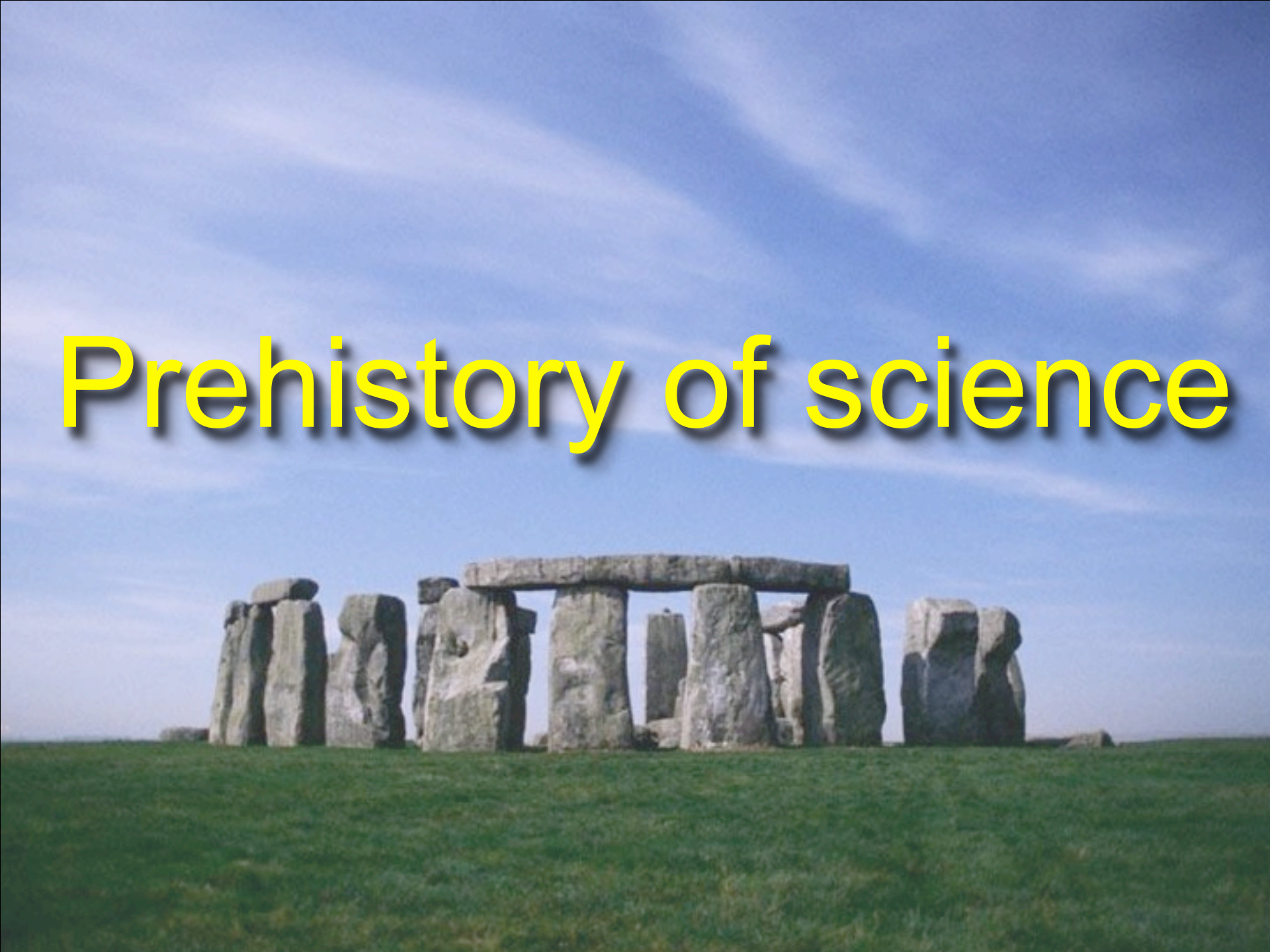
Prehistory of science

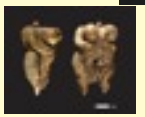


”When did science begin?... It began whenever and wherever men tried to solve the innumerable problems of life. The first solutions were mere expedients, but that must do for a beginning. Gradually the expedients would be compared, generalized, rationalized, simplified, interrelated, integrated; the texture of science would be slowly woven. The first solutions were petty and awkward but what of it? A *Sequoia gigantea* two inches high may not be very conspicuous, but it is a *Sequoia* all the same. It might be claimed that one cannot speak of science at all as long as a certain degree of abstraction has not been reached, but who will measure that degree? When the first mathematician recognized that there was something in common between three palm trees and three donkeys, how abstract was his thought?...”

