement.

Man is a biological, and thus physical, system, and as such there is no scale that measures improvement. Only when we refer to meta-physical concepts, can we justify the notion of the "improving" man. Thus the evolutionary "progress" of a creature as he becomes ever less hunched and hairy and less ape-like is potentially misleading; modern human evolution biologists consequently avoid using this concept, but it is used in museums and children's books.

Even more dangerous, we tend to assign evolution the time scale of our own past, thinking of our ancestors as being less evolved beings. Are we more evolved, say, than the Similaun Man? How many of us would have the courage to say no? Yet look at him: he is perfect in terms of his own needs and the technology required to fill them. If we take the same copper he used to make an ax, it is very unlikely that we could make one better than his. We would not be able to reproduce his flint knife without the proper training. And so on . . .

Technology progresses, and the scale that measures technology is absolute: a Pentium computer with a central processing unit of 2-gigahertz is literally billions of times better than one of those 286 processors from 1985. However, the purposes necessitating the technology do not progress at the same speed; in 1985 most computers were used only to write text and to manage small databases and simple graphics. Today, most computers are used only to write text and to manage databases and graphics (and also to navigate the Internet, an operation that hardly requires huge computing capacity, however). And though it would be impossible to convince a 286 processor to run a 2008 word processing program (and vice versa), the outcome does not change much. If I am good at writing, the result will be the same as in 1985; if I am not good, my writing will not be any better just because my processor is.

From this point of view, it becomes difficult to establish an evolution of any kind at any temporal scale (with the notable exception of gaming software, which invariably requires the latest and most powerful processors). Are we, for example, more evolved than in the mid-1960s, when we began planning the first trip to the moon? Today those images of the astronauts seem almost comical to us, as if they had been lifted from some low-budget science-fiction movie, all aglow with those green computer screens of earlier decades. However, we do not go to the moon anymore, and would we be able to put men on the moon today using the technology of 40 years ago?

Apart from the fact that it would be hard finding anyone willing to try, the answer is probably no. Who today knows how to program with the punch cards that were used back then? Who has the patience to wait an hour for a calculation that a cheap pocket calculator can do instantly? Let's admit it: it seems strange to us today that people managed to land on the moon in 1969. It is almost not to be believed (and in fact there are even people who are convinced the moon landing was a hoax). Perhaps in another 200 years it will be difficult to understand how they did it. Perhaps in, say, 4500 years it will be almost impossible. So what explanation might an archaeologist of the future invent to explain the motivation, the determination, the intelligence, and the sheer audacity that led astronaut Neil Armstrong and an entire civilization with him to set foot on the moon? Who is more "evolved", us or them?

13.4 Through Respect Comes Understanding

There is thus the danger of assuming a misguided attitude toward the past if we blindly swallow the notion that change means improvement, if we confuse the fact that civilizations change over time with a false, albeit reassuring sense of evolution. Ugo de Santillana and Ertha von Dechend (1983), in their *Hamlet's Mill* (see also Chapter 15) summarize the problem as follows:

> Our period may some day be called the Darwinian period, just as we talk of the Newtonian period of two centuries ago. The simple idea of evolution, which is no longer thought necessary to examine, spreads like a tent over all those ages that lead from primitivism into civilization. Gradually, we are told, step by step, men produced the arts and crafts, this and that, until they emerged into the light of history. Those soporific words "gradually" and "step by step," repeated incessantly, are aimed at covering an ignorance which is both vast and surprising. One should like to inquire: which steps. But then one is lulled, overwhelmed, and stupefied by the gradualness of it all, which is at best a platitude, only good for pacifying the mind, since no one is willing to imagine that civilization appeared in a thunderclap.

We cannot understand the past without respecting it and respecting the intelligence of the people who lived then, without forcing them into our own way of thinking. For that often reveals our schemas to be totally inadequate to the task of understanding the dynamics of another civilization's thought. In addition, our schemas are often incorrect, such as those referring to ancient peoples as "noble savages" living in some idyllic "golden age." As recently as the 1950s the Mayas were still considered a peaceable population of farmers who idly "marked the passage of time."

It is curious how these schemas are so deeply ingrained that we can look straight at reality and fail to see it. For example, many people, myself included, have visited the mummy of the Similaun Man at the Bolzano Archaeological Museum. The man died with the knife in his hand, which the naked eye can easily see by simply looking at his contracted right hand. Yet until recently it was not noticed, for who would imagine that a wandering shepherd or hunter-gatherer or shaman communing with nature would have died while stabbing someone?

When we conduct a scientific experiment, measuring instruments "see" for us. If they have been designed properly, the results are objective. It is another situation entirely when we are dealing with an archaeological artifact, a work of art or architecture, something made according to codes that are unknown to us, canons and meanings that we are excluded a priori from understanding. Since our eyes are our measuring instruments, if we look at things without realizing what we are seeing, we are at risk of understanding nothing, to the extent that we can look at a monumental statue, in the middle of a desert, that has been eroded by rainwater without recognizing this elementary feature (it is called the Sphinx; see Chapter 16).

Freeing ourselves from schemas, therefore, is a necessary condition if we want to understand people who were more or less of the same intelligence as us but who had different ways of thinking—neither better nor worse, neither more nor less evolved. We have to be careful, for the insidious tendency to take the past for granted is widespread and deeply rooted—and this applies to the past in general, not just prehistory. Many of us were taught in school that in the Middle Ages the earth was believed to be flat, a conviction that a famous animated film has seen fit to pass on to the children of later generations. The problem is, it's not even *remotely* true. It is a legend, confabulated around the middle of the 19th century and commonly believed ever since.

I do not know what a poor medieval farmer thought about the form of the earth, except that it probably did not interest him much. I do know, however, that Greek scientists, Eratosthenes specifically, had calculated the circumference of the earth fairly accurately, and that medieval scholars knew this.

The reason why Columbus was urged to forgo his voyage was not for fear that his ships would sail off the edge of the earth into the void, but because the trip was too long, and in fact it would have been if the Americas had not been there to interrupt it.

Further evidence that scholars of the Middle Ages did not think the earth was flat can be found in Dante's *Divine Comedy*. When Dante leaves the

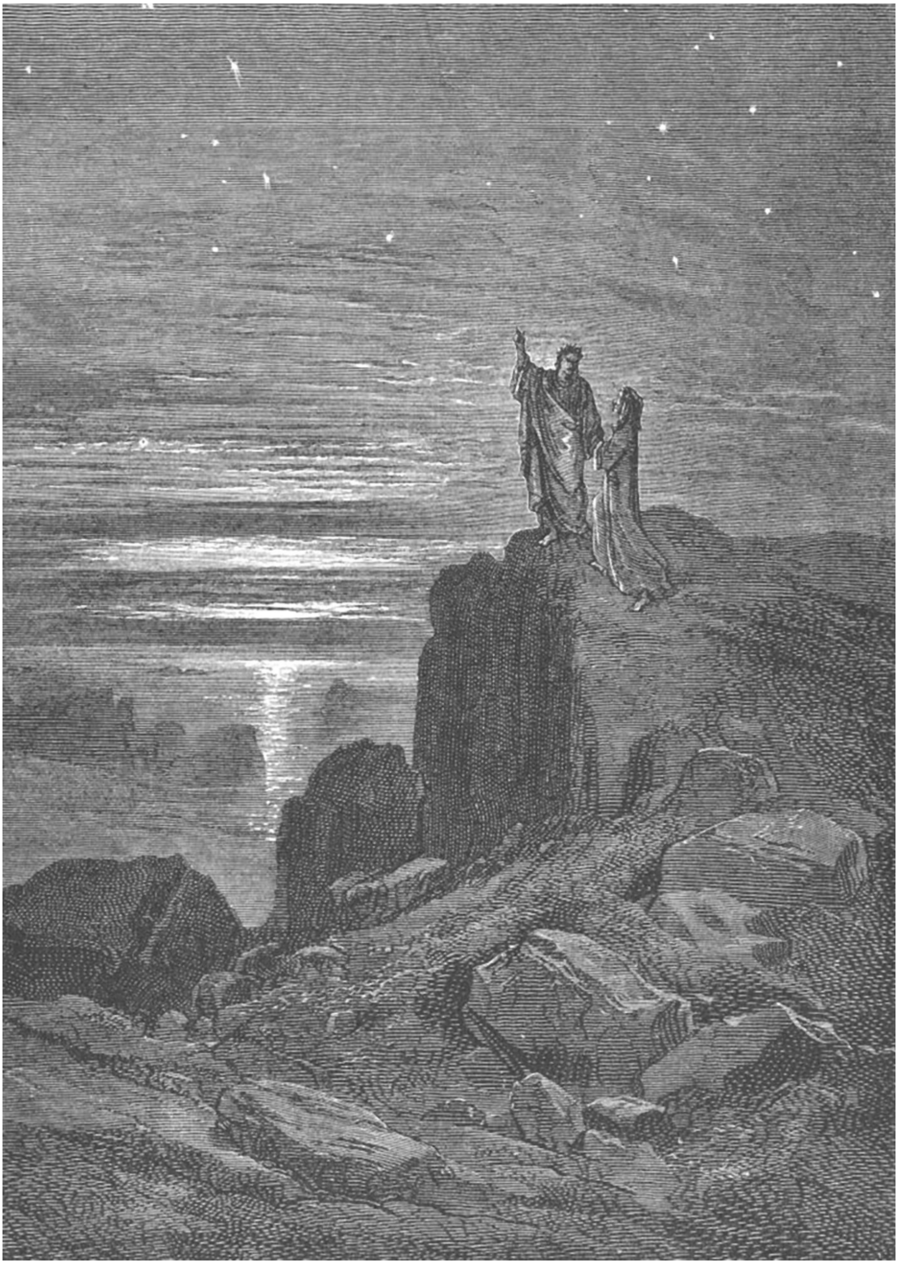
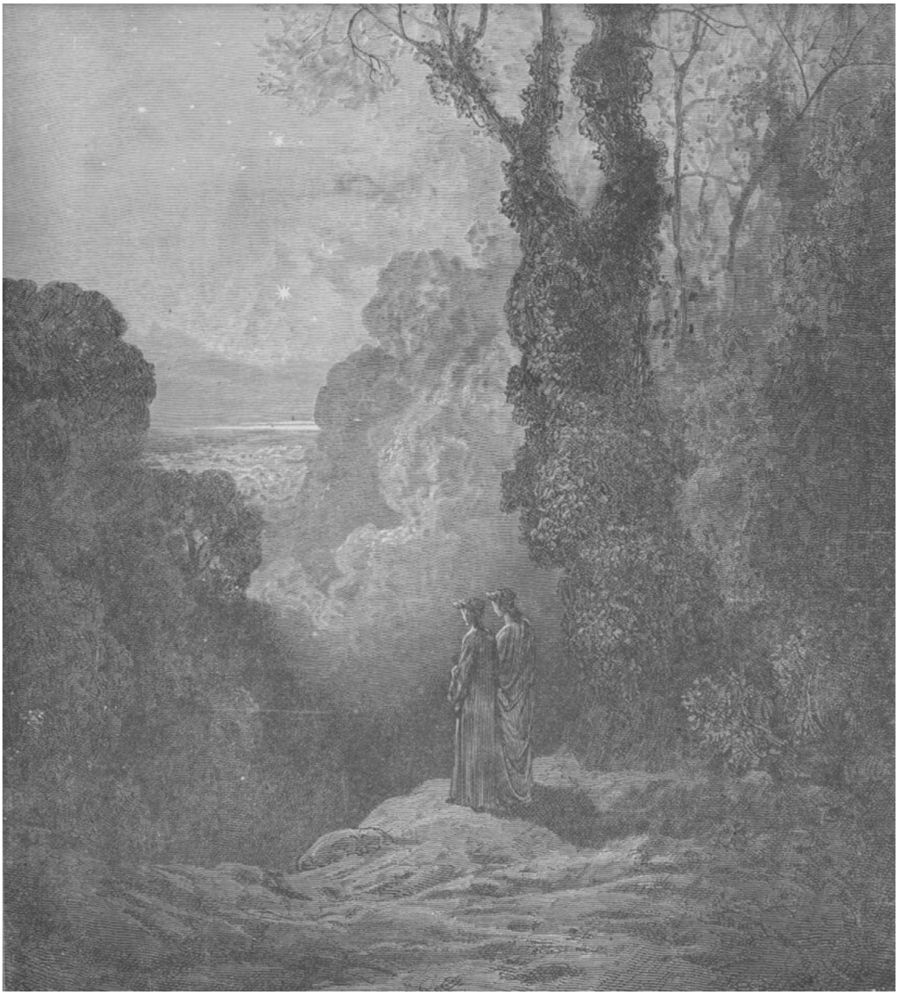


Figure 13.1



Figures 13.1–2: Dante and Vergil come out from the Hell and see the stars of the southern hemisphere, in two famous drawings by Gustave Dore.

Inferno he and Virgil emerge on the other side of the globe, demonstrating knowledge of southern astronomy. He sees "all the stars of the other pole" and watches the circumpolar stars of the Northern Hemisphere set behind the horizon. Further, Dante's masterpiece is riddled with double meanings and the dual nature of things, both terrestrial and celestial. Even if not many commentators had the courage to say so, it is highly probable that Dante had information of a quantitative nature about the skies of the Southern Hemisphere, obtained from travelers who had gone far enough south to observe them. The following lines come from Purgatory, Canto 1, tercet 22, as translated by Henry Wadsworth Longfellow:

> To the right hand I turned, and fixed my mind
> Upon the other pole, and saw four stars
> Ne'er seen before save by the primal people.
>
> Rejoicing in their flamelets seemed the heaven.
> O thou septentrional and widowed site,
> Because thou art deprived of seeing these!

The four stars are undoubtedly, in Dante's mind, seen as an image of the four Theological Virtues. But neither is there any question that the Southern Cross with his four (or five) bright stars is a fundamental constellation for the navigation of the Southern Hemisphere, and indeed the explorer Amerigo Vespucci, in a letter penned on July 18, 1500, and addressed to Lorenzo di Pierfrancesco de Medici, noted that the stars cited by Dante had to have been the Southern Cross. The same constellation reappears in Purgatory, Canto 8, tercet 88:

> And my Conductor: "Son, what dost thou gaze at
> Up there?" And I to him: "At those three torches
> With which this hither pole is all on fire."
>
> And he to me: "The four resplendent stars
> Thou sawest this morning are down yonder low,
> And these have mounted up to where those were."

The "three torches" could be the stars of the Austral Triangle, another important navigational constellation in the Southern Hemisphere (around the year 1300, the Southern Cross, followed by the Austral Triangle, was visible on the southern horizon at a *northern* latitude of about 24 degrees).

So, avoiding schemas and preconceptions means completely and definitively accepting that there is no evolution of intelligence. The Romans were as intelligent as we are, as were the Egyptians. The same applies to the neolithic peoples, to the builders of the megalithic temples, to the artists of Lascaux.

These people did not leave us manuals or explanations. All they left us are their works. And it is time that we recognize the possibility that there exist objects about which we understand *nothing*—objects that are as puzzling to us as those equidistant disks were for the characters of *Roadside Picnic.* It is time to admit that we do not know what they are for or how they work.

However, in our case these objects were not left by extraterrestrials, or by some unknown antediluvian civilizations as some would unfortunately have us believe (thereby betraying themselves immediately as being among those who do not respect and therefore cannot understand our predecessors). They were left by people like us, which means we can understand, because while they were no less intelligent than we, neither were they more so.

Predicting the Past

14

> One afternoon, I walked from Maras to Misminay with an old man with whom I had become well acquainted. Midway along our walk, we stopped for a few minutes and sat down in a ditch to shelter ourselves from the cold wind. The inevitable bottle of trago was produced, and the wind became warmer. He asked how my work on astronomy was going, and I told him that I still felt completely ignorant. I then asked him if he thought that I would ever understand the sky and the stars. He thought for a minute, and indicating the land around us with a wide sweep of his arm, he asked me if I understood the land and the community yet. When I said that I did not, he drained another cup of trago and asked how, then, could I possibly hope to understand the sky.
>
> —Gary Urton, *At the Crossroads of the Earth and the Sky*, 1982

14.1 The Etic Approach

In the first part of this book I invited you to join me on an informal trip around the world to look at some of the monuments that best represent the astronomical knowledge that people have had over the course of history. I also tried whenever possible to present only factual information and, when it was impossible to avoid interpreting those facts, to at least do so in a light-handed, even skeptical way. The reason was explained in the previous chapter: I think we are too laden with schemas, too accustomed to attributing meaning to words that are *a priori* empty and filling them with content that comes exclusively from *our* way of thinking.

However, the moment has come to try to understand a little more about the motivations that drove so many peoples of the past to build such splendid astronomically anchored structures, even to plan entire cities on the basis of "cosmographic" principles.

In talking about humans, and therefore about human thought and knowledge—religious, astronomical, technological—we are faced with two apparently irreconcilable approaches (Murray 2000) that we can call the

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_14,

rigorous method (or *etic approach)* and the humanistic method (*emic approach).*

The rigorous method treats a monument or group of monuments like a lab sample to be analyzed: one approaches the site as if landing on Mars, with measuring instruments, maps, and computers, taking data from 300 megalithic tombs or 50 Nascan geoglyphs, plugging them into a computer, and then publishing the results. But by doing this we are imposing our own mental framework on the evidence. In fact, we are using the king of all schemas, that venerable old mainstay known as the scientific method to which we scientists are attached like chicks to a hen, the one that allows us to make predictions on the basis of models, to elaborate models on the basis of data, and to sneer at inanities such as flying tables, pranotherapy, and the "memory of water." For example, a table cannot fly powered by thought. If it seems to be flying, it is a trick. Physical actions never occur from a distance but are always mediated by particles, such as photons, that is, light. The brain does not emit particles, and so the table cannot fly; the scientific method tells us so, in an unequivocal way.