George Sarton, *A History of science*, vol.1

George Sarton

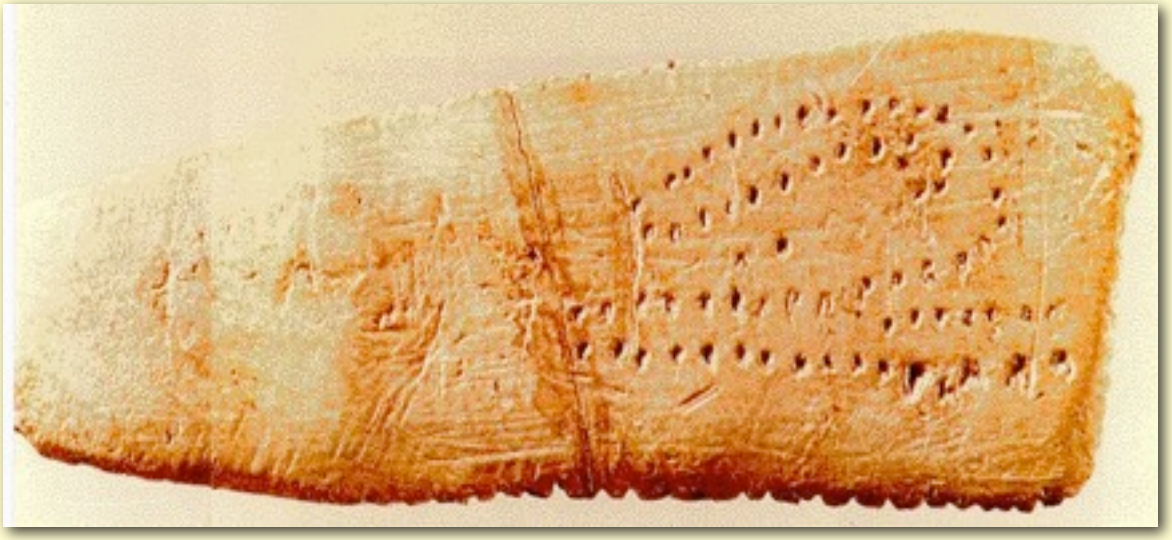
UPPER PALAEOLITHIC	Millenium B.C.
Mousterian	XL
Chatelperronian	XXXV
Aurignacian	XXX
Perigordian	XXV
Solutrean	XVIII
Magdalenian	XV
MESOLITHIC	~ VIII
NEOLITHIC	VII Near East IV Western Europe III America II China



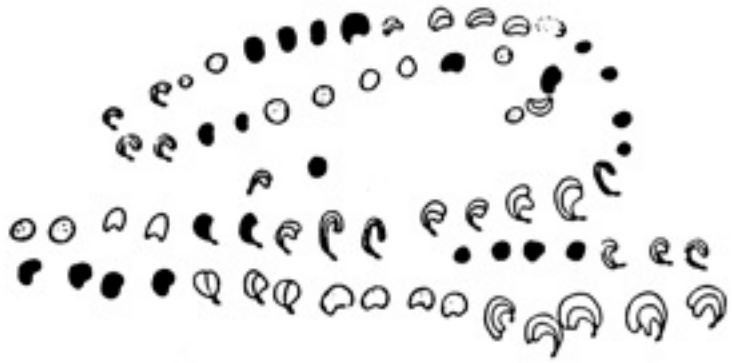


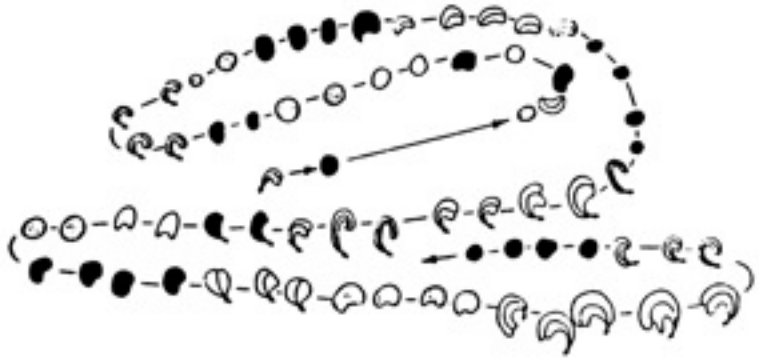
The oldest scientific artifact?

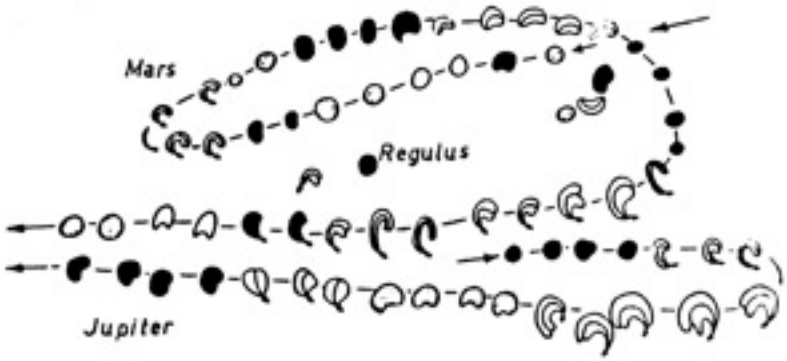


Blanchard bone (XXXth millenium B.C.)