In this same way, the rigorous approach can give formidable results in archaeoastronomy; we need only think of the case of the orientation of the Maltese temples discussed in Chapter 3, which had been an enigma until Klaus Albrecht meticulously diagrammed alignments of the altar stones to the left of each structure's entrance, thereby demonstrating their solstitial alignment.

However, if we go to Cusco to measure the alignments of the ceque system there (Chapter 10), and then compare them with a series of important astronomical events visible to the naked eye, applying to this the "rigorous" method, we will discover that the astronomically significant directions appear to be lost in a tangle of others that are not significant at all, and we will therefore confidently conclude that the ceque system had nothing to do with astronomy—thus missing completely the profundity of Incan thought.

The solution to the fascinating problem of interpreting the *ceque* lines and their symbolic content must take into account all the available sources: colonial accounts (ambiguous and untrustworthy though they may be), excavations in the field, and ethnological investigations such as that of Gary Urton, who found many aspects of the Incan vision of the skies living on in the indigenous population of Misminay. The scientific method must therefore be mediated by and integrated with the human component. This does not mean renouncing rigor. If tables do not fly, then neither do the 300-ton stone blocks of Sacsahuaman. Whatever the solution to the question of how the blocks were put in place, a problem that has by no means been satisfactorily resolved (see Appendix 2), it must be compatible with the basic laws of dynamics. But no physical law prevents the human mind from thinking in a nonsequential way, so that there was nothing stopping paleolithic man from inventing pottery 16,000 years before agriculture. And this is exactly what happened, as we learned in Chapter 1, when someone at Dolni Vestonice figured out how to make vessels from clay and harden them by fire, 160 centuries before such vessels would have served to store food. Accepting this fact was very difficult for scholars, because there was a "law" of history, a law clearly based not on scientific rigor but on preconceptions—and therefore a *false* law—that prohibited such a thing.

In the end, if we limit ourselves to studying only the technical-practical aspects of things (how the Babylonians made astronomical observations that were accurate within an arc minute, how the Incas managed to move stones the size of containers, how the Egyptians worked diorite without iron tools, etc.), there is no room for alternative approaches; the scientific method is *the* method, for the simple reason that the ancients used systems based on the same laws of physics that apply to us and every thing else in the universe. Far more insidious, on the other hand, is the question of motivation: not *how*, but *why* would anyone build walls with 300-ton boulders instead of 20-pound stones?

In a case like this it is difficult to distinguish between real, inviolable scientific limits and what are essentially nothing more than debatable dogmas. This is not intended to offend in any way those who dedicate their work to the fascinating problems of ancient history. In a certain sense it is easier being a scientist, knowing that you can rely on the rigor of your equations and the repeatability of experiments, than an archaeologist, where you cannot repeat your experiment—the archaeological dig—and you risk seeing your theories dissolve due to new excavations.

14.2 The Humanistic Approach

While a strictly rigorous point of view cannot work, it is equally risky to embrace a completely humanistic, or emic, approach. When applied to archaeoastronomy, this approach seeks to identify the cultural matrix in which astronomical knowledge developed, availing itself of ethnological information so as to determine which traditions and values to mine for the right content. There are, however, several frameworks to the reconstruction of the cultural context in which the study of a monument or an astronomical alignment should be situated. If there is a connection—real or presumed—with a population that still exists, one can try to exploit it. Such is the case, for example, in the link between the ancient Anasazi and the modern Pueblo and Zuni peoples. Archaeologists and archaeoastronomers have thus analyzed the available ethnological material on these populations for clues that might help them understand the frenetic astronomical activities of the Chacoans, particularly their roads (Ellis 1975).

Though getting a handle on what really happens in today's Pueblo rituals is a difficult enterprise, certain points are clear. Pueblo cosmology is full of roads. Life is a road, and the spirits are custodians of the various roads that branch off from it. When humans first emerged from the *sipapu*, the hole in the floor of a *kiva* (see Chapter 7), they remained close by. But the site was so sacred that they were eventually asked by the gods to move further south. Consequently, when they died their spirits would travel northward, returning to the *sipapu* and back into the womb of the earth. The spirits then return each year to visit the living, using the roads that had led them north, and these roads are often described as being straight. When a person dies, a holy man places offerings for him in a canyon to the north of the village on the road toward the *sipapu*, including containers of food for his final journey. The Pueblo are also well documented as undertaking what we would call pilgrimages to sacred sites. Often these journeys are as long as 500 kilometers and can last for months, a specific example being that of the Pueblo who live near Chaco, whose pilgrimage takes them northward from Chaco proper to a *sipapu* in the form of a small lake in the San Juan Mountains.

Among the Zuni, a pilgrimage is undertaken every 4 years at the summer solstice toward a lake believed to host the spirits of the dead. During the journey, one of the holy men lights fires along the road. In both Pueblo and Zuni cosmology, the lake is seen as the "middle place," the navel of the world, a sacred point where all the cardinal directions converge. Sun and moon play complementary roles in governing religious rituals and agricultural activities; the year begins, for example, with the first full moon following the winter solstice, or "weak sun." The solstice also figures prominently in Pueblo mythology, such as the legend that has the solstice sun impregnating a virgin through a window. The Pueblo and the Zuni, finally, share an interest in the passage of the noonday sun, which may be significant as a method of determining south (Zeilik 1985, 1986).

Does all this information on the descendants of the Anasazi increase our knowledge of the Anasazi? It's hard to say. We have learned something, and intuited perhaps something else. However, there is nothing in the practices of the modern-day Pueblo or Zuni even remotely comparable to the "scientific" attention dedicated by the Anasazi to celestial phenomena, or to the corresponding building craze that transformed Chaco into a complex machine of astronomical observations. To cite just one example, the Pueblo of today are not aware of the 18.6-year cycle of the lunar stations, which were well known to the Anasazi.

Ambiguous or mutated traces of the past are commonly found in ethnological data. Despite the fact that some traditions filter down easily through the centuries (particularly common with calendars, to the extent that some Mayan populations, for example, still use the Tzolkin calendar today), it is very difficult to reconstruct a civilization's thought—in the sense of its overall view of the world, which would include the extravagant monumentality of its astronomically anchored architecture—on the basis of the objective and often difficult conditions of the contemporary life of these people.

Still more complex and thorny is the problem of understanding if it is possible to apply ethnological interpretations by analogy.

14.3 The Analogical Approach

The French anthropologist André Leroi-Gourhan (1970) warned against the risks of allowing oneself to be tempted by the retroactive ethnological interpretation of prehistoric peoples:

> If we wish to let Paleolithic man speak, we must refrain from putting in his mouth an artificial jargon of Australian, Eskimo, and Bantu words pronounced with a European accent. When left to express himself, what he loses in loquacity he gains in intelligibility and, not surprisingly, in intelligence.

Signs and symbols, even when they are technically identical but distant in space, time, or both, may have been codified in completely independent ways, and would thus have completely different meanings. This represents a real methodological risk, and we must remain mindful of it. However, in many instances analogy may be of help in understanding the past. To illustrate, I will discuss a few examples of recent attempts to apply modern ethnological models to the study of megalithic civilization.

As we saw in Chapter 2, megalithic man is staggeringly, utterly *distant* from us. Distant in time, insofar as his first constructions date back more than 6000 years before present, and distant in spirit, for we must base whatever reconstruction of his thought we dare to attempt on the meager traces left to us in the form of pottery, stone constructions, and the signs inscribed thereupon.

As we have seen, many such carvings are "geometric" and include spirals

Figure 14.1: Carvings on one of Newgrange megaliths

and ovals. Many similar representations have been *ethnologically* identified as being inspired by "altered states" in modern-day populations who make use of hallucinogenic substances (for more on this, see Chapter 15). On the basis of these studies, Jeremy Dronfield of Cambridge University has posited that the characteristic geometric figures carved in megalithic tombs (e.g., Newgrange and Gavrinis, in Chapter 3) are also the result—and the representation—of mental states altered by hallucinogens, and the same schema has subsequently been applied to the figurative art of the paleolithic culture, especially in the case of the representation of half-man–half-animal beings, such as the Lascaux Bird-Man.

To prove his thesis, Dronfield proceeded as follows. First he asked a number of volunteers to draw images generated spontaneously while in hallucinogen-induced altered mental states, and then sought to identify any distinctive shared characteristics among them. He then randomly mixed drawings done by "altered" subjects with drawings done by people in a "normal" mental state, organizing them by subject (e.g., spirals), and conducted blind tests to check that it was possible to distinguish between them. He then proceeded to assume that the application of this method *does not depend on the epoch* in which the drawings were made, that a megalithic man in an "altered state" would have produced images similar to those you or I would make if we were tripping on mushrooms. If we accept this idea, it should be possible, by extension, to apply the method in comparing megalithic drawings to modern ones (or to other megalithic drawings) and thus identify "altered states" (Dronfield 1995). Dronfield applied his method to the stone inscriptions of the megalithic sites in the Boyne Valley, particularly Newgrange and Knowth, finding evidence of "altered states" in a number of cases.

How valid are these results? The method itself is sound, and therefore, in my view, it has been reasonably proven that the drawings in some way represent "altered states." The problems, however, begin when archaeologists try to see these results as providing an *interpretation* of Neolithic art, which is entirely not the case. Indeed, since it takes days, even months, to carve images as complex as those found at Knowth into a slab of stone, then clearly, at least to me, the carvers did not work in altered states, but rather *represented the visions they had in such states.* Why? Nor can the method answer these questions: Were the carvers the same individuals who had the visions, or were they working from previous drawings? Why are the images represented inside the chambers supposed to be burials? Is this a proof that they were not tombs, or at least not only tombs, but sites used for other ceremonies as well? If so, which ceremonies?

Still more controversial is the recent theory that compares the builders of Stonehenge with the modern-day natives of Madagascar. In Madagascar there is an ancient tradition of erecting megaliths that is still practiced today. In 1998, a new interpretation of the sacred landscape of Stonehenge based on ethnological studies of contemporary megalith builders in Madagascar was proposed (Parker et al. 1998, Pitts 2001).

For the Madagascar natives, the two principal building materials, wood and stone, one perishable, the other eternal, are associated with the living and dead, respectively. Stone monoliths are erected in honor of the ancestors, while the earthly existence takes place in huts of wood. This led these authors to propose, by analogy, that Woodhenge and Stonehenge were, respectively, the place of the living and the place of the ancestors. The interpretation is strengthened by the fact that Woodhenge is to the east (where the sun rises) of Stonehenge (like Durrington Walls, the astronomical orientation of which, however, is not clear). This puts Stonehenge to the west with respect to Woodhenge, in the same direction as the distant Preseli Hills, whence the bluestones were quarried. Further confirmation should be found in the food remains found at Woodhenge, which comprise pigs, thus associating the site with life and proliferation, whereas at Stonehenge the remains are mostly bovine.

The idea of a place of the living and a place of the dead is certainly suggestive, and recalls the pairs of temples, one above ground and one below, found at Malta, such as Tarxien and Hal Saflieni, as we saw in Chapter 3. However, it remains puzzling that both Woodhenge and Stonehenge are oriented to the summer solstice, given that the numerous examples we have already seen show that the place of the dead seems to be, as a rule, associated with the winter solstice. A possible solution might rely on the fact that the main alignment of Stonehenge to summer solstice sunrise is imprecise and difficult to define, and one could also consider the possibility that it was looked at from the outside as an alignment to winter solstice sunset (Ruggles 1999c, Sims 2007), thereby enhancing the connection with the dead and, perhaps, the afterlife. The builders knew anyway, of course, that the two phenomena occur, with a flat horizon, in the very same direction.

14.4 The Problem of the Code

One of the more unfortunate aspects of the "creeping evolution" mindset is the idea that scientific knowledge can only be handed down through the written word, along with the concomitant notion that the only knowledge that can be passed on orally is of a mythological or roughly historical nature (traditions, lives of the ancestors, etc.).

But if you think about it for a moment, you realize that there is *no reason* why this should be so. Information of the quantitative sort, such as scientific information, could have been committed to memory and repeated just as easily as any other, just as it could have been recorded on alternative "supports" that we might not even recognize as such, like a *Quipu*.

A further, interesting possibility, however, is that information was *codified*. Codification of astronomical knowledge might be embedded in a variety of ways in any number of practices. It could have been incorporated into rituals, like the period of invisibility of Sirius that coincided with the duration of the mummification ritual in ancient Egypt, or it may have been materially manifested in a building or other architectural structure, like the duration of the 260-day "religious" calendar, codified at Teotihuacan in the orientation of the city's layout. In other cases it may have taken the form of elitary knowledge reserved for adepts, such as the memorization of the Vedas (Chapter 5), just as it could have been embedded in esoteric occult practices. However, even if knowledge was actually passed on in any or all of these ways, it should not be necessarily thought of in terms of a "secret code." Mythology, for example, by definition available to all, is acknowledged to have been used for the transmission of technical information, and it is possible that it was also used to pass on astronomical knowledge.

The first scholars to systematically investigate the idea that mythology contains a code for the transmission of ancient astronomical knowledge were Giorgio de Santillana and Hertha Von Dechend in their study *Hamlet's Mill* (1983). The *Mill* is a highly complex book, written by two people with encyclopedic knowledge that enables them to move about in space and time with balletic ease. It has often been misinterpreted, particularly by those driven to expose at all costs its mystical or blatantly ahistorical aspects. Yet the central hypothesis of the book is quite simple and, in principle, provable: de Santillana and Von Dechend posit that myth—typically, but not necessarily handed down without the use of the written word—may constitute a sort of technical language, analogous to the “language” of chemistry, devised to describe celestial events, in particular the existence and dynamics of the precessional cycle. Indeed, although every book of history of science reports that the discovery of precession was made by Hipparchus of Rhodes around 127 BC, and therefore quite “late,” the Egyptians, Babylonians, and other civilizations had been studying astronomy for millennia.

According to de Santillana and Von Dechend, all of the cultures that took a deep interest in astronomy (the aforementioned Babylonians and Egyptians, but also the Mayas and the Indo-Sarasvati) were quick to recognize the phenomenon of precession, though this neither implies nor excludes that they would have understood the physical reasons for it. de Santillana and Von Dechend maintain that, in a certain sense, the discovery was traumatic—so traumatic as to have been cast as the cornerstone of the principal cosmological myths. The trauma was that precession is a rupture of the harmonically cyclical repetition of the celestial rhythms. In particular, precession causes the constellations of the ecliptic plane to appear ever later for their appointment with the sunrise, eventually giving way to the next constellation. So the position of the equinox point that moves along the ecliptic plane demarcates extremely long “hours” of the precessional cycle, each of which measures the duration of the sun’s being in a given constellation. Since there are 12 constellations of the zodiac and the cycle lasts approximately 26,000 years, each “hour” is roughly 2,200 years long.

According to de Santillana and Von Dechend, the discovery of precession was, thus, traumatic because precession is almost hidden, a phenomenon whose rhythm is so slow as to be barely perceptible over the course of a single human life. No other natural cycle is so drawn out, not even the relatively long one of the lunar stations. So if nature’s rhythms were the mirror and the motor of earthly cycles, then the existence of “precessional ages,” once discovered, could only correspond to the existence of related human cycles. As a consequence, according to these two authors, precession (often visualized as a millstone, hence the book’s title) dictated a succession of “world ages” that fell under the various zodiacal constellations: the Age of Taurus, the Age of Aries, and so forth.

Hamlet’s Mill offers a great number of hints to support this thesis, covering all imaginable times and places and cultures, invariably finding the same images, the same numbers, and the same mythological structures. However, these hints lead us into extremely perilous terrain, in the sense there is nothing more intellectually reckless than to trust analogical reasoning based on images, numbers, or the roots of names.

Images, such as the “wheel” that makes the world turn, which de Santillana and Von Dechend find just about everywhere, can have different meanings in different places. Numbers, such as 72—the number of years that must pass in order to observe a single degree of precessional movement—typically depend on the unit of measure being used (in this case the measure of the angles in degrees), which varies from culture to culture. Finding the same numbers in different times and places therefore means, in and of itself, *absolutely nothing*, though this does not stem the flood of ink that continues to be spilled in the name of “numerology.” Lastly, shared or similar etymological roots can be no less misleading, for they may have been influenced or modified in ways that are impossible for us to know, or they may simply be coincidental.

The main thesis of *Hamlet’s Mill*, therefore, is to be considered not as *demonstrated* in the text but rather *presented in a reasonable way*, and remains untethered to the massive amounts of quantitative research that would be necessary to either prove or disprove it. For example, Sellers (1993) concentrates on predynastic Egypt, seeking to determine the origin of the myth of Osiris’s death and resurrection in precessional terms. Sellers’s work, however, though interesting, employs the same method as *Hamlet’s Mill* and therefore fails to demonstrate its validity; the same applies to Sullivan’s (1996) work on the Incas.

In my view, *Hamlet’s Mill* nonetheless constitutes an extremely interesting attempt to break free of existing schemas, particularly that of the written word, to look for other codes, other means of communication that may have been utilized to pass on knowledge. As for the question of its scientific validity, there is still no adequate study on the discovery of precession by ancient civilizations, and such a study would be a necessary prerequisite for any serious effort to address the problems raised in *Hamlet’s Mill*. But the present book does provide us with enough material to at least attempt an outline of the status of this problem.