Studied by Alexander Marshack
The Roots of Civilization (1972)

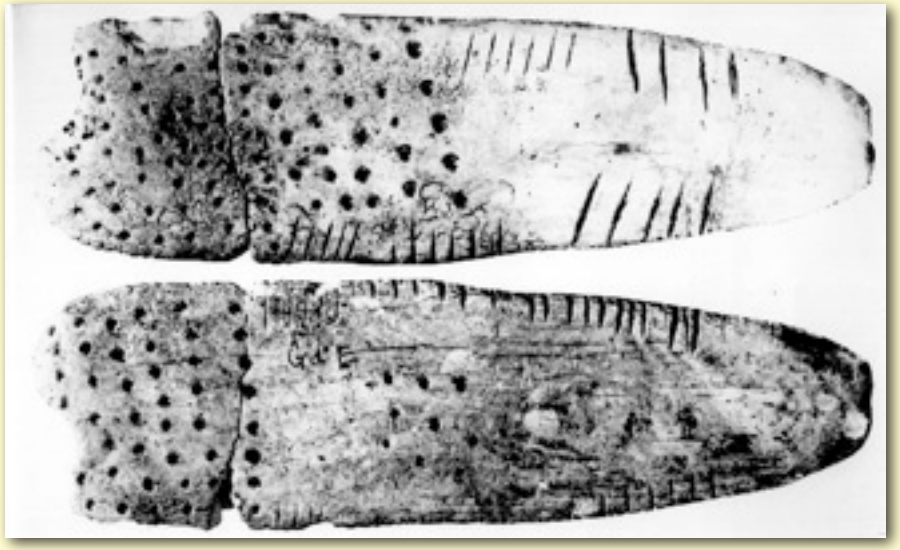






Marshack's interpretation

Kuijk's interpretation



Lartet bone
(XXXth millenium B.C.)

Laussel ”Venus”
(XXVth millenium
B.C.)

Le Placard bone
XVth millenium B.C.

Ishango bone
older than 20,000 B.C.?

The oldest cave paintings !

Chauvet-Pont d'Arc (Ardèche) - discovered in 1994
XXXVth - XXXth millenium B.C. (results published in April 2016)

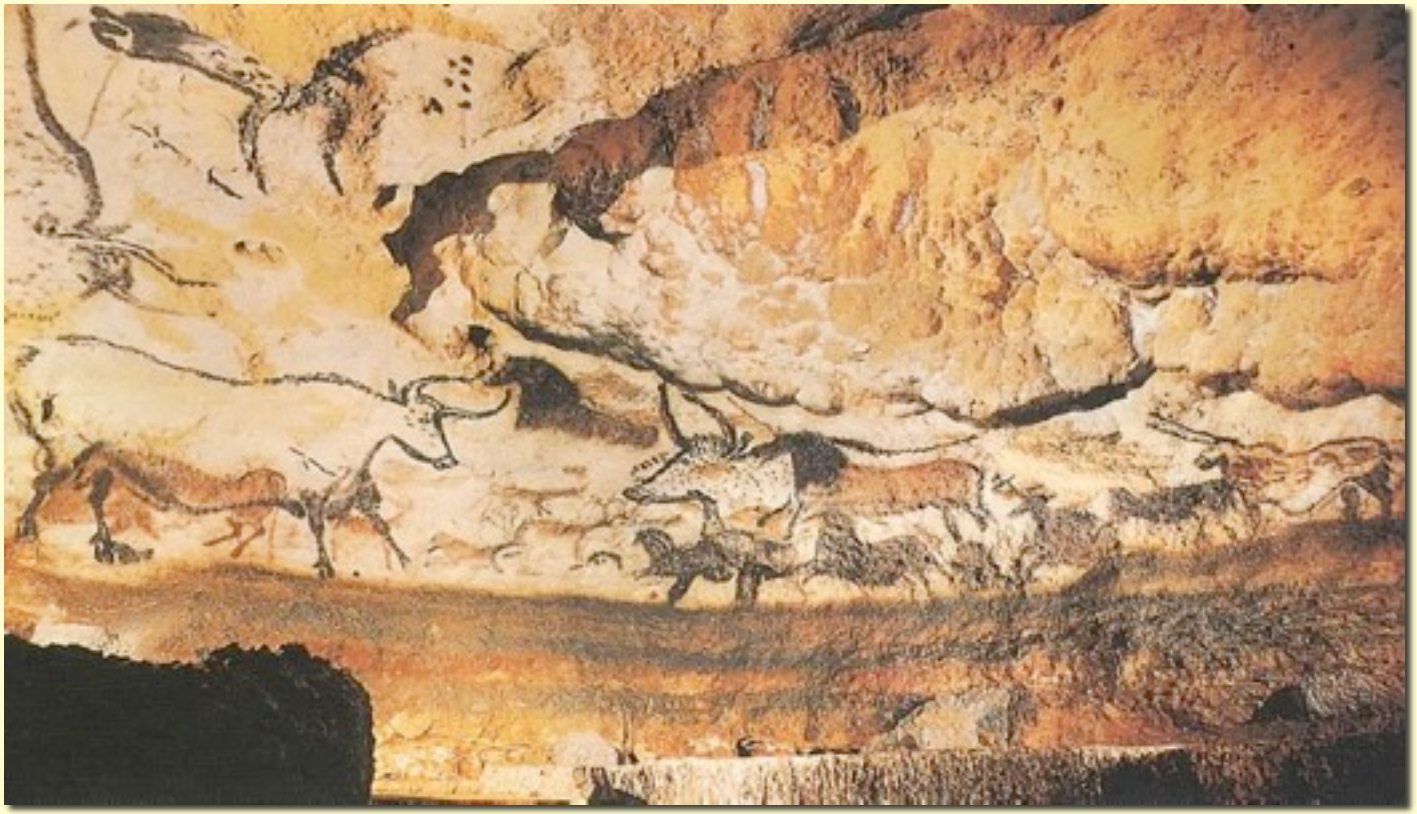
Niaux
ca. 12,000 B.C.

Lascaux
ca. 15,000 B.C.