14.5 The Discovery of Precession Before the Discovery of Precession

It is virtually impossible for one single person to discover the precession of the earth's axis by means of observations, even over many decades, since the phenomenon changes far too gradually. Nevertheless, it is sufficient to have precise information, for example, regarding the position of the heliacal rising of a star over the space of 200 or 300 years, or the position of the equinoctial point over an analogous period of time, to notice that *something is happening*: the shifting of the rising point of the star, or the fact that the sun is rising against a background of different stars. Hipparchus worked in this way: he catalogued an enormous number of astronomical observations (on over 800 heavenly bodies), based on data taken from the observatory of Alexandria, established 150 years previously, and probably also using data from even further back, of Babylonian or Egyptian origin. It is quite reasonable, therefore, to suppose that this phenomenon could be tracked, in exactly the same way, by anyone who kept meticulous and accurate recordings of astronomical observations over many years. For instance, the Babylonians' observations of the heliacal rising of stars were accurate on the order of an arc minute (Chapter 5). Thus in a very short space of time (a few dozen years) astronomers could have become aware of the precessional shift. In India, observations of equinoctial constellations went on for thousands of years. It is certain that Vedic astronomers knew that the stars related to the rising of the sun at the equinoxes change over the centuries, because their lists of heavenly bodies started off with these stars and it was noticed that they changed from century to century (Chapter 5). Observations of the Decanal stars in Egypt had begun during the Middle Reign or possibly before (Chapter 4), although they were not as accurate as those of the Babylonians. They stretched over at least 2000 years, a long enough period to show macroscopic precessional effects; the theory that the Egyptians discovered the precession by watching the Decans was first put forward by Zaba (1953). The Mayas unquestionably had sufficient technical ability to discover precession quite readily (Chapter 8); in addition, the occurrence of the solstices at the intersection of the ecliptic with the Milky Way, a fact of fundamental importance in their cosmology, lasted—again due to precession—for a relatively short period of time. However, while we know a great deal about their planetary and lunar observations, we know little about the study of stars or the existence of star archives or catalogues among Mayan astronomers. The deciphering of the Codex of Madrid or the discovery of some new codex in future may be of help in assessing this issue.

Another aid in discovering precession may have been the reuse of stellar alignments bequeathed by predecessors, noticing that these would have become inaccurate. Some examples follow:

1. The central axis of the temple of Ggantja I in Malta was probably oriented on the Cross/Centaurus group of stars. Some centuries later, a second temple was created, absolutely analogous with the first, but with its axis shifted more to the south, almost certainly to take into account precession (Chapter 3).
2. The orientation of the Sardinian Nuraghi toward the stars of the Cross-Centaurus group appears to change over time in accordance with the precessional shift of these stars (Chapter 3).
3. In various Egyptian temples, we can see deviations in axis direction occurring during rebuilding or amplification work. The only logical explanation for at least some of these divergences is that they derive from the need to take into account the precessional shifting of the stars that their alignments pointed to (Chapter 4).
4. The Medicine Wheel of Moose Mountain shows that the alignment with the star Fomalhaut was "adapted" over the years owing to the precessional shifting of its rising point (Chapter 7).

I believe that in each of these cases it is extremely likely that the astronomers realized that something was going on, very slowly, in the sky. And yet, without any explicit sources to provide support, we cannot be certain of how they interpreted this, nor can we rule out a priori that they simply put the disparity down to an error in their predecessors' measurements. The question of the discovery of precession is thus quite elusive, and, despite a great deal of clues, we lack any unequivocal evidence that it took place before Hipparchus. As a consequence, although I am *not* keen at all on it, I must admit that many clues indicate that precessional effects had been discovered by numerous astronomers of the past, but that the discovery was kept hidden, and that only an elite of initiates were privy to this arcane knowledge.

Indeed, also some extremely interesting and curious evidence dating from the age just *after* Hipparchus's supposed breakthrough seems to point in this direction.

14.6 A *Corrida* in the Sky

Hipparchus discovered precession around 127 BC in Rhodes. The war against the pirates, in which Pompey was to feature so prominently, took place 50 years later, and it was because of this war that Roman legions first came into contact with a religion— the cult of Mithras—that was to spread quickly throughout the empire in the following two centuries, only to collapse and be swept away in the end by Christianity.

The cult of Mithras is a mystery religion—"mystery" has here a technical meaning; a religion is referred to in this way if its rituals were kept secret from the noninitiated. Hence we know very little about what went on in the *Mithraea*, the underground grottos shaped like a tunnel with an apse at the end, where the followers of Mithras gathered (there are many throughout Europe; in Rome a famous one is in the St. Clement catacombs). The main iconography of the cult, however, is widely known, since numerous sculptures and paintings found in recesses in the apses of the Mithraea have survived. Mithras is always seen killing a bull with a sword in these images. The god is facing away from the animal, below which a scorpion is depicted, stinging its genitals. There are usually also a dog, a snake, a raven,

Figure 14.2: The mithraic iconography

a lion, and a cup. Ears of corn often sprout from the bull's tail. Further, it is not unusual to find the signs of the zodiac and planetary symbols encircling the Mithraic iconography. Up to the 1960s, however, interpretations of the Mithraic cult (of which, I repeat, there exist no written evidence) were based on some dodgy notions cobbled together by a Belgian scholar, Franz Cumont, in 1896, who saw in the cult of Mithras the reflection of an ancient Iranian cult transplanted to the Roman Empire. Despite the fact that many aspects of the mystery cult of Mithras had very little to do with the ancient Persian cult, and there was not even the faintest hint of the killing of a bull, Cumont based his ideas on the theory that Mithraism had been molded in conjunction with subsequent variants from Iranic cults, for example, one in which the killing of a bull (the *tauroctony*) does actually take place, but at the hands of a completely different figure, Ahriman, a force of cosmic evil in the Persian religion, and *not* Mithras.

This Iranian dogma is an excellent example of how easy it is to be dazzled by a great figure (or one deemed to be great) and let oneself be deluded into concocting theories that are unproven or sometimes even downright absurd.

The first criticisms of Cumont finally began to appear in 1971, and it was soon clear that Mithraic scholars would have to reconsider their discipline from scratch. Actually, as early as 1869, the German academic Kurt Stark had pointed out that all Mithraic iconography seemed to allude to observations of a map of the heavens. Cumont, however, "debunked" Stark's hypothesis, stating that astronomical contents had only secondary importance in the doctrine and were only appropriate for the beginners, before being admitted to the full knowledge of the esoteric Iranic traditions. After 1970 scholars studying the significance of Mithraic iconography were forced to start afresh, and they immediately hit on the hypothesis of astronomy once again. Some authors suggested, for instance, that the iconography refers to the heliacal rising of the constellation Taurus (the bull), and that Mithras might represent Orion, but this idea does not fit well with the fact that Orion lies under Taurus. In fact, the complete solution was within the grasp of anyone who knew where to look and was familiar with the precession phenomenon. But, as usual, simple things are only simple when someone points them out—in this case, David Ulansey (1989).

Ulansey started by noting that the most natural constellation the god might be identified with is Perseus, a constellation documented as far back as the fifth century BC, represented by a warrior sporting a Phrygian cap (an oriental conical cap with front turned forward, similar to that sported by Mithras) who is raising his sword "to the bull." If then the scene represents a sky in which the bull "dies," then the scorpion must stand for the Scorpio constellation. At this point, the interpretation becomes quite obvious to

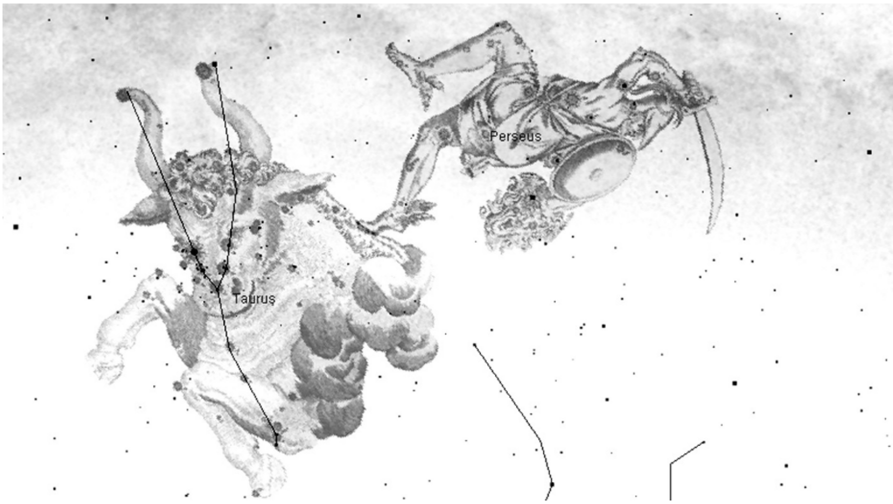


Figure 14.3: The mithraic iconography in the sky

anyone who is familiar with precession: the scene represents the celestial equator at the time of the precessional era of Taurus, the period between the fourth and the second millennium BC, in which the equinoctial constellations were Taurus and Scorpio. Corroboration of this interpretation comes from the fact that the celestial equator crossed the Taurus, Canis Minor, Hydra, Crater (or Cup), Corvus, and Scorpio constellations (and a fragment of Orion's "stick"), that is, precisely the constellations found in Mithraic iconography apart from Leo, whose presence is easily explained, however, since it was the constellation associated with the summer solstice in that same age. Further, the ears of corn sprouting from the bull's tail can be interpreted as linking the figure with the vernal equinox.

The most interesting part of Ulansey's theory about the origin of Mithraism is that it comes from Hipparchus's discovery, developed into a symbolic framework by the School of Stoic Philosophy at Tarsus. It was customary for Stoic philosophers to see a manifestation of the divine in natural forces. According to Ulansey, therefore, the Stoics conjectured about the existence of a new divine being who was responsible for this hitherto unknown movement of the heavens. The divinity was then identified as Perseus, already worshiped in Tarsus and associated with the corresponding constellation. In Ulansey's view, the birth of the Mithraic mysteries represented, therefore, the response of an original group of intellectuals to the staggering discovery that the universe was not as simple as had been believed up to then.

If all this occurred, it occurred in an incredibly short period of time—

about 50 years. The cult is supposed to have come into being, spread far and wide, been consolidated, and then taken up by pirates with whom Roman legions then chanced to come into contact—all in 50 years. Ulansey's arguments on this score sound a bit shaky, although he cites the fact that these pirates constituted an actual "nation" and had contacts with intellectuals. Moreover, as navigators, they would be familiar with the stars.

I find it all a bit difficult to accept. I cannot find similar examples or analogies in the entire history of humanity: a scientific discovery that becomes a cult practiced by pirates—all in 50 years. The most difficult assertion to accept is that the predictions following this discovery were applied *backward in time*, thus not in the *eschatological* sense, as would be more natural for a religion. In other words, if a scientific discovery is to give rise to a cult, one would expect that what the discovery said about the future would be accorded religious significance—thus becoming the anticipation of some sacred event—rather than what it asserts about what happened in the past. So I would expect the iconography to be based on the imminent end of the Age of Aries (the equinoctial point gradually passed from Aries to Pisces around the centuries straddling the year 1 AD) and not on the end of the Age of Taurus, which had occurred some two thousand years previously.

This objection (albeit not quite couched in such terms) has already been raised: Why did the iconography not refer to the arrival of the Age of Pisces rather than to the arrival of the *previous* age, which was just about to end? (By the way, it should be noted that one of the symbols of the early Christians was, coincidentally, the fish). Ulansey's reply is that Hipparchus apparently estimated the rate of precession to be one degree per century (getting it with a macroscopic error, given that it is actually one degree every 72 years), which would have led to a prediction that the Age of Aries would end in 800 years' time, and not almost immediately.

If this explanation is valid, then it may have been this incorrect prediction that contributed to the waning of the Mithraic cult in the early centuries AD. But I think it is more likely that the cult did not emerge from a scientific discovery, but rather from previous traditions and cults, which had accumulated knowledge of the precession of the equinoxes over centuries or even millennia.

Another equally interesting (and surprisingly similar) clue comes from another unexpected source, the *Gundestrup Cauldron*. It is a large silver bowl, dug up from a Danish peat bog in 1880, and now at the National Museum in Copenhagen. It is perhaps the most famous artifact of the Celts, the civilization that originated among the Bronze Age peoples of the Danube area and spread mostly between the fifth and second centuries BC. The cauldron is exquisitely decorated with embossed scenes and figures and can

Figure 14.4: The Gundestrup cauldron, central plate, and its astronomical interpretation

be attributed stylistically to the Celtic art of the final centuries before Christ (Taylor 1992). And yet it also displays certain oriental influences, such as elephants. Precise dating of the cauldron is impossible, but archaeologists currently place it in the second or first century BC, which makes a big difference, as we shall see.

Numerous interpretations of the decidedly puzzling scenes depicted on the vessel have been proposed. While some figures in the central plates can be plainly identified as well-known Celtic deities, such as Cernumnos, the god with stag horns also found in rock carvings in Val Camonica, the scene depicted on the central plate has so far eluded any convincing explanation. The center is occupied by a bull in an unnatural position, possibly dead. Around the edge there are figures, less heavily embossed, and these are, going clockwise from the bottom, a bear (or she-bear), a lizard, a dog, and a warrior. There is also a tree-branch motif.

Many interpretations have been suggested to explain the scene: ritual sacrifice, a hunting scene, ritual fighting with bulls, and fighting (ritual or otherwise) between bulls and dogs. Actually, only the bullfight (*corrida*) is missing. But recently a French scholar, Paul Verdier (2000), had enough faith in the intelligence of the creators of the Gundestrup Cauldron to suggest

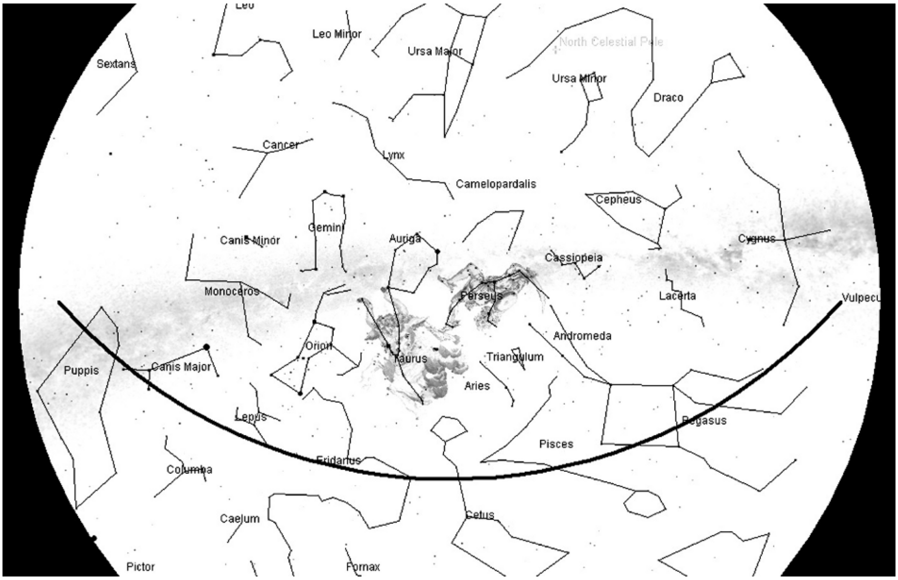


Figure 14.5: The sky likely depicted in the Cauldron

that the symbolism on the vessel has an astronomical meaning. One of the side plates contains two registers of images separated by the branch of a tree. In the upper register the four horsemen may symbolize the solstices, in the lower register the 12 soldiers symbolize the months of the year, and the tree along which the figures glide is the Milky Way. The central scene of the Cauldron immediately acquires significance if one could have seen the sky in the southwest on a night in one of the years around 2000 BC. Going in succession clockwise from the east we would have seen Canis Major and Orion. In the middle is Taurus, and the scene with the dying bull alludes to the end of the Age of Taurus.

In Verdier's original work, the identification of the lizard with the modern constellation of the same name is posited, but this, as has been observed by J. Belmonte (personal communication) cannot be true, since the Lizard is a modern constellation; the stars that constitute it have been grouped under this constellation only since the 17th century. The animal, however, may represent the constellation Draco or perhaps Tiamat, the monster similar to a dragon of Babylonian origin habitually identified, even in ancient times, with what we call today Cetus, situated under Orion. I would also suggest, in contrast to Verdier, that the figure of the warrior might, as in the Mithraic iconography, be identified with Perseus rather than Orion, and thus the scene on the Cauldron might be exactly the same as the scene represented in the Mithraea (see Magli 2004a for further details).

It is extremely difficult to glean any other information from the iconography here, since we know little about the Druids' (Celtic astronomer-priests) knowledge of astronomy. Most of the information comes from accounts written by others (including a Greek from the Stoic area, Posidonios, and the Romans). Nevertheless, some archaeological clues (such as the Coligny Calendar, a calendar of 62 lunar months engraved on a bronze plaque, with Roman numerals but in the Gallic language) show that the Druids may have inherited a long tradition of celestial observation (Gaspani and Cernuti 1997). Perhaps this tradition can be traced back to the Bronze Age, as the discovery of a disc bearing a symbolic depiction of the sky with 32 stars, a half-moon, and the sun unearthed in Nebra, Saxony, within a 16th century BC archaeological context, seems to confirm.