Lascaux

Altamira

What was the function of cave paintings ?



What was the function of cave painting ?

The symbols found
in cave painting

(André Leroi-Gourhan, 1964)

A ”school” ?
Instruction for hunters ?
Sympathetic magic ?
An ”art gallery” ?

”...magic rests everywhere on two fundamental principles: first, that like produces like, effect resembling cause; second, that things which have once been in contact continue ever afterwards to act on each other. The former principle may be called the Law of Similarity; the latter, that of Contact or Contagion... Practices based on the Law of Similarity may be termed Homoeopathic Magic; those based on the Law of Contact or Contagion, Contagious Magic. Both derive, in the final analysis, from a false conception of natural law.”

James George Frazer, *The Golden Bough*

”What is usually called magic, and often dismissed as primitive and abortive science, is also a pragmatically important cultural force.
A careful study of the contextual influence of magic would reveal first and foremost that magic never encroaches on the technique or subject matter of practical work. Whenever in a culture full technical control has been achieved over certain processes, magic never enters into the manipulation of such processes. Thus, for instance, magic never occurs in fire-making, in the production of stone implements, in the making of pottery, in cooking, in cleaning, or in washing...
But in any type of activity where chance and uncontrollable forces are likely to upset human reckoning, magic invariably comes in. Thus in war and courtship, in pursuits dependent on rain and drought, wind and tide, we have inevitably magical beliefs and ritual.”

Bronisław Malinowski,
The Dynamics of Culture Change

Music was practised by humans since very ancient times

In 2004 a flute made of a mammoth bone was discovered during excavations in a cave near Ulm in Germany. Radiocarbon dating gave about 30,000 B.C.

Music was practised by humans since very ancient times

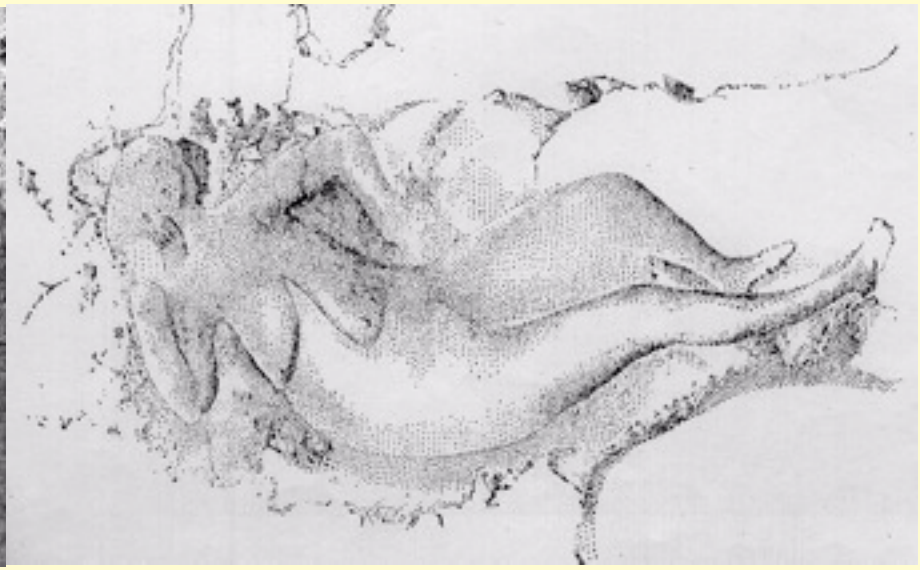
In 2009 a flute made of a griffon vulture bone was discovered during excavations at Hohle Fels Cave in south-west Germany. Radiocarbon dating gave about 40,000 B.C.

The oldest ”Venus” from the Hohle Fels Cave in South-West Germany

At least 35,000 years old according to the new radiocarbon dating, thus about 10,000 years older than ”Venus from Willendorf”

”Venus” from La Magdelaine

(XVth millenium B.C.)



Francisco Goya

The naked Maja (1797)

Let us squeeze the last 36,500 years to 1 year
(in this scale 1 day ≃ 100 years)

Oldest flute, oldest figurine	1st week of January
Chauvet cave paintings	2nd week of January
Blanchard bone	1st week of February
Lascaux paintings	end of June
Great Pyramid (Cheops)	14 XI
Aristotle	7 XII, morning
Almagest by Ptolemy	13 XII, afternoon
De revolutionibus by Copernicus	27 XII, 6 p.m.
Principia by Newton	28 XII, 4 p.m.
Maxwell's theory	30 XII, noon
Special relativity theory	30 XII, 9 p.m.
Quantum mechanics	31 XII, 2 a.m.
Apollo 11 landing on the moon	31 XII, 1 p.m.

”Primitive” humans
who lived about a thousand
generations ago
were rational beings
and possessed quite sublime
notion of beauty, although
their knowledge of the world
was still poor

Irrigation, metallurgy, potter's wheel, wheeled cart, plough, lever, sail, balance, writing

3000

Old Sumerian period

Gilgamesh

Menes

Imhotep,
Snofru, Cheops

The Old Kingdom

Stonehenge I
great pyramids

Stonehenge II, III

2000

Old Babylonian period

Hammurabi
Ammizaduga

Middle Assyrian period

The Middle Kingdom

The New Kingdom
Tutankhamen

Hsia ?