14.7 Predicting the Past

The Mithraic iconography and the central scene of the Gundestrup Cauldron are two glaring examples of how difficult it is to understand astronomical ideas without adopting a global approach that takes account of all sources of information and knowledge available (Iwaniszewski 2003, 2005). For this reason, archaeoastronomy needs to develop its own research method, and since it is something of a borderline science lying halfway between exact sciences and human sciences, this method has to be borderline as well (Magli 2005a). But since a real science is able both to develop models based on data and to make predictions regarding expected experimental results through the elaboration of theoretical models, if archaeoastronomy is to be a science, it must be able to "predict the past." Actually, some examples already exist. As we saw in Chapter 6, the function of the Medicine Wheels had been a complete enigma until physicist John Eddy discovered its astronomical alignment with Big Horn. When Eddy applied his astronomical interpretation to the wheel of Moose Mountain, he was able to predict approximately the age of the artifact. In Chapter 9, we saw that a Mayan site and its close relationship with Uxmal were recovered by studying the alignment of the Governor's Palace of Uxmal with what looked like a natural hill, but which turned out to be a pyramid almost forgotten in the jungle. A third example comes from Michael Hoskin's studies on the Mediterranean islands, which we encountered in Chapter 3. As we saw, both Minorca and Majorca contain megalithic sanctuaries (though the characteristic structures known as *Taulas* are found only in Minorca). In one of the oldest megalithic sanctuaries, *Son Mas*, archaeological digs have come up with evidence of human presence since the Copper Age (around 2000 BC). This seems to have been suddenly interrupted, however, around 1700 BC, in such an inexplicable fashion that archaeologists continued to think that, by some trick of fate, those centuries were "missing" from the radiocarbon dates. As we saw in Chapter 3, Hoskin's studies in Minorca revealed an interest in the Cross-Centaurus group. When Hoskin investigated *Son Mas*, he realized that a long alignment made with a large rock pointed to the end of a valley, southward, in such a way that it framed the arc of sky crossed by this very group of stars. However, due to the relative height of the horizon, he also realized that precession caused the disappearance of the lower star of the Cross around 1700 BC. As a result, if the site was connected with such astronomical observations, it must have been abandoned about that time. When Hoskin obtained this result, he was unaware of the radiocarbon dates. However, he later met Mark Van Strydonck of the Royal Institute for Cultural Heritage at Brussels, who had himself been responsible for processing the radiocarbon samples from the site, and confided in him his "pressing need for a crisis around 1700 BC." Then, in Hoskin's words: "Astonished, Van Strydonck pulled from his pocket the draft of the latest paper on the radiocarbon dating, which again proposed an (hitherto inexplicable) site abandonment around 1700 BC."

Of course, if a scientific model works, it should also be able to draw

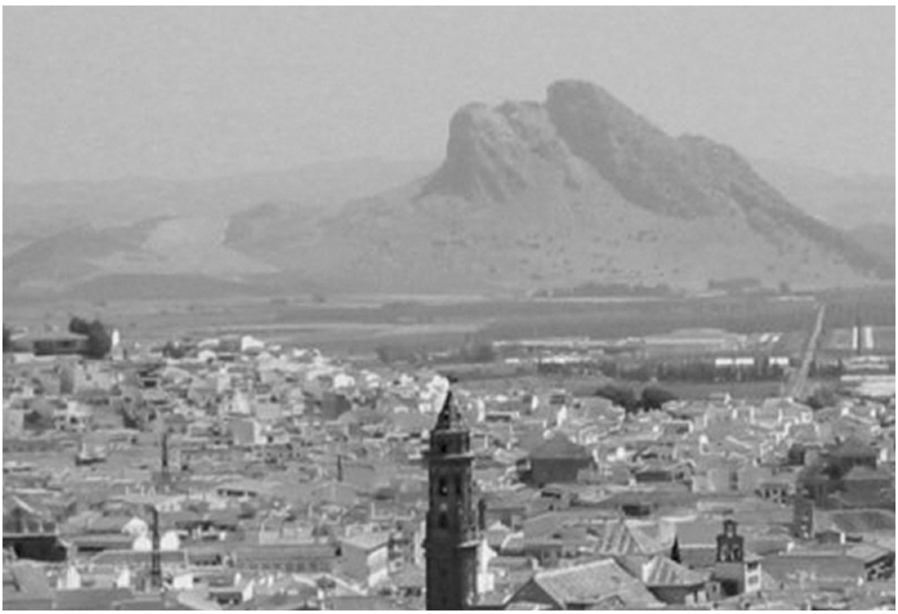


Figure 14.6: A sight view of Antequera (Malaga, Spain)

conclusions in the negative. This is indeed what happened in certain cases, as I shall explain with another example, again from Hoskin's work.

Spain is rich in megalithic monuments. The largest are to be found in the region of Antequera, 35 kilometers north of Malaga, and the most impressive of all is the *Dolmen de Menga*. Despite its name, it is not a simple Dolmen but a large chambered tomb, 18 meters long and 6 meters wide, built entirely with enormous slabs (the roof of the chamber is made of a slab that is 2½ meters thick, 6 meters wide and 7 meters long). The orientation of the monument is unusual for the region, a few degrees east of north (Hoskin et al. 1994); however, the axis is oriented toward a prominent mountainous peak, of quite unique shape, which suggests the profile of the face of a reclining man. It is thus extremely likely that the tomb is *topographically* aligned in a direction that had symbolic, and not astronomical, significance.

In this case, therefore, archaeoastronomical methods allowed a conclusion to be drawn in the negative and at the same time the symbolic content of the landscape to be identified with some certainty.

Unfortunately, such predictive examples are still the exception in archaeoastronomy. This discipline is considered a "technical" science (read "secondary") by many archaeologists. On the other hand, often the attitude of archaeoastronomers is too timorous, and it is very rare for a historical-archaeological proposal to be based on archaeoastronomical data and cross-checked with the archaeological record, and it is even rarer for such a proposal to be accepted by the archaeological community. As a consequence, as we shall see, only in recent years are we beginning to understand the most renowned, fascinating, and complex archaeological site on planet earth. Before we make its acquaintance, however, we need to collect the ideas discussed so far to aid us in our interpretation.

Power and Replica

15

To be inhabited, the world must first be founded.

—M. Eliade

15.1 Three Levels of the Cosmos, Four Parts of the World

When we talk about men and stars, we are talking about the *cosmos,* which is made up of three things. The first is space, which belongs to man. Even though man is a three-dimensional creature, man's space is to all effect flat, since it is the surface of the earth. The possibilities of a "third dimension" have always been extremely limited, and there exist few exceptions to this frustrating two-dimensional world. Caves provide limited access to an underground dimension, and mountains are almost unreachable at high altitudes. Therefore, anything set at another level has always been watched, feared, exploited, worshipped, and studied—caves, mountains, and the sky.

The sky has its own cycles and special phenomena, which man cannot hope to interfere with in any way. In fact, the only way to interfere is to predict: forecasting an event confers power on the one who predicts and affords comfort to the one who waits for it to happen, for example, an eclipse or the heliacal rising ("rebirth") of a star. But events occur in the sky that are not predictable, such as the explosion of an extremely bright supernova.

The earth has its own cycles and special phenomena, which man also has no chance of interfering with. Here, too, the only way to interfere is to predict such events as the Atlantic tides or Nile floods. The earth, too, has events that are not predictable, such as droughts, earthquakes, and volcano eruptions.

In the sky, the most important body is the sun. It is the sun that marks the rhythm of the seasons and thus governs the swings between hot and cold, rainy and dry seasons, sowing and harvesting. Keeping track of the sun's behavior is basic for human activity. The persons who studied, understood

G. Magli, *Mysteries and Discoveries of Archaeoastronomy*, DOI: 10.1007/978-0-387-76566-2_15,

and predicted the solar cycle became a sort of intermediary, guaranteeing the calendar and annual repetition of the cycle.

Since our world is two-dimensional, once the other celestial/subterranean dimensions have been identified, seeking a privileged axis comes naturally. In fact, unless one lives on the equator, one sees the stars rotating around the celestial poles (north or south) and by simply reaching out toward the pole, one can in a way *become* part of this axis. The direction determined on the horizon by projecting the axis, that is, by lowering one's arm until one sees the point on the horizon in the same direction as the pole, is naturally privileged for the simple reason that anyone is able to determine it. This privileged direction is associated with the stars, and accordingly with the night.

The night's sky has two main bright objects: the moon, whose movement over a month seems to imitate the sun's one over a year; and Venus, whose behavior alternates between "announcing the sun" and "following the sun." At night things happen in the sky that the sun cannot "see"; the night is thus the time when communication with the afterlife, the "other world," becomes possible. During the night the signals, the cogs in the constantly moving celestial machine to which a special significance was attached, had to be duly monitored and verified, such as the rising of the Pleiades in Teotihuacan, the cycle of Venus in the Yucatan, the lunar cycle in Carnac, and the heliacal rising of Sirius and of other Decans in Egypt.

If the north–south direction is the preferred direction of night observations, the east–west direction is the preferred direction of observations in the daylight. Indeed by observing the sun's movement during the day, it soon becomes clear that if one takes the direction that the rising sun indicates halfway through its trajectory and traces it back and forth at the horizon during the year, this direction, along with the north–south axis, splits the world into four equal segments. Thus a second privileged direction is determined, the one associated with day and light, or with the end of the day and sunset: east–west.

This division into four parts is unquestionably natural, for the simple reason that two coordinates are required (hence two axes to measure them on) to determine the position of a point on a plane (this is what we call the Cartesian plane). Note that the concept of cardinality does not rule out knowledge that the earth is spherical. Man's world is two-dimensional in any case, given that two co-ordinates, latitude and longitude, are sufficient to be able to locate one's position on a sphere. Further, cardinality does not always rely on the cardinal points: as we have seen, in Central Mexico the cardinal points were not especially important, and the cardinal directions were instead the result of selecting a calendar based on astronomical events that define directions, such as the zenith passage of the sun and the rising of the Pleiades, which depend on the position of the observer, whereas north–south/east–west directions do not. The cosmological interest in the zenith is also confirmed ethnologically speaking, for example, among the Warao, in Venezuela, who see the zenithal axis as one of the main axes of the cosmos.

As a result of the "cosmization" procedure, the space itself becomes *ordered*, a place that has been founded and prepared for human life; thus, space becomes sacred space. The religion historian Mircea Eliade was probably the first to understand this mechanism in details. He wrote: "The Experience of Sacred Space makes possible the 'founding of the world': where the sacred manifests itself in space, the real unveils itself, the world comes into existence."

Since the world is divided into four parts, there is a point at which the axes intersect and the four parts become one. It is a privileged point, a center, the navel of the world. All Roman roads lead to Rome, but all Incan roads lead to Cusco, all Anasazi roads lead to Chaco, and so on. The navel of the world is the ideal place for communicating with other levels, the place where power resides and manifests its identity physically. So it is often also a place where one chooses to replicate the cosmos, or even a place chosen for the reason that it seems to replicate the cosmos itself, like Cusco or Chalcatazingo.

Man's space is symmetrical in relation to the axis of the world, as man himself is symmetrical, and the axis passes through the navel. In some communities in Bolivia, there still exists the idea of living in a mountain area shaped like a supine man. It might happen, then, that a man who lives in the "head" says he has married a woman from the "left arm," meaning a woman who hails from a village to be found in the relevant part of the man-shaped "map of the cosmos" (Bastien 1985).

The center of the world is also a place of rebirth, and so we have Pacal, portrayed on the lid of his coffin at the intersection of the celestial "axes," which were the Milky Way and the ecliptic for the Mayas. In some Mayan chiefs' tombs, for example in "tomb 12" in the Rio Azul site, the walls of the chamber are frescoed with glyphs of the cardinal points, almost as if the soul of the deceased was being oriented, on the one hand, and the deceased himself was being placed at the center of the four parts and thus at the site of rebirth, on the other (we do not really know if it was one or the other, or both). The Egyptian tombs had "magic bricks," one for each of the cardinal points. In the Kivas of the Hopi Indians, every ceremony initiating young males into adulthood documented by ethnologists in the 19th century was preceded by the construction of an "altar" oriented on the cardinal points, of which the *Sipapu*, the door leading to the "world beneath," took up the center. As we saw in Chapter 8, the Aztecs erected a temple on the peak of Mount Tlaloc, dedicated to the Rain God, and indicated the cardinal points there with boulders. In one of the Aztec codices (chronicles regarding the pre-Columbian world written after the Spanish conquest), the Borgia Codex, we can see an illustration in which Tlaloc stands out at the center of the depiction, centering himself (i.e., treading on) a female figure undoubtedly associated with the earth. The sky is cloudy and rain swept, and the fields around the female figure are neatly cultivated. At the four ends of the painting, there are four copies of the same scene, suggesting that the advent of the God (the Rain God, with any luck) can occur anywhere in the four parts of the world.

Cosmological symbolism was not necessarily restricted to monumental centers and was often reproduced in miniature in the very structure of houses or huts. For instance, among the Mongols the sky was conceived of as a large tent hanging on the axis—the pillar—of the world, of which every tent, with a central pole sticking out the roof, was seen as a replica.

15.2 The Man Who Climbs the Tree of the World

The man who dealt with fundamental activities, such as tracking the annual solar cycle, monitoring the cycles of the night stars, or establishing the cardinal axes and their center, wielded enormous power (Krupp 1997a). Sometimes power was concentrated in the same person who held temporal power, as in Palenque, and sometimes the two figures remained distinct. From an ethnographic point of view, it is tempting to identify the holder of spiritual power with the figure of the shaman.

The word *shaman* originated among the Tungu, a people of eastern Siberia, and was coined in the 17th century. I am not sure that the designer of Newgrange and the author of the Dresden Codex would be happy to be labeled shamans, and perhaps we should describe them in a different way. One possibility would be to follow Mackie's definition of astronomer-priests, but admittedly one advantage to using the word *shaman* is that it is rooted in the real world.

The shaman (usually male, although the shaman may be a woman in some communities) is the custodian of the celestial cycles and of the calendar, and an intermediary between the human level and other levels (the gods and the spirits). He directs the rhythms of rites and celebrations, and is in a sense responsible of the cyclical renewal of nature. Consequently, this figure is nearly always linked, more or less explicitly, with knowledge of astronomy. But this self-proclaimed rapport with the skies goes much deeper: he believes (or pretends to) that he is able to open doors through which the two levels can communicate, and he often sets himself up as the only intermediary through whom such communication is possible.

One of the main experts on shamanism is the historian Mircea Eliade (1959, 1982), from whose work I shall cite a classic example, taken from the Turco-Altaic populations of central Asia. For these people the sky is the kingdom of the God Bai-Ulgan, and it is divided into nine levels, each of which is assigned to a sister of the God. This kingdom is visited by the shaman on a mystic flight, to which the iconography of a duck is related. During the flight (in a trance state, see below), the shaman imitates the duck's call. A birch pole carved with nine notches is placed at the center of the shaman's tent and represents the Tree of the World. As it is the central axis of the world, the tree is the ideal extension of the polar axis, and it is in fact the part of it that passes through the center, through the umbilicus of the world. By means of a simple stick with nine notches, then, the human plane is transformed into an image, a replica, of the cosmos, and the shaman's tent is the heavenly vault, the point at which the axis passes into the earth is the center of the world; in a way this provides certainty that the world exists and can thus be inhabited, and one can be certain of living in the right place.

This link with the axis of the world is therefore central to the shaman's living iconography. Shamans usually carry a wooden stick, sometimes topped with a carved symbol, often a bird. The stick symbolizes the axis, the same axis that anyone could trace by stretching an arm out to the celestial north pole, but one that only he can pass along, often represented by a one-legged being—as in the recess of Lascaux (Chapter 1) or in the astronomical ceiling of Senmut (Chapter 4) (Rappenglueck 1999).

The axis of the world is what allows the existence of directions, the breaking of spatial homogeneity, and is thus crucial for man's very survival. For example, for the Achilpa, an Australian tribe, the world was founded by a divine being who after creating order ("cosmizing") and creating their ancestors, made himself a pole out a rubber tree, scaled the pole into the sky, and disappeared. The pole is the axis of the world, and the Achilpa always carry it with them. Eliade says that they decide the direction to be taken according to its inclination. Certainly, carrying the axis of the world around all the time is what enables them to move, and legend has it that a group of Achilpa whose pole broke left themselves to die.

15.3 The Man Who Opens the Doors

It is seminally important that the shaman should demonstrate his skills tangibly, physically. He has to have a special ability that sets him apart from the rest of the community. This is the function of *trance*.

Describing a trance state is not easy without wandering off into the realms of the so-called (and nonexistent) paranormal. And so let me propose a practical definition: the emotional state of a person can be considered to be a trance if it is clearly different—it is *other*—compared to the normal behavior of the individuals in a group, and the group is duly interested or frightened by such behavior. This altered state is induced by appropriate actions or substances, which are also different in the above sense. These actions include self-sacrifice (that is, deliberately injuring oneself, as happened with the Mayas and the Aztecs), drug-taking, hallucinogen-smoking, obsessive repetition of drum sounds or alienating gestures (like the whirling of the Dervishes) or a combination of these (Devereux 1973). The use of hallucinogenic substances is well documented in ethnological studies in many parts of the world, in particular in Mesoamerica, among the Mayas and the Incas, and, as we have seen, evidence—indirect, but convincing nonetheless—is to be found in images in megalithic art (Chapter 14).

Interestingly, the use of hallucinogenic substances has been long suspected also for the most famous oracle of the classical world, that at the sanctuary to Apollo at Delphi. Devotees to the sanctuary had first to purify themselves in the spring that spouted from a crack in the rocks between two crags, known as the Fedriades, which tower over the entrance to sacred zone. Then they ascended a "sacred way" and were finally admitted to the hollow cave of the actual oracle, a woman called *Pythia*, who spoke to the faithful in a state of trance. Up to a few years ago, it was unclear whether Pythia used hallucinogens, but it was discovered recently that the sanctuary had been deliberately built at a place where friction between two faults produced hydrocarbon vapors. Methane was released, combined with ethylene, which has a sickly sweet smell and may cause a state of euphoria, or even lead to unconsciousness. Indeed the historian Plutarch writes that the location of the sanctuary had been discovered by pure chance and that a sort of perfume could often be detected in the Pizia's lair.

By means of his trance, the shaman purports to be a veritable voyager through the skies, the portals to which are known only to him. On his celestial trips he often uses the Milky Way, which is universally identified with the flowing of a liquid—in some communities sperm, believed to be divine as well as having fecundity, and which the shaman has power over. Since the voyage is "in the sky," it is only natural that birds and men-birds feature prominently in the iconography; this indeed forms the basis of Rappenglueck's interpretation of the scene in the grotto in Lascaux.

Just as there exist designated places in the sky where doors open, so there are also designated places on earth, "sanctuaries" where the shaman carries out his duties, and often the sanctuary contains a representation of the sky, a replica of the heavens to which the shaman is a conduit.

In his cosmic journeys the shaman uses, or purports to use, cosmological maps, which encompass the whole universe; there are many examples of these maps, from all over the world, usually sketched on skin or carved on rocks. Once the appropriate procedures have been performed, the trance state is proclaimed to have been attained. It should be stressed that the good faith of the shaman does not concern us here, nor are we interested in establishing whether the trance allows the shaman to genuinely carry out otherworldly operations, such as seeing into the future or talking to spirits and eliciting their help or benevolence (of course, as a physicist, I do not believe it at all). But what matters here is that the shaman is credited for having these skills, and this confers enormous power on him. The shaman thus becomes also the medicine man, treating the sick, assisting in childbirth, and officiating at death rites. The term *healer,* rather than medicine man, is sometimes used, but it is pointless and possibly risky to dwell too much on the choice of words. Let me give an example.

One of my friends happened to be in a godforsaken spot on the Mexican-Guatemalan border, a 24-hour drive from the closest hospital. After a fall he suffered an extremely painful and worrying multiple fracture in his shoulder. He was then taken to the local healer, who proceeded to subject him to a half-hour of chanting and propitiatory fumigation. At that point the patient was quite astonished, but still very concerned about his shoulder. The healer finished his rituals and used pieces of strong canvas and an amalgam of chewed herbs and cinnamon sticks to immobilize the fracture, in such an appropriate way that when the patient was later able to reach a hospital, the doctor praised the healer's treatment.

Apart from the powers that we might define as death-related, the shaman also invests himself with life-related powers. This function might be defined as divinatory or, if we like, astrological. The astronomer was consulted as a repository of celestial knowledge, and on the basis of such knowledge, he made predictions, auspicious or inauspicious as the case might be. The importance of these predictions, and the prestige deriving from them, should not be underestimated. For example, as we have seen, among the Babylonians, astrologers were even able to trigger the mechanism of the royal substitute (Chapter 5)—replacing the king with a hapless wretch destined to be sacrificed if the king was thought to be in danger. Among the

Mayas, any official action took on cosmological significance, for instance, war, which had to be synchronized with heavenly events, especially the cycle of Venus, as is shown in the frescoes of Bonanpak, a Mayan site about 100 kilometers from Palenque, which boasts the only example of a Mayan pictorial cycle that has come down to us intact. In the Bonanpak cycle, the celebration of a victory in battle (a celebration that involved the extraction of the fingernails of nine prisoners, possibly the scribes from the vanquished city) is dated 2-8-792. On that date, the sun was passing at the zenith, while Venus was in the lower conjunction, that is, in the brief period when it disappears from the sky before reappearing as the Morning Star.

I am often asked by students if the astronomy of the past was real astronomy or was it something more akin to astrology. Well, if we consider the sheer mass of facts that I have described in the first part of the book, and bear in mind that the vast majority of them are unquestionably true, we can only conclude that the ancient peoples' study of the sky was much closer to astronomy than to astrology. In fact, I have no way of knowing whether a Babylonian or a Mayan astronomer genuinely believed in his predictions, though I have my doubts, just as I have no way of knowing whether a modern astrologer genuinely believes in his predictions, and I have more than a few doubts on that score. The "astrology" of the past contained, however, something that we do not find in "modern astrology": data, models, and predictions of physical events—in short, all the things that go to make up "science."

15.4 The Earth and the Goddess

The four-part structure of space together with its center was, as I have said, also a reflection of the human body. Moreover, the male–female duality had its counterpart in the cosmos as well, being reflected in the structure of the sacred. The most common, although not universal, way of identifying this dichotomy was by associating the sky, in particular the sun, with a male divinity, and the earth with a female divinity. Thus the divinity usually identified as Mother Earth or Mother Goddess came into being (Gimbutas 2001).

This is not the place to explore the complicated issues of the symbolism of the Goddess Earth, which has been ubiquitous since the beginning of the Paleolithic Age in the guise of female statues or statuettes, mostly characterized by overweight bodies and overendowed breasts. These Mother Goddesses continue to appear up to the Neolithic Age, especially, as we have seen, in Malta; the idea of the mother-creator divinity was then to filter through into the main religions, in Egypt, and then in Greece and Rome. I shall restrict myself to cosmological and astronomical aspects, which are almost certainly tied up with the male–female duality.

The cycles of the earth and of the sun are connected. The cycle of the sun is tied up with that of the seasons, hence the "fertilization" of the earth and the rebirth of plants and fruit. This probably gave rise to an earth–female/ sun–male connection—common to many cultures—which developed long before widespread agriculture was established, and thus was linked to the seasonal cycle well before the very same cycle became a calendrical reference for agriculture. This association was reversed in Egypt, where there existed a Goddess of the Sky—Nut, portrayed with her body arching over the world in order to support the heavenly vault—while the male divinity Geb was associated with the earth. The reason for such an inversion is most likely the fact that the fertilizing power usually associated with the rain/sky was here related to the Nile/earth, though it is possible that these associations date back to a time when Egypt's climate was more humid and thus quite different from that of the last 6000 years; in that case, more thorough analyses would be needed.

The solar cycle is naturally marked by the two solstices. The winter solstice in particular, which would have been followed by the cycle of terrestrial rebirth, may have been viewed as a sign or harbinger of rebirth, possibly even of accomplished earth–sky fertilization. The fertilization-rebirth at the winter solstice was then represented physically and replicated in the construction of temples or chambers aligned to it.

Malta is the best place to look for the proof of this. In Malta, everything hinges on "she." The statues, from the smallest to the most enormous, found in Tarxien. Further, the most incontrovertible, self-evident proof has been staring us in the eyes, since Chapter 3: one only has to look at the actual *shape* of the temples. The internal lobed layout is indeed clarified when one realizes that it is the body of the Goddess, seen from above. Thus the entrance of the solstitial sun striking the left corner of the altar in the temples betokens that the fecundity of the Goddess has been accomplished, in a hierophany that mimes the sexual act between the two deities.

Access to the "earth" dimension, made tangible in Malta by the replica of the body of the Goddess in the temples, is normally only possible via caves, which thus take on the significance of symbolic places of rebirth, where, again, it is possible to open doors, and consequently places where the shaman wields his power. For instance, the Californian Chumash Indians identify the access to the earth in a natural vagina-shaped formation, Painted Rock (Krupp 1997a). Another extraordinary example is to be found in Yucatan, in Balamkanché, not far from Chichen Itzà.

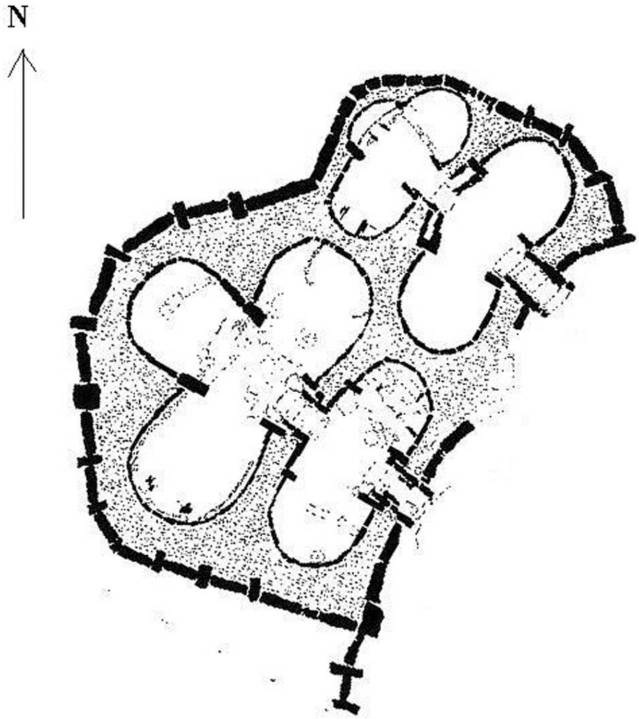


Figure 15.1: Plan of the ''twins'' Ggantija temple

Figure 15.2: A statuette found in the Xagra' circle near Ggantija, representing a couple of ''Goddesses'' (National Museum, Gozo).

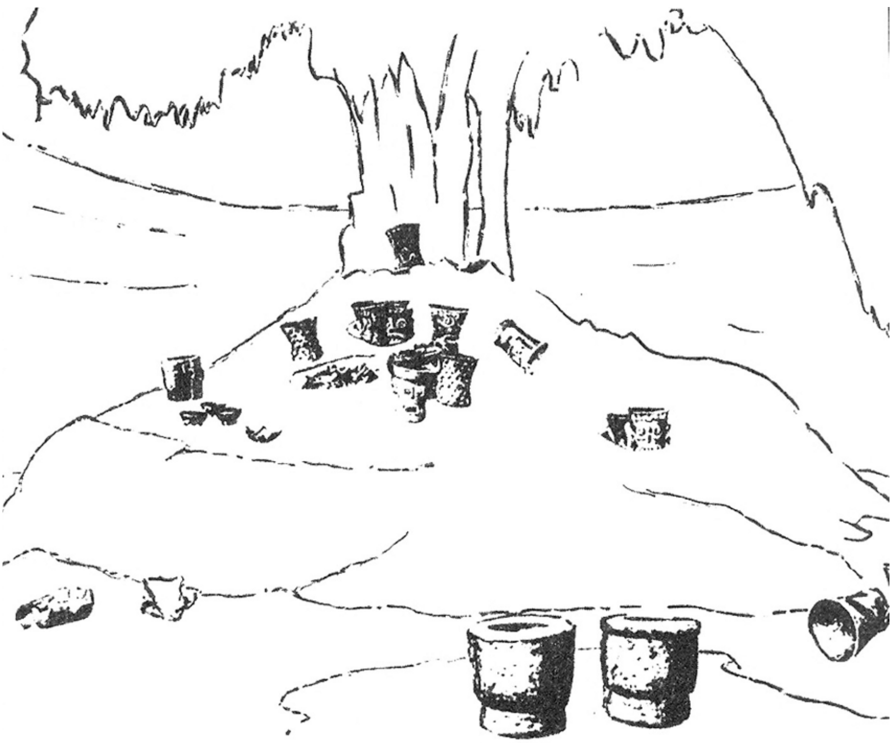


Figure 15.3: The Balamkamche' cave.

In 1959, a local guide, José Humberto Gomez, discovered a fake wall in a cave, which gave access to inner chambers, probably sealed off by Mayan priests since the time of the conquest in order to prevent its destruction. In the chambers there were (and still are) numerous ceramic vessels bearing depictions of the mask of the Rain God. The main room of the complex is occupied by a huge column created by the joining of a stalactite and a stalagmite. Myriad other stalactites hang from the ceiling, and the result is breathtaking; it feels like being in front of a stone tree, an *underground replica* of the Tree of the World. (I think that the tree also resembles a stylized Mayan profile.)

The earth is not only "mother" but also "death." In death one returns to the earth, and so we have an intrinsic duality in the earth symbolism. The caves and recesses are thus places of the spirits, of life after death. Admission to this underworld was through doors. In some cases, such as the Olmecs at Chalacatzingo, these doors were explicitly carved with the jaws of monsters; in other cases the appropriate places were the chambered cairns, rebirth incubators, designed to be part of the anthropomorphized landscape.

Megalithic monuments in Europe also most probably contained allusions to this duality, but it is difficult to be more specific than these somewhat superficial observations. For example, if the chambers at Newgrange and Maeshowe were simply tombs, their link with the solstice undoubtedly had something to do with the idea of the afterlife, but the details escape us. Yet, as already mentioned, it cannot be ruled out that the chambers were used for rituals, possibly of initiation, involving the living (remember that Maeshowe closes from the inside and Newgrange had a window). Stonehenge unquestionably plays a special role, being practically the sole true building constructed on the ground (i.e., not covered by a tumulus) out of the main architectural element of the megalithic builders, the trilithon. Many have made it out to be an actual temple dedicated to the Goddess, and its structure does lend itself vaguely to the interpretation that it could represent a vulva; the solstitial sun rises in rough alignment with the Heelstone and so the shadow of this stone passes along the monument's axis before giving way to the sun itself, although the accuracy of this jerophany is very poor and it was equally poor in the ancient past.

15.5 Power and Replica

We have now reached the main section, dare I say, the *navel,* of this book. The considerable astronomical knowledge of ancient civilizations that we learned about in the first part of the book, as well as the few interpretative notions that we have gleaned, all come into play. We are about to set off on a journey to a place and a time that I have jealously kept apart up to now. But first we have to seek the roots of this exasperating obsession with monuments, which drove so many peoples to erect such grandiose astronomically/correlated structures.

As we have seen, power was asserted by the ability to communicate with other levels, particularly the celestial and the subterranean, and by the ability to predict and hold sway over the cycles of nature, that is, imposing the *cosmic order*. The only event that this power was not capable of foreseeing was death. Thus, power had to somehow encompass the ability to communicate, control, and even "survive" after death.

Various mechanisms were employed to achieve this, from the divine status of the pharaoh in Egypt (a handy solution), to the ancestral mummy cult of the Incas, to the complicated and often painful rites of self-sacrifice that accompanied the investiture of Mayan sovereigns. But the frustrating two-dimensional quality of man persisted. For this reason there was the need for power to root itself explicitly at a human level, in a *monumental replica* of the celestial level—a replica that is often also the manifestation of power over death, possibly symbolized by a cycle of rebirth. Anyone contributing to this process, from the architect to the lowliest laborer, did not see himself as a slave, but considered it rather an honor (or sacred burden) to be identified with the sanctity associated with the work. Those who design or commission the building derive their power from the ability to replicate and control and offer eternal life, while those who carry out the building are more often than not motivated by the assurance this provides.

The result is that the landscape is modeled, modified, reconstructed, even created afresh, and becomes a sacred landscape (or "sacred space" in Eliade's terminology). It is a place where the religious content is a crucial element, but this content is mingled with and indistinguishable from the physical content. In particular, the knowledge—scientific, not superstitious—of the heavenly cycles is nearly always an essential ingredient of the sacred wisdom required to build a structure in which, consequently, the human and otherwordly planes are fused.

Here are some examples we came across in the first part:

1. The entire area of the gulf of Stenness in the Orkneys was conceived of as a stone replica of the natural landscape (Chapter 2). Each element of the landscape-replica was astronomically anchored, as was the chambered tomb of Maeshowe, oriented toward the winter solstice and erected in a place where the sun "rises twice."
2. The Maltese megalithic temples (Chapter 3) were earthly images of the body of the Goddess, destined to be fertilized by once a year by the solstitial sun.
3. The Emperor Qin, Son of Heaven, wished to have a replica of his army and perhaps his whole court in his grave (Chapter 5).
4. The huge Hopewell earthworks were created on the basis of astronomically anchored geometrical shapes, or they replicated, on the ground, living beings who may have represented constellations (Chapter 6).
5. Chaco Canyon was laid out on the basis of a complex framework of solar and lunar alignments. Chaco was also the exact center of an oriented road network, whose precise significance eludes us (Chapter 7).
6. Teotihuacan (Chapter 8) was intended to be a monumental replica of the landscape, and the surrounding mountains were copied in the two main pyramids. When the city was planned, the layout was anchored astronomically, by means of the complicated astronomical orientation of the urban axes.

7. Among the Mayas, the "celestial" basis of power and accession is clear at Palenque, where Pacal was entombed in the heart of a nine-tiered pyramid, a symbol of the nine levels of the afterworld, and where the solstitial sun legitimized the power of his successor annually (Chapter 9).
8. Cusco (Chapter 10) was created in between two rivers, in such a way that the town constituted (in an gigantic aerial image) the shape of a puma. The puma in turn was most likely an image, a replica of the heavenly puma. The four lines that divided the world into four sectors converged in the ideal center of the universe constituted by the Sun Temple and placed between its genitals.
9. The large zoomorphic geoglyphs of the Nasca plain (Chapter 11) were executed according to an overall scheme, whose structure has yet to be understood. The scheme had undoubtedly strong astronomical links, however.
10. Easter Island was literally overrun with hundreds of enormous anthropomorphic statues (Chapter 12). The statues seem to emerge from the stone of the Rano Raraku volcano and to be a replica of the volcano itself, as if it were a sleeping giant. We have no clue about the true significance of all this.