Shang

Rig-Veda

1000

New Assyrian period

Ashurbanipal
Chaldean dynasty

ALEXANDER THE GREAT

Chou

Confucius

Ch'in

Han

Homer

foundation of Rome

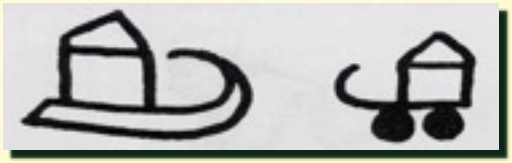
Thales

Aristotle

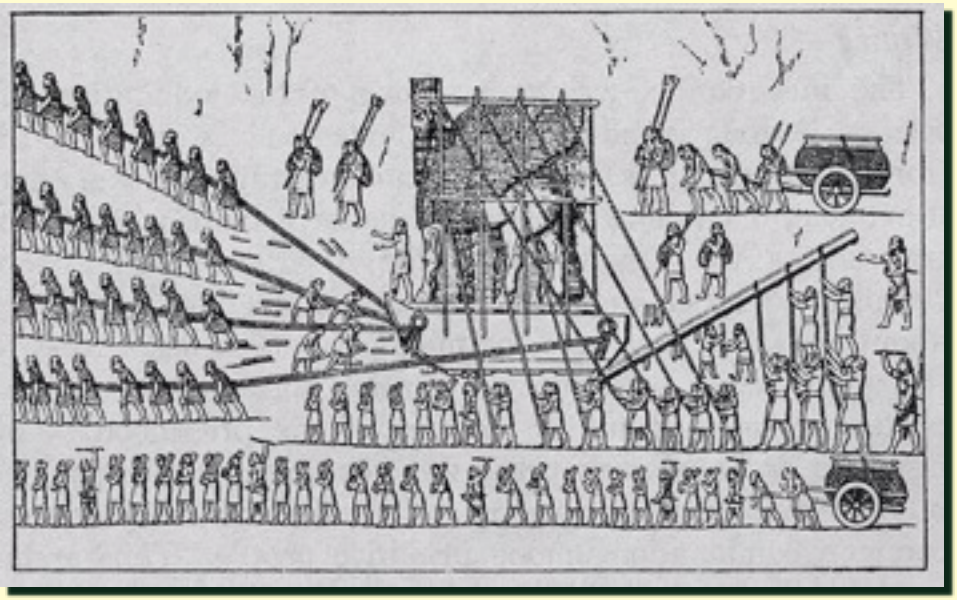
Caesar

–1
+1

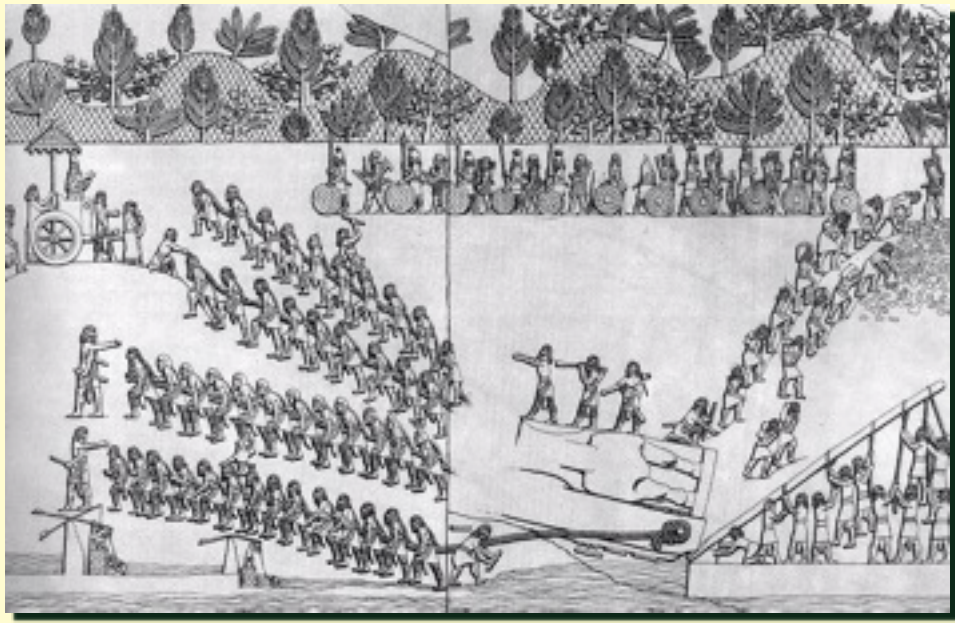