In many of these examples (from which you will notice that only Old-Kingdom Egypt is missing) astronomy plays a key role. In addition, particularly relevant is the case of the astronomical hierophanies, the phenomena whereby the sacred landscape is animated and the divine materializes in a sort of sacred machine set in motion in correspondence to a celestial cycle. We have discussed some spectacular mechanisms:

1. The niche at the end of the corridor in Newgrange is lit up by the solstitial sun, which filters through a specially placed window.
2. The statues in the chapel of the Abu Simbel temple are illuminated in succession one after the other by the sun on special days of the year.
3. At Palenque, a complex game of light and shadows recalls the death of Pacal and the accession to the throne of his son once a year on the day of the winter solstice.
4. A sophisticated combination of deftly created architectural effects brings to life the Plumed Serpent on the staircase of the pyramid of Chichen Itzà on the days near the spring equinox.

All in all, hopefully, a few things have become clearer. Of course, the best way to understand a model is to apply it in a new context and see if it produces consistent results. From this point of view, we are lucky:

historians, archaeologists, and Egyptologists, on the one hand, and pyramidologists, numerologists and archaeo nutcases, on the other, have competed up to a few years ago to preserve the mystery of the most fascinating and spectacular sacred landscape on planet Earth—a sacred landscape we are now going to visit together.

Appendix 1: The Sky with the Naked Eye

1.1 Measuring the Motion of Celestial Bodies

The earth rotates around its own axis in approximately 24 hours, and moves on an ellipse, with the sun at one focus, completing a revolution in approximately 365 days. When they are seen by a fixed observer on the surface of the moving earth (the only point of view that concerns us here), then, all heavenly bodies move.

If we extend the plane on which the earth moves around the sun, imagining we are cutting the celestial sphere, we can define a circle known as the *ecliptic*. The earth's axis is not perpendicular to the plane of the ecliptic, but is inclined about 23½ degrees with respect to it. This is thus the angle that the ecliptic forms with the *celestial equator*, that is, with the projection into the sky of the terrestrial equator. The inclination, or *obliquity*, of the ecliptic gives us the alternating seasons and is thus essential for life itself. (Over thousands of years it undergoes only slight variations). For us earthlings the ecliptic also represents the path of the sun in the course of the year in relation to the stars dotted around in the background.

If we imagine prolonging the terrestrial axis onto the celestial sphere, a point in the sky is identified that we call the celestial *pole* (north or south depending on the hemisphere of the observer; but to simplify matters, I shall refer only to the north pole). If we lower the perpendicular to the horizon from this point, geographical north can be determined. Once geographical north is known, two *coordinates*—that is, two numbers—are needed to determine the position of a star in the celestial sphere at any moment, just as longitude and latitude are needed to identify a point on the earth's surface. There are many *systems*, that is, pairs, of possible coordinates, but two pairs are fundamental. The most intuitive system, hence the one preferred in this book, is based on *azimuth* and *altitude*. Given a point *P*, whose coordinates

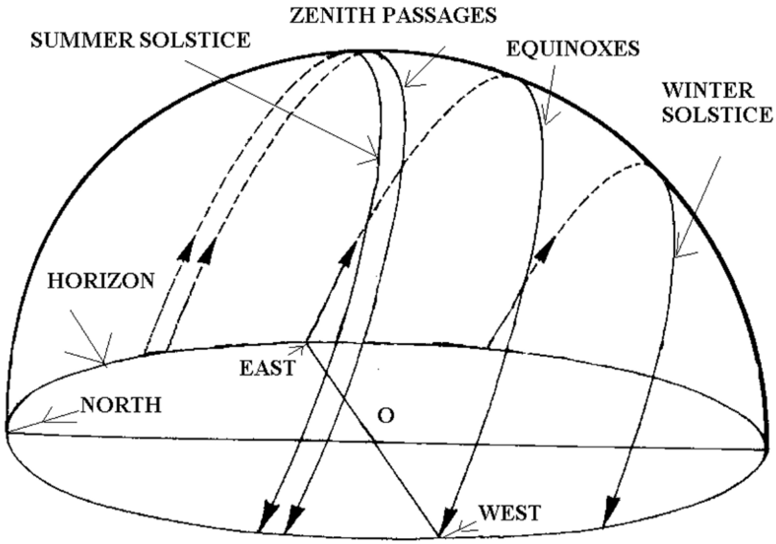


Figure A1.1: The path of the sun during the year, viewed by an observer at northern tropical latitude.

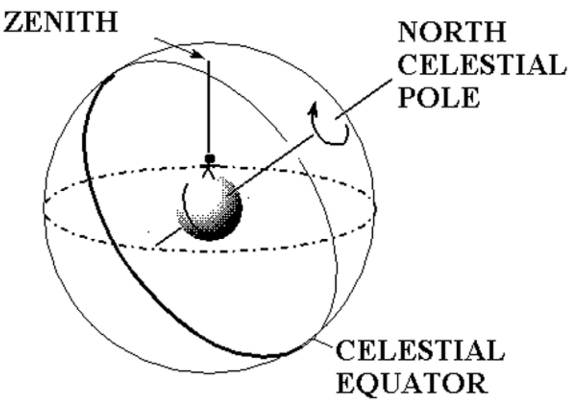


Figure A1.2: The north celestial pole

we wish to find, we imagine tracing the vertical plane that passes through this point. This plane intersects the horizon of the observer at point *A*; the *azimuth* is the angle between north and the point *A* on the horizon, counting positively from north to east, and the *altitude* is the angle measured on the vertical circle from *A* to *P* (in particular, the altitude reached by a star when it passes the celestial meridian, that is, the ideal projection of the observer's meridian into the sky, is called the *culmination*).

The second system of coordinates is easily understood if one imagines measuring the latitude and longitude of a point on the celestial sphere. The angular distance of the point from the celestial equator toward the pole gives the analogue of the latitude and is called the *declination*; the analogue of the longitude is called the *right ascension*, and it is measured from a point (the vernal equinox) along the celestial equator to the "hour circle," the maximal circle passing through the pole and the point.

1.2 The Sun

The movement we are most familiar with is that of our star, the sun. The sun rises at a certain point on the eastern horizon, varying each day; it makes an arc in the sky and sets at a certain point on the western horizon, varying each day, following a cycle that includes two extrema (also called *standstills*): a maximum one, a northernmost rising point, the *summer solstice*, and a minimum one, a southernmost rising point, the *winter solstice*. At these two rising points, the sun rises only once a year; at all the other points in between it rises *twice* a year. Twice a year the sun crosses the celestial equator and therefore has vanishing declination; these days are termed the *spring equinox* and the *autumn equinox*. The definition of the equinoxes in a *cultural*, therefore archaeoastronomical, context, is extremely delicate, however; see Ruggles (2005) for details. The motion of the rising point throughout the year is sinusoidal, very slow around the solstices and very fast around the equinoxes.

The Tropics are the two parallels, symmetrical with respect to the equator, that mark a belt outside of which the sun never passes to the *zenith,* that is, vertically above an observer's head at midday. Within the tropical belt, the sun passes to the zenith twice a year, the first after the spring equinox, and the second after the summer solstice; at the Tropics themselves the sun passes to the zenith on the same day as the summer solstice.

If we observe, for instance, the eastern horizon, day after day, from a fixed position, it is possible to identify and mark on the ground the directions in which the sun rises on the days of the zenith passages and the direction of the rising point at the day of the summer solstice. The naked eye is assisted in this type of measurement by "foresighting," that is, observing the star with an instrument interposed, which might be a finger, a stake, a cross-staff, or a fork. Once markers have been set out on the ground indicating the various directions on the horizon—stones, for instance—the corresponding positions of the sun can be deduced and subsequent positions can be forecast. The measurements will be more accurate if the alignments are long, and for this reason, to achieve greater precision, it is better to adjust the position of the observer in order to use, for the desired alignment, a marker located on the horizon (for example, a far-off mountain peak or a notch).

1.3 The Moon

The way the observer on earth sees the motion of the moon is quite complicated. The moon rises in the east and sets in the west with a cycle similar to that of the sun over the course of a year, that is, with one extreme located north of east and the other, symmetrical, south of east, a cycle that only lasts 27.2 days, though. So we talk about northern and southern lunar standstills, similar to the two solstices. The *lunar phases* depend on the fact that an observer on the earth only sees the part of the visible face of the moon that is illuminated by the sun. The cycle of the phases is completed in 29½ days. The ideal plane that contains the earth and the orbit of the moon is inclined by about 5 degrees (5 degrees and 9 arc minutes) compared to the plane of the ecliptic (the two intersection points of the orbit of the moon with the ecliptic are called *nodes*). This fact has extremely important consequences. Indeed, there would be many *eclipses*, periods of time when the moon is located between the earth and the sun, obscuring the latter, or the earth is between the sun and the moon, obscuring the latter. On the contrary, since eclipses occur when the three points are aligned, they can

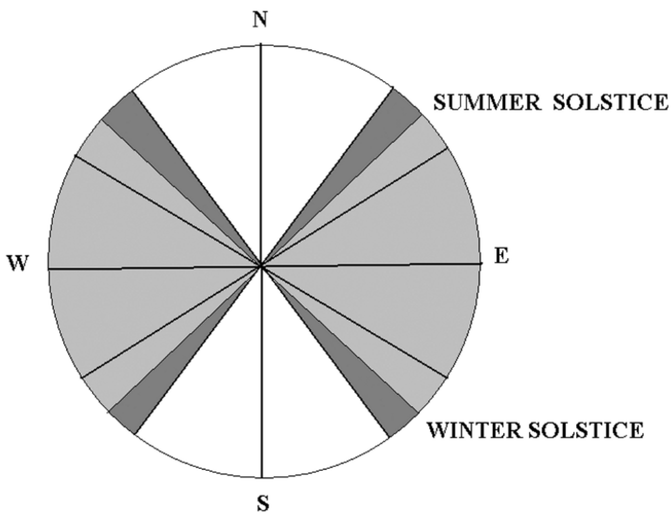


Figure A1.3: The rising-setting azimuths of the moon at the two standstills (heavy solid lines) compared with those of the sun.

only take place in the vicinity of one of the nodes. Eclipses thus follow cycles that can be studied, enabling future predictions to be made (see Aveni 2001 for a complete discussion of the subject).

As a result of various factors that would take too long to go into, the node line of the moon revolves clockwise in relation to the moon, completing a cycle every 18.61 years. Thanks to this phenomenon, lunar standstills, unlike their solar counterparts, are subject to an oscillation, whose complete cycle lasts 18.61 years. During this cycle the azimuths of the northern lunar standstills fluctuate between a maximum that is further north than the summer solstice and a minimum that is further south than this, and a symmetrical situation occurs for the southern lunar standstills. Accordingly, we talk about north and south *major and minor lunar standstills*. A slight effect called *wobbling*, with a cycle of 173 days, also causes the position of the lunar standstills to oscillate slightly by approximately 9 arc minutes.

1.4 The Planets

The motion of the planets is simple: they move along ellipses of which the sun occupies one of the focuses. This, however, is what an observer from outside the solar system would see. We are on one of the planets, and so what we see of the motion of the others depends on this limited position of ours. The inner planets, that is, those between us and the sun, Mercury and Venus, seem to swing back and forth in the vicinity of the sun. Venus is by far the most brilliant body in the sky after the sun and the moon. The time it

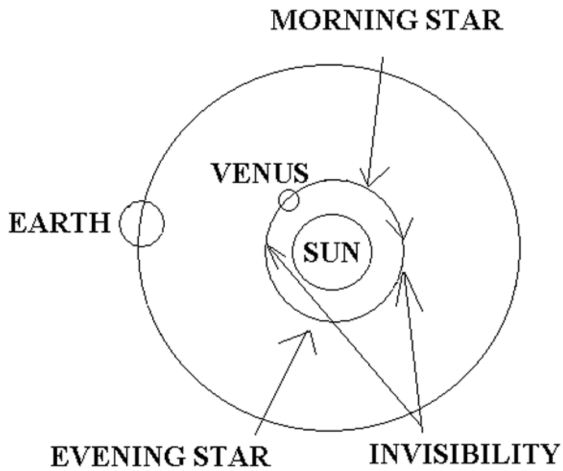


Figure A1.4: Visibility/invisibility of Venus

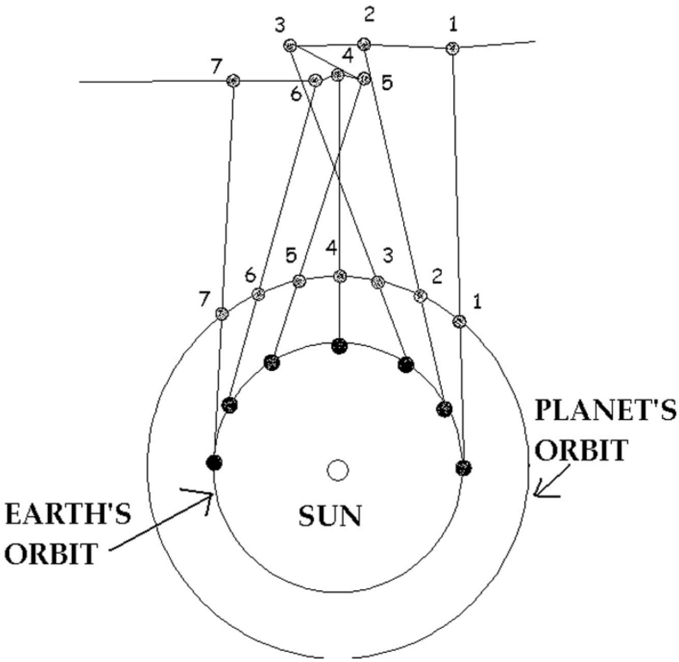


Figure A1.5: The apparent retrograde motion of an exterior planet as seen from the earth

takes Venus to make a complete revolution around the sun (sidereal period) is 225 days, but clearly the earth also revolves around the sun, so from our viewpoint the planet reappears in the same configuration relatively to the sun after a much longer (synodic) period of 584 days. During each cycle, Venus, which gives the impression of swinging like a pendulum, disappears from sight ("behind" the sun) for about 8 weeks, to then reappear as the Evening Star, visible in the west immediately after sunset; then it disappears from sight ("in front of" the sun), to then reappear as the Morning Star. The motion of the other inner planet, Mercury, is similar to that of Venus.

The motion of the outer planets that are visible to the naked eye, Mars, Jupiter, and Saturn (Uranus is right at the limit of visibility with the naked eye and does not seem to have been observed in antiquity) is characterized by a phenomenon known as *retrograde motion*. This refers to the fact that from time to time the earth "overtakes" a planet, with the result that the latter seems to go backward in relation to the stars, to then resume its normal path.

As far as the observation of rising and setting on the horizon are concerned, the planets follow a cycle similar to that of the sun, whose extremes, however—as happens with the moon—vary between two positions, maximum and minimum, both in the north and the south.

1.5 The Stars

Given that we are on the earth and the earth revolves on its axis, we see the stars rotating around the celestial pole (north in the Northern Hemisphere and south in the Southern Hemisphere). The movement of the stars is rigid; that is, the relative distance between the stars remains constant (only a few stars break this rule—Sirius, for example—in that they have a significant *proper motion*; however, their movement in relation to other stars is in any case extremely slow with respect to the human life span and appreciable only in the course of many millennia). The stars situated sufficiently near the pole never set and are termed *circumpolar*. The stars sufficiently near the *opposite* pole to that of the observer never rise, and hence are never visible. The visible portion of the heavenly vault thus depends on the position of the observer. Furthermore, it depends on the day of the year. In fact, on certain days a certain star may only be visible during the hours of sunlight, thus effectively being invisible due to the presence of the sunlight. The *heliacal rising* of a star takes place on the first day on which it becomes visible again, for a brief moment, rising immediately before the sun on the eastern horizon. Circumpolar stars are visible every day of the year.

Since time immemorial, humans have mentally joined up the bright dots of the stars in order to form stylized patterns or figures, the *constellations*. All the constellations of the ecliptic taken together are called the *Zodiac*. The constellations of the ecliptic are those that form a background to the motion of the sun as seen from the earth, and thus the sun "shifts" from one constellation to another in the course of the year.

Many constellations were identified as such in ancient times, times in which there was no distinction between astronomy and astrology; it is a beautiful thing that scientists continue to use a language dating from such far-off times; indeed, the traditional names of the constellations are commonly used in astronomy and are used throughout this book too. But please bear in mind that today's so-called astrology, the kind you find in magazine articles about making predictions, while using the same terminology, has absolutely nothing to do with science and, therefore, with reality.

It is fundamental to emphasize that, generally speaking, different constellations were identified in different places and times. This is partly due to the fact that different constellations can be seen from different

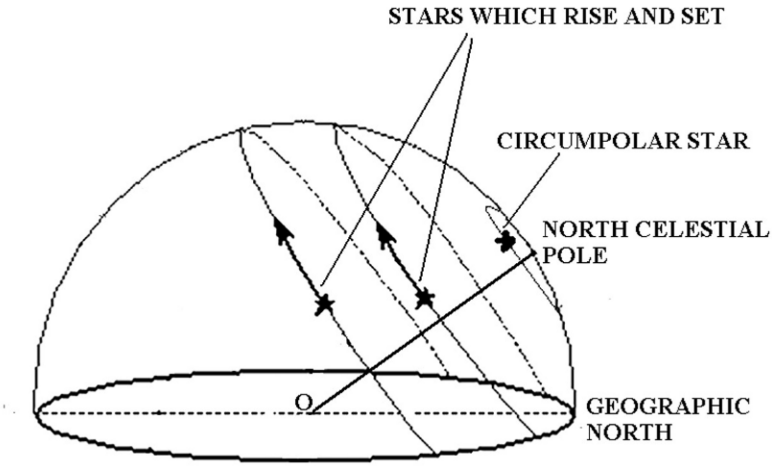


Figure A1.6: The motion of the stars visible from an observer in point O.

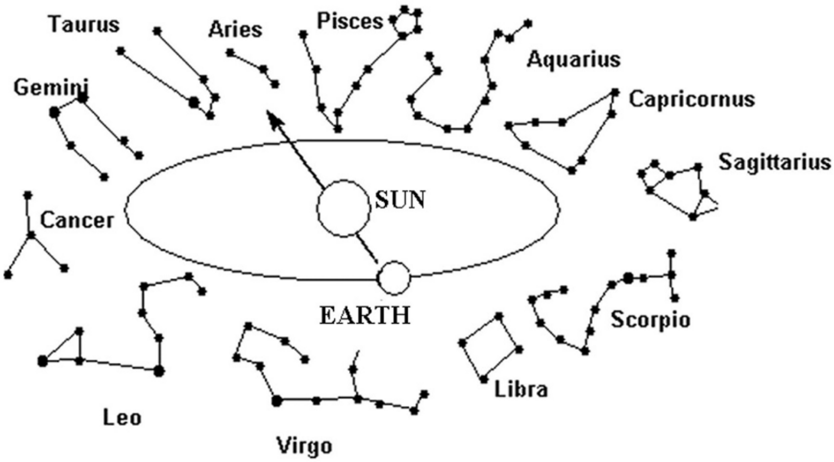


Figure A1.7: The rising sun as seen from the earth in the ''background'' of the zodiacal constellations during the year.

latitudes, but also to the fact that cultural ideas and mental associations vary considerably from people to people. For instance, the Egyptians saw a Hippopotamus in our Draco constellation, the Mayans saw two peccaries (hogs) in our Gemini constellation, and the Minoans did not distinguish between Sirius and Orion, identifying the combination as a two-edged ax, with Sirius at its base.

By convention, each star is given a name, consisting of a progressive Greek letter plus the name (or abbreviation of name) of the corresponding constellation, separated by a hyphen. Many stars, however, have their own individual names. Thus *alpha-Canis Major* is Sirius, *beta-Ori* is Rigel, and so on. The stars are not all equidistant from us. Yet we are unable to appreciate the sheer depth of the heavenly vault and we tend to see the sky as a spherical, two-dimensional surface. The only things we are able to distinguish clearly are varying degrees of brightness, and there are a few dozen exceptionally bright stars. The most brilliant by far is Sirius, followed by *alpha-carinae* (Canopus), *alpha-centauri*, *alpha-bootes* (Arcturus), *alpha-lyrae* (Vega), and *alpha-aurigae* (Capella).

The practical problems one faces in carrying out precise observations of the sky with the naked eye are beyond the scope of this appendix. I shall merely say that there are a number of factors (apart from the more mundane atmospheric and light pollution), such as parallax and atmospheric refraction, that affect the results of measurements and must be taken into account.

1.6 The Milky Way

The sun belongs to a very common category of star—the "main sequence"—and there exist billions and billions of very similar stars. Stars are grouped into galaxies, systems usually extremely "squashed," in the shape of a disk, made up of billions of stars rotating around a central nucleus. The sun is no exception to the rule, and is situated at a certain point of one of these disks. We who dwell on an insignificant planet orbiting around an insignificant star belonging to an insignificant galaxy—call it the Milky Way. Because we are *inside* it, and because it is shaped like a disk, we see it as narrow band of diffused luminosity traversing the sky. Since its luminosity is diffuse, the Milky Way is not clearly visible when pollution or artificial light is present, whereas its presence becomes quite striking and spectacular if the night sky is clear and we are viewing it from a very dark area.

1.7 The Precessional Motion of the Earth's Axis

All the heavenly phenomena I have mentioned so far can be appreciated from one day to the next, or at least within timeframes of months (for example, the sun moves between the two solstices in 6 months), years (for example, the cycle of Venus), or at most a few dozen years (for example, the cycle of lunar standstills). There is, however, another phenomenon that evolves over times that are much longer than the average human life: precession.

The earth, like all rigid bodies, is subject to three rotational movements. The first is the revolution around its axis in 24 hours. The earth's axis, however, rotates around the perpendicular to the ecliptic, completing a revolution every 25,776 years, and it also undergoes a slight "swing." These two movements are known as *precession* and *nutation,* respectively. The effects of nutation are negligible for the purposes of archaeoastronomy, while knowledge of precession is essential for reconstructing the skies as ancient peoples saw them. To visualize the precessional motion of the earth, the easiest way is to arm oneself with a spinning top (preferably a real one, or else a simulation program on a PC), place one end on the floor, and watch its movement after spinning it and leaving it with a certain inclination with respect to the vertical. It can be seen that the axis of the top, just like the earth's axis, begins to circle around the vertical while the top spins around the axis.

Precession has a significant effect on the observation of heavenly bodies, an effect that is extremely slow in terms of the human life span, though. First, the North Pole shifts against the background of the stars. In fact the North Pole is none other than the ideal intersection between the prolongation of the earth's axis and the heavenly sphere. Since the axis describes a cone, the pole describes what we see (or rather would see, if the change were not so slow as to be almost imperceptible) as a circumference (not quite closed in reality, owing to certain perturbations, which I shall not go into). It should be stressed that it is not the background of stars that move, but the polar axis that points to different regions of the sky; what we call the Pole Star, for instance, is the star that the heavenly north pole is near today.

Just as the North Pole shifts, so too does the South Pole, and this results in some constellations being, at certain times, completely invisible from a certain latitude (because they are too far south) and then becoming visible again with the passing of time. It is evident at this point that precession also has an effect on the apparent motion of all the other stars, which vary, in particular, in terms of azimuth of the rising point and altitude at the meridian. On the other hand, precession has no effect on the apparent motion of the sun and, in particular, on its solstitial points, which are only subject to a small displacement (appreciable over thousands of years) due to the slight variation that the plane of the ecliptic is subject to.

The effect of precession on the zodiacal constellations, that is, the constellations that the sun has "as a backdrop," can be visualized as a slow rotation of the backdrop itself; since there are 12 zodiacal constellations, if

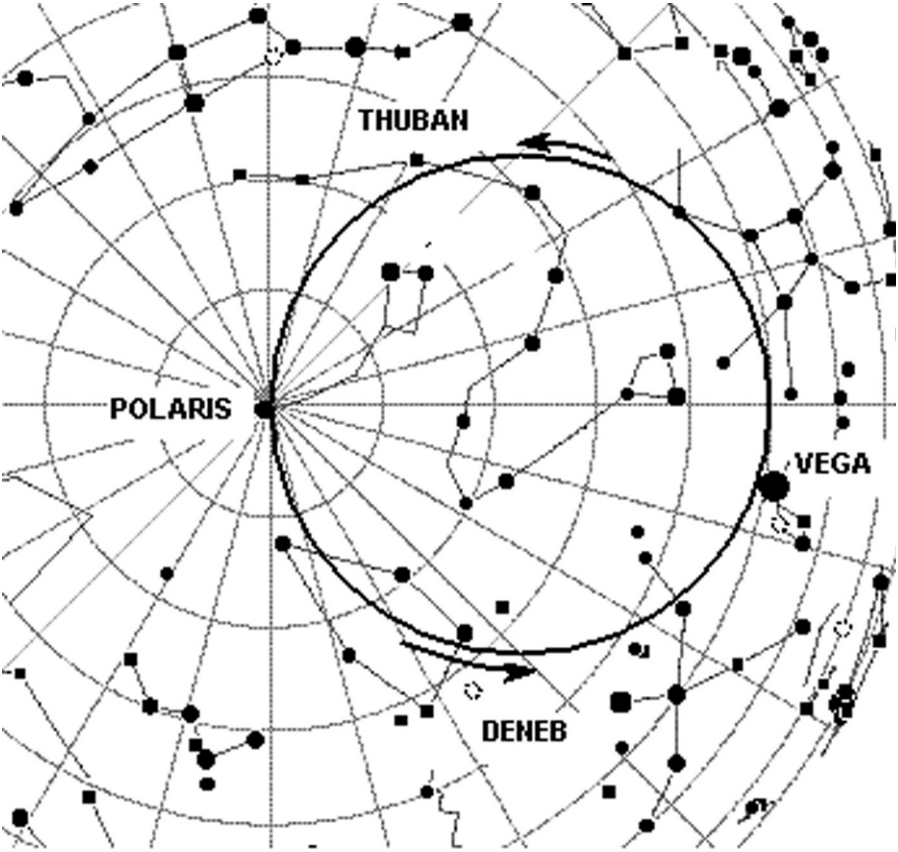
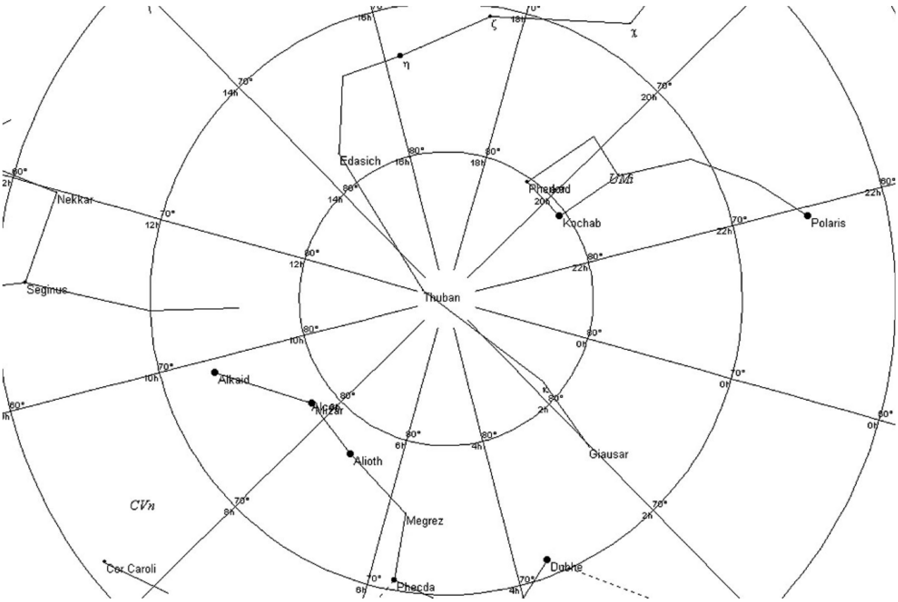


Figure A1.8: The path of the north pole with respect to the stars, due to the precessional cycle

the sun rises against ("in") a particular constellation on a particular day of the year, after about 2200 years (25,776 years of precessional cycle divided by 12, the number of zodiacal constellations, gives 2148 years), it will rise on the same day in the background of the constellation located to the left of the original one. In particular, the constellation against the background of which the sun rises at the vernal equinox defines what is usually called a "zodiacal age" (currently we are at the end of the Age of Pisces and passing into the Age of Aquarius). Once again, however, I stress that we are speaking here of a well-defined, very slow but observable physical phenomenon using a traditional terminology; curiously, the so-called signs of the zodiac used in horoscopes, which (according to modern astrologers) should enable our destinies to be forecast, are actually well out-of-date, exactly because of precession.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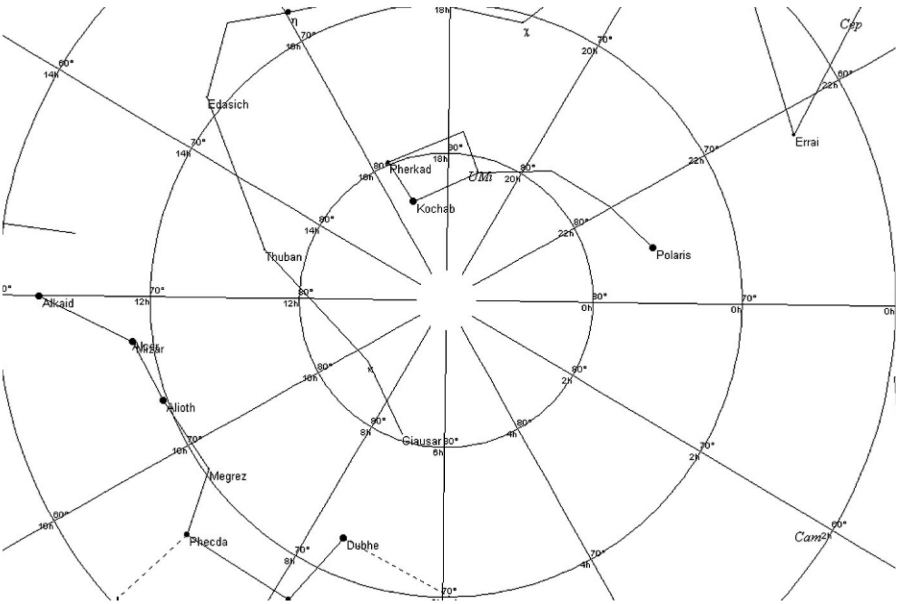
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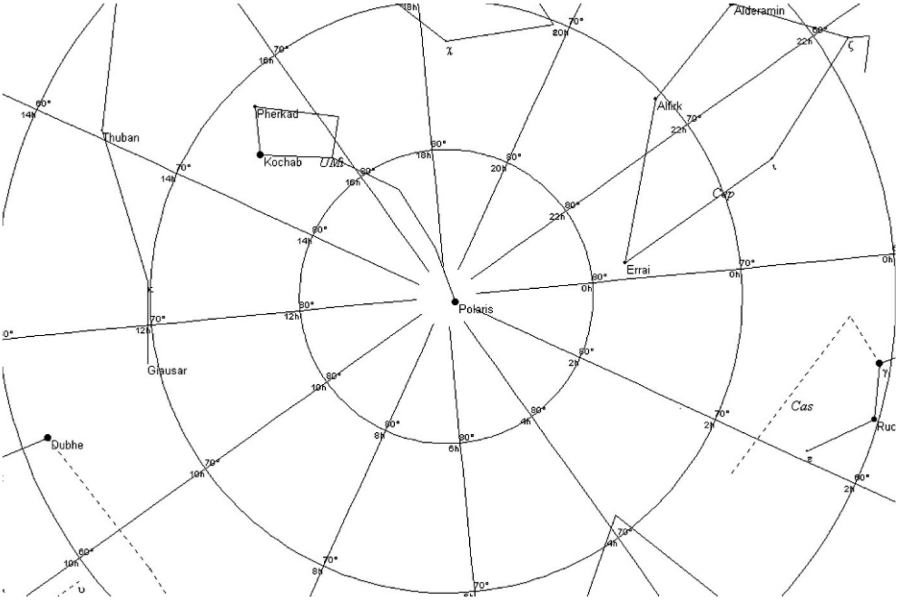

Figure A1.9/10/11: The position of the north celestial pole with respect to the stars in 2500 BC (there is a ''pole star'', Thuban); in the Roman times (no pole star), today (there is again a pole star, Polaris)

1.8 Making Measures in Archaeoastronomy Fieldwork

To make any kind of measure in archaeoastronomy, it is in principle advisable always to use a surveyor transit, which enables measuring azimuths and the corresponding altitudes at the horizon with an optimal accuracy (within 1 arc minute or less). There are times when the accuracy required in archaeoastronomical studies must be very high, such as when ancient monuments were oriented with astonishing accuracy, for example, the pyramids of Giza, or when they exhibit perfectly conserved and measurable architectural features, as with many Greek temples (for the practical use of the transit in archaeoastronomy, see Aveni 2001). However, in many situations the careful use of a very simple, hand-held instrument, such as a combined *clinometer* (to measure altitudes) and magnetic compass, may suffice (for further discussion, see Belmonte and Hoskin 2002, Hoskin 2001). To use the magnetic compass properly, it is important to remember that the earth acts like a magnet. Therefore, an iron needle rotating freely on the earth's surface points toward the poles of this magnet, in a direction called *magnetic north*. While geographical north (sometimes called true north in this context) is defined invariably by the projection of the earth's axis into the sky, magnetic north depends on a number of factors, and although it may chance to coincide with true north, it generally varies according to the place one is in, as well as the time. The magnetic compass, therefore, gives an indication of the direction north, which has to be corrected by using (readily available) *magnetic declination* values; further, *magnetic anomalies*, which are special geological features of the site (or the presence of modern iron gates in temples) have to be taken into account.

Appendix 2: Moving Large Stone Blocks in Ancient Times

In ancient times, the most colossal, bulkiest stone blocks imaginable were excavated, transported, carved, and then laid in place. The sight of these gigantic megaliths astounded visitors in the past, and even today one cannot but be dumbfounded by feats that seem to stretch human ability to, if not beyond, the limit. Up to now, however, insufficient research, and particularly fieldwork, has been carried out on the methods employed. The situation is further complicated by the fact that ancient peoples have handed down very little information on their techniques; and besides, such information as we have has often been interpreted wrongly.