Transport and machines in Antiquity



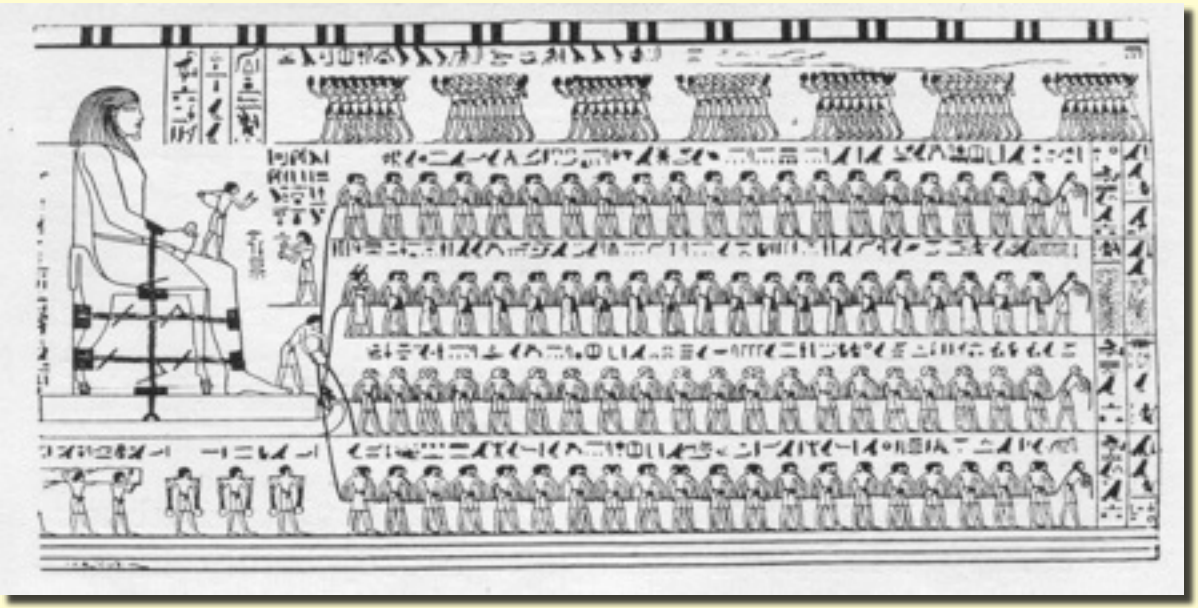
Uruk ca. 3500 B.C.



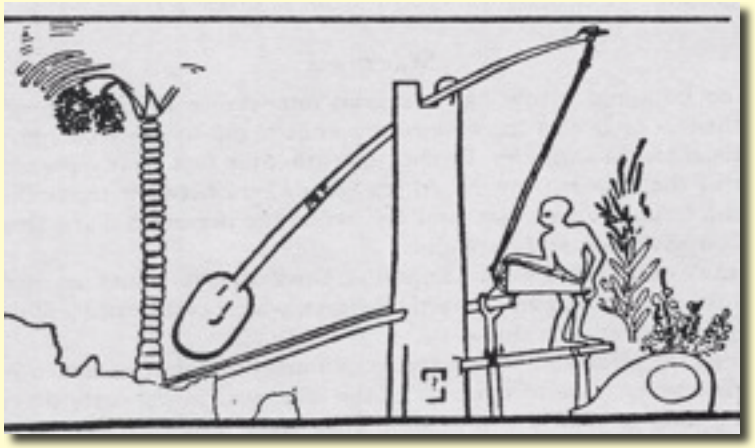
Nineveh 8th century B.C.



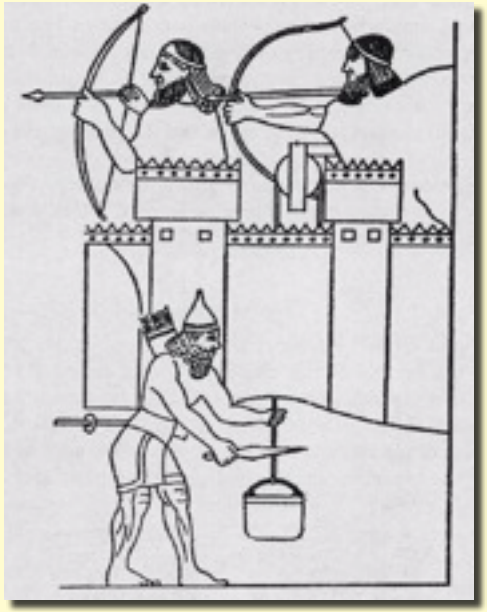
Transport and machines in Antiquity



Transport of a statue
(12th dynasty,
ca. 1900 B.C.)

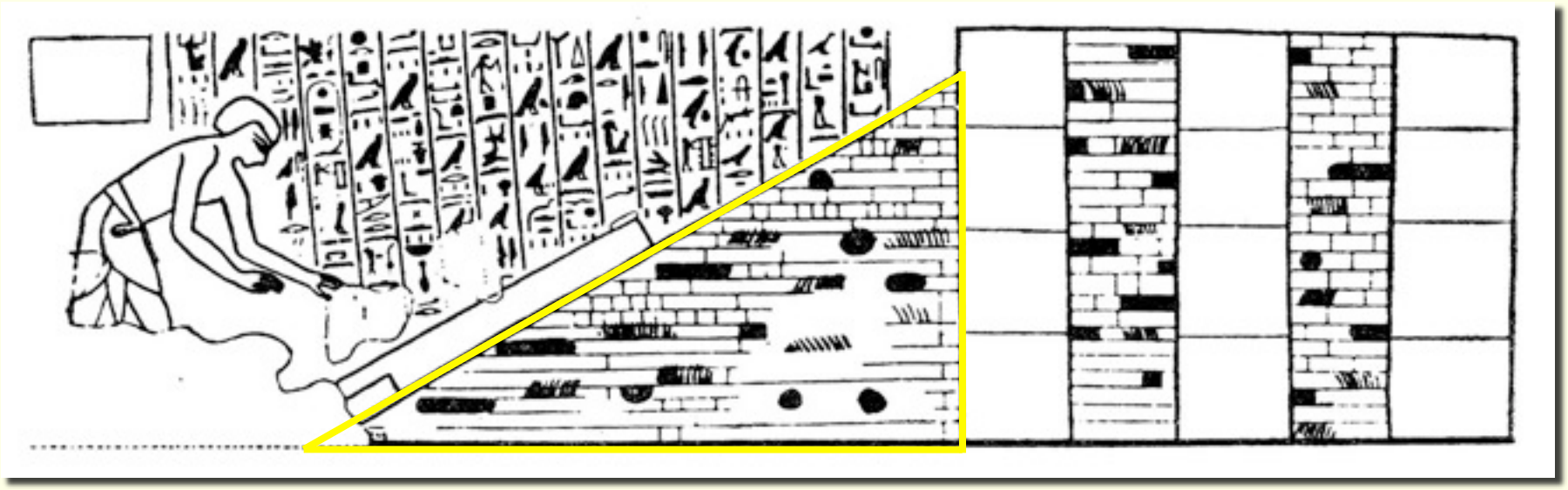


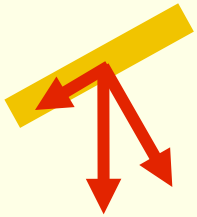
Crane (12th dynasty, ca. 1500 B.C.)



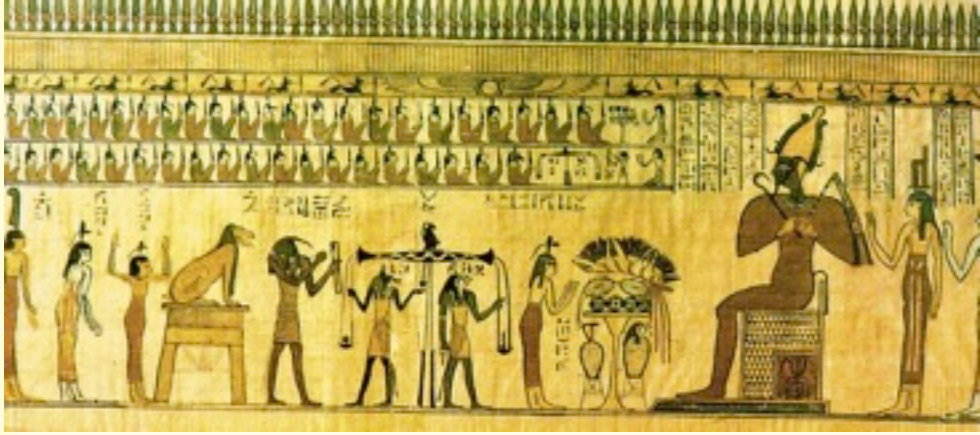
Pulley, Assyria
(8th century B.C.)

Drawing of a fresco from the tomb of vizier Rekhmire (XVIIIth dynasty, ca. 1500 B.C.)





Sailing ship (ca. 2400 B.C.)



Balance (ca. 1350 B.C.)

Siphon (ca. 1450 B.C.)

All female musical trio
(18th Dynasty, ca. 1420 B.C.)

Pyramids in Egypt

Step pyramid of Zoser
(3rd Dynasty)
ca. 2700 B.C.

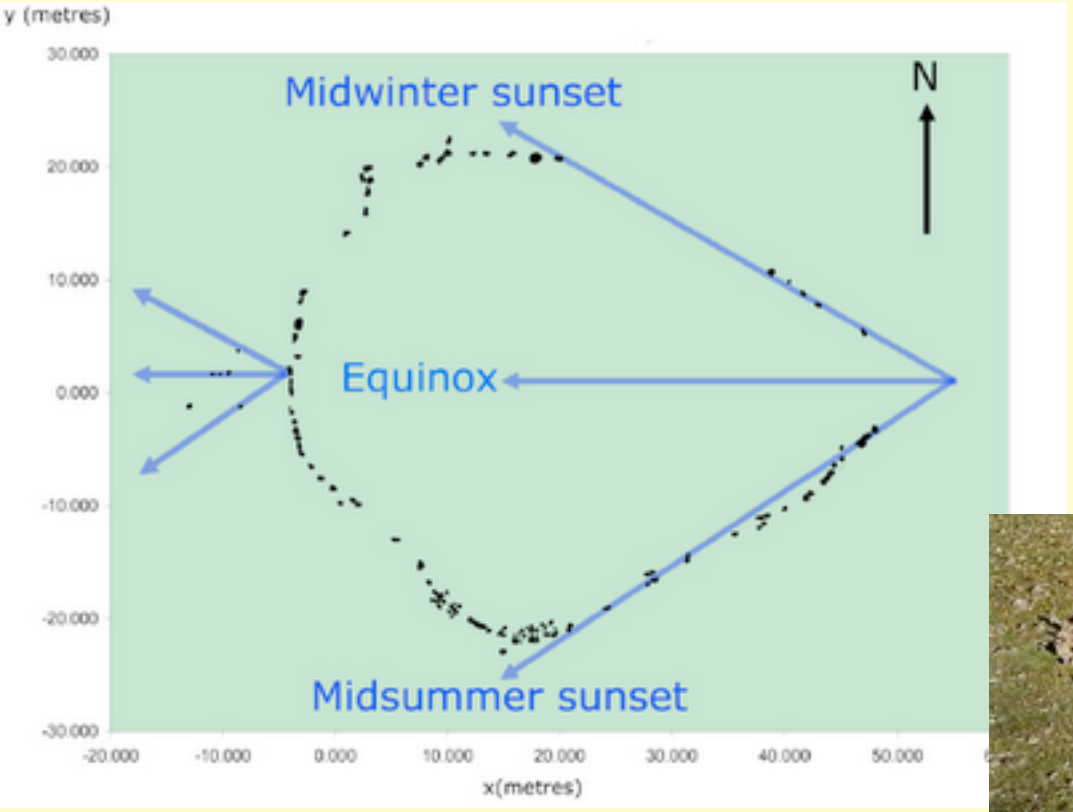
Pyramids in Gizah (4th Dynasty)
ca. 2600 B.C.