The classic, much quoted, example is the fresco found in the tomb of Djehutihotep in Bercia, Egypt. Djehutihotep, who lived in c. 1900 BC, commissioned a huge statue, in sitting position, and the fresco symbolizes its transport. If we trust the artist who painted the scene and assume that the statue and the men dragging it are represented on the same scale, then the statue must have been about 7 meters tall and weighed 70 tons (if the material was limestone; if it was hard stone, then the weight could have been much greater). The monolith is being dragged along on a sled by 172 people, while an assistant is pouring a liquid, possibly oil, in front of the sled to reduce friction, I believe, although some authors have suggested that a ceremonial act was taking place (Heizer 1990). In any case, with or without the oil, it is obvious that 172 people cannot pull a weight of 70 tons, and I also think that this was obvious to the artist depicting the scene, who was simply "filling up space" with groups of people dragging to give the idea that there were many of them, as did the artist who painted the battle scene at Kadesh found in the temple of Rameses II at Abu Simbel, where the pharaoh is seen fighting against a lot of enemy chariots. The difference is that, while nobody would try calculating the number of Hittite chariots deployed in the battle of Kadesh by counting them one by one in Ramses II's frescoes, many authors have stated that the Bercia painting demonstrates how easy it was for less than 200 men to move 70 tons of statue . . .

To start with I think it advisable to divide the problem of transporting and

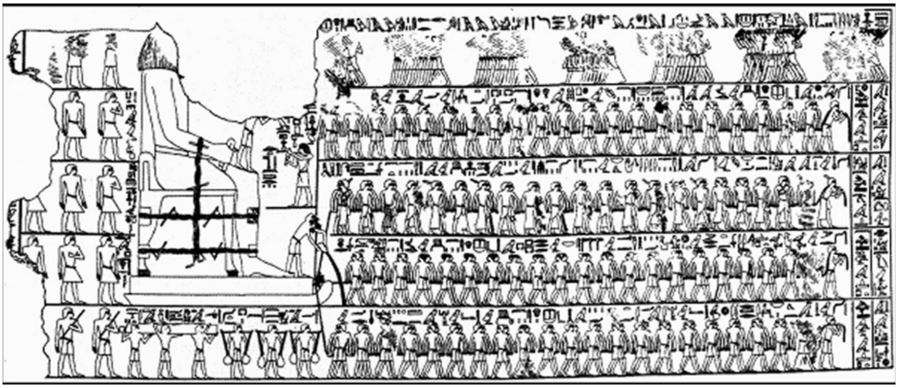

Figure A2.1: The transport of the colossal statue of Djehutihotep

erecting huge masses with human labor (though the whole scenario could easily be readjusted to fit animal traction) into three distinct categories, depending on the weight involved.

The first category—*standard problems*—would cover weights of up to 10–15 tons. Here we are dealing with what would be standard work for well-trained, motivated, and skilled teams of laborers. This category would include the majority of the blocks for the pyramids of Giza; the stones used by the Incas in square-block walls; the Easter Island "standard" statues (about 12 tons); the granite slabs used for the temples at Giza (up to 15 tons); almost all the megaliths of Mycenaean, Hittite, and central Italy polygonal walls; and the stones used in the great monuments of Minorca and Malta.

The second category—*large problems*—would include loads of up to about 90 tons. Falling into this category would be the Sarsen stones of Stonehenge, the granite slabs covering the relieving chambers of the Great Pyramid, many blocks making up the Sacsahuaman at Cusco, and the architraves of the Mycenaean tombs.

The third category—*mega problems*—covers loads of between 100 and 400 tons. This would include the Great Menhir and other megaliths of Carnac (350 tons), the limestone blocks used in the Khafre and Menkaure temples (up to 250 tons each), many Egyptian obelisks of the New Kingdom (between 200 and 400 tons), and several dozen blocks used in Sacsahuaman (300 tons).

There are, finally, a very few instances in which even heavier loads were transported: these include the so-called Colossi of Memnon (giant statues of the pharaoh Amenhotep III at Luxor, near the Valley of the Kings, weighing up to around 600 tons), and some of the blocks used in building the Temple of Baalbeck in the Lebanon (believed to have been built by the Romans or possibly the Phoenicians) of similar weight.

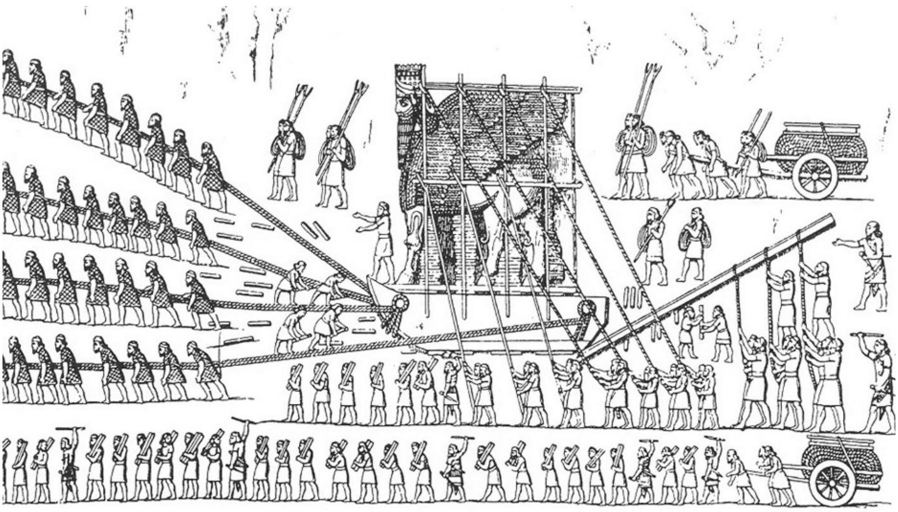

Figure A2.2: Transport of a huge Human-head Bull, from an Assyrian relief

Before proceeding, it might be sensible to try to get an idea of the modern scale involved here. An average-sized car weighs about a ton. A giraffe crane (the ones you often see in city building sites) can lift up to 15 tons, though not without difficulty. For loads of up to 90 tons, massive self-propelled telescopic cranes are used—a relatively common sight. Greater loads, however, are usually only lifted by overhead-traveling cranes (commonly yellow in color), the type often seen in the docks. Normal giraffe cranes need counterweights and self-propelled cranes need to be heavily weighted at their bases. But overhead-traveling cranes (whose load is basically "hung" from a moving girder) exploit the resistance of the girder. It follows then that this type of load is usually moved on fixed paths fitted with rails (for example, between two areas of a steelworks, or between pier and freighter). A famous example of such cranes is the pair called *Samson and Goliath*, in a dock in Belfast, Northern Ireland. Each crane can lift loads of up to 840 tons; thus, they would certainly be capable—but only just—of moving Memnon's Colossi for a few hundred meters.

Moving one-off extra-large loads a distance is, even today, a tricky matter that strong financial or social reasons would have to justify. A recent example of a case where the transport of an outsized load of this kind came close to failure is the Italian submarine *Toti*, weighing 450 tons, 46 meters long, and 4.75 meters wide. The submarine, after finishing active service in 1999, was towed by river to Cremona without any mishaps. It was then supposed to proceed by land to Milan, where it was to be displayed in the Science and Technology Museum, situated in the city center (the decision to display an instrument of war in a science museum which welcomes very young children was in itself questionable in my view, though fortunately the submarine, built in the 1950s, was never involved in any kind of combat). After long deliberation, it was decided to drop the costly Herculean task of moving the monster as it was, since there was also the risk that the road would give way under the massive weight, and so the *Toti* ended its career somewhat ingloriously in Milan's sewers. To transport the huge object to the final destination, the Milan City Council decided it was necessary to perform some plastic surgery, removing over 100 tons of ballast and other weight and sawing through the conning tower to remove it and make the monster more manageable. Finally, stripped of its splendor and mounted on a specially designed truck, the *Toti* crossed the city miraculously, with an articulated truck in the rear guard mournfully carrying the sawn-off conning tower and with the backup of a steel gantry crane belonging to the military engineers, just in case.

Let us now try to gain more of an insight into the problem by looking at the force F that is necessary to apply to a load of weight P to drag it up a ramp with friction coefficient μ and inclination α. By doing a simple calculation of elementary physics, this formula comes out as $F = P(\mu \cos \alpha + \sin \alpha)$. In practice, however, the angles of inclination of the ramp are always very small and hence $\cos \alpha$ can be taken equal to one and $\sin \alpha$ approximately equal to α. Assuming that a man can move T kilograms, and letting $F = NT$, we can obtain the required number of men with the final formula $N = (P/T)(\mu + \alpha)$. Thus the number of men is directly proportional to the weight to be moved and to the sum of μ and α, which one needs to make as small as possible. To make it clearer with an example, if we assume that a man can move $T = 30$ kg (it should be remembered that it is not like lifting a weight just for a moment as one does in a gym, so this is a reasonable estimate) and that a method is used that reduces friction to a minimum (by pouring oil on the ramp, for example), estimating the friction coefficient to be 1/5, we obtain for transport on flat ground: $N = P/150$ (P in kilograms). So it takes less than 20 men to move a block of 2½ tons (2500 kg), that is, one of the two million standard blocks used in the Great Pyramid (quite a reasonable result that shows that to solve a "category 1" problem of, say, 15 tons, about 100 men were required on flat ground). We have to add all those who did ancillary work, such as checking the smooth running of the sleds, keeping the teams in rhythm, feeding and watering the workers, and so on. Any time it was necessary to cross an irregular terrain, the number of men pulling would have to be increased substantially (for example, on a ramp with a gradient of 1/10 we would obtain approximately $N = P/100$).

When the weight to be moved begins to increase appreciably, normally the size of the object in question will also increase, as will problems of finding sufficiently resistant ropes—to say nothing of the logistics of coordinating a large number of men and making enough space for pulling the object. Yet I believe that as long as the weight is kept below a certain threshold (which might be reckoned to be in the region of 80 to 100 tons), we can assume that the degree of difficulty is still proportional to the load being shifted. In other words, it is quite reasonable to suppose that our formula is still fully valid. For example, to pull one of the Stonehenge Sarsen stones weighing 50 tons, we would require about 330 men, which sounds quite plausible.

The laws of physics are indifferent to the problems of mere mortals, and hence our formula continues to be valid, in principle, for any load to be moved. If we wish to move a 300-ton block, we would need *at least* 2000 men. But it is not quite so simple. In fact, even if the formula says 2000 men pulling together would move the block, it does not say how to arrange a sufficient number of ropes for tugging, or how to get everyone to pull at the same time, and it takes for granted that you have enough physical space for performing the maneuver and that the block will go where you want it to rather than where *it* wants to.

Even with more moderate loads, a larger number of men would be needed than those predicted by the formula. For instance, we have ethnological reports on the erection of some small monoliths on the island of Sumba, Indonesia, where megalithic monuments are still being put up today, which confirm this fact. These accounts show that a whole village contributes to the erection of a monolith, with hundreds of men working together at the same time, each with his own task to carry out (families save up for years to be able to sponsor the creation of a monument in honor of a dead relative). I tend to think, therefore, that the difficulties involved in transporting excessive loads are much greater than they might appear on paper, and so I must disagree with Robert Heizer (1990), one of the acknowledged experts in the field, who stated: "If a man can complete, with the help of simple tools and techniques, a quantity X of work per day, then 100 men can complete a quantity of work equivalent to 100 X".

To summarize, I believe it is impossible to come up with a magic formula to explain how enormously complex technical difficulties were solved in the past. The only way of really understanding it is to study each problem individually, as indeed is the case today when faced with projects of exceptional difficulty.

Interesting hints might come from those transportation and construction problems that the ancients did *not* solve. Think, for example, of the unfinished Moai on Easter Island, or the unfinished obelisk, an enormous monolith that cracked during the excavation stage and was abandoned in a quarry at Aswan, or the most massive monolith ever shaped by men, a block some 30 meters long weighing more than 1100 metric tons, which lies in the stone quarry of the Baalbeck temples. In other cases, however, as we have seen, the puzzle has been solved. The simplest case to consider might be that of the great Egyptian obelisks, for example, that of Thutmose III, today standing in Rome, in Piazza S. Giovanni in Laterano, which weighs approximately 420 tons.

Obelisks were excavated in wide areas in the open air on the banks of the Nile. They were hewn out of the rock by immensely patient stonecutters, who used stone hammers for this long, drawn-out work (they may also have employed wooden wedges, inserted under the blocks and then dampened with water to make them expand, though the use of this technique has been documented with certainty only in Roman times), and then dragged onto huge barges. When the Nile flood level rose sufficiently, the barges floated up and their journey could begin. With this technique, which ingeniously exploited the river and the force of gravity, the Egyptians probably managed to move not just obelisks, but also enormous blocks, such as those required for the Colossi of Memnon.

Another important example is that of the Incas. Thanks to important studies by J. Pierre Protzen (1985, 1993), we have fairly good knowledge of

Figure A2.3: The Colossi of Memnon

the techniques adopted by Incan workers when megalithic blocks of *standard* weight (up to 10–15 tons) were quarried and moved. Protzen successfully performed some experimental tests showing how the blocks could be carved until they fitted together perfectly, using stone hammers of various sizes. But we cannot automatically attribute the same techniques and the same solutions to the construction of the gigantic Incan walls, such as those in Sacsahuaman, in Cusco, since no modern experimental testing has ever been done with even remotely comparable weights. For instance, it is quite difficult to imagine that blocks weighing up to 300 tons could be lifted and lowered the innumerable times that would have been necessary to obtain the perfect Incan joints.

It is to be hoped that in the future a systematic analysis on the extraction and erection techniques used in the past, specifically in erecting the great megaliths, will be carried out. Any such analysis will only be successful, I believe, if as much consideration is accorded to the human aspect as to the technical aspect, using, therefore, the same approach to the past that is typical of the scientific discipline we have been dealing with in this book.

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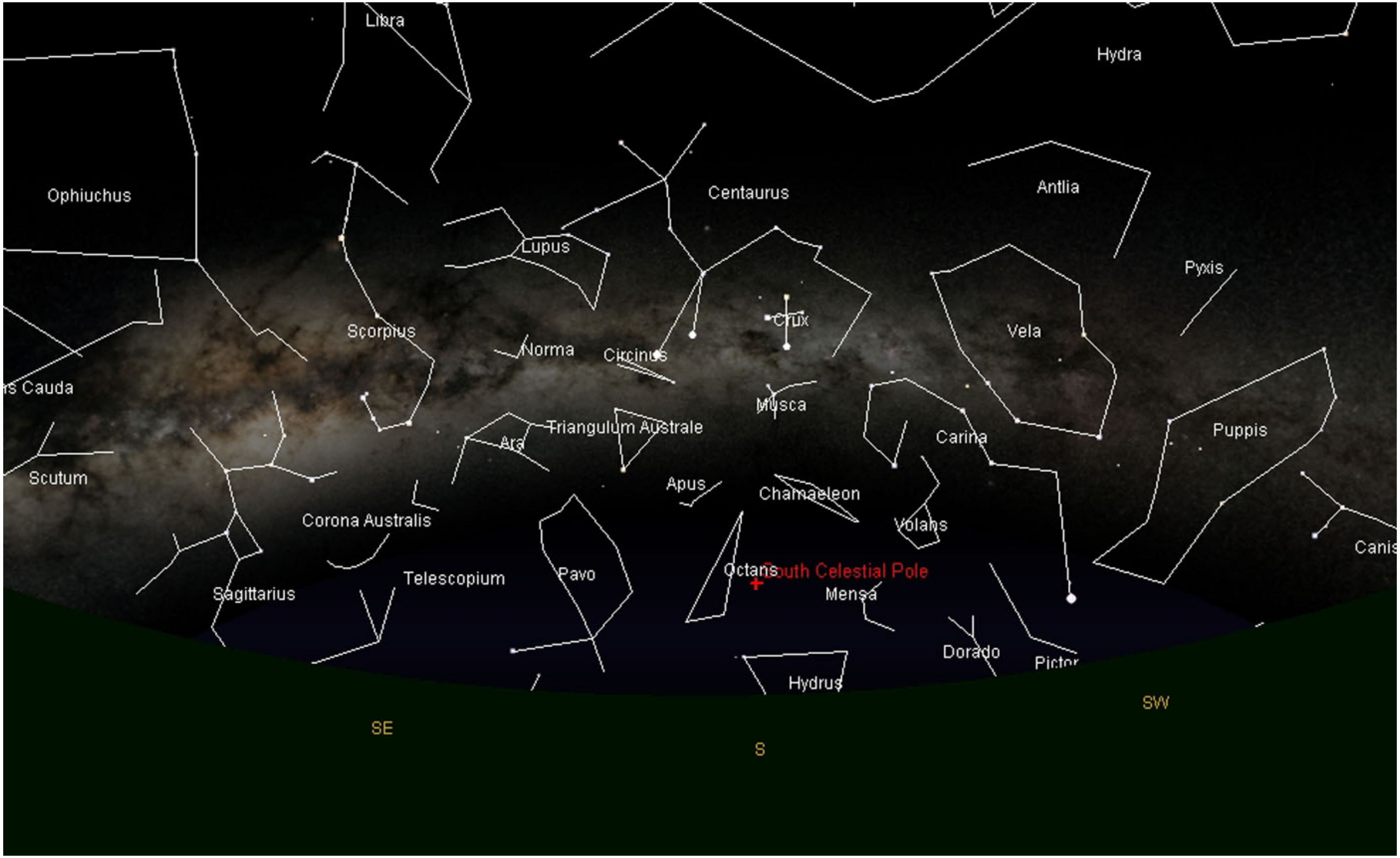

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