Orientation of the Great Pyramid (Chufu)

S wall	1'57" S from W
N wall	2'28" S from W
W wall	2'30" W from N
E wall	5'30" W from N

Walls: 230.453; 230.255; 230.359; 230.392 meters

”Horizontal” astronomy



Wurdi Young
Australia

Other examples: Carnac (Brittany), Avebury and Callanish (Great Britain), Namoratunga (Kenia), Sarmizegetuza (Romania), Majorville (Alberta, Canada), Big Horn Medicine Wheel (Wyoming, USA)

”Horizontal” astronomy

Big Horn Medicine Wheel
(Wyoming, USA)

Callanish, Scotland

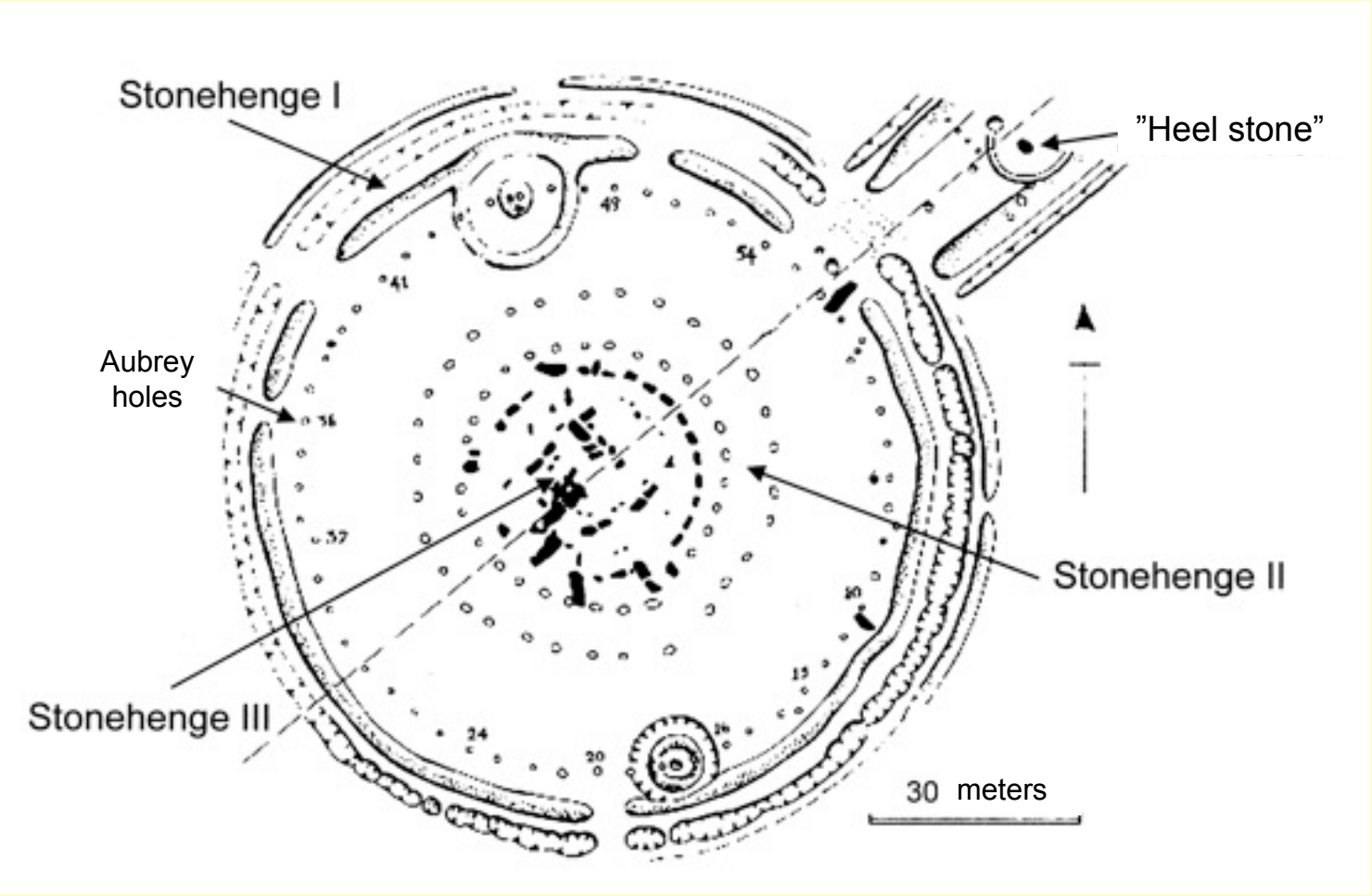
Carnac,
Britanny, France

Other examples: Avebury (Great Britain), Namoratunga (Kenia), Sarmizegetuza (Romania), Majorville (Alberta, Canada), ...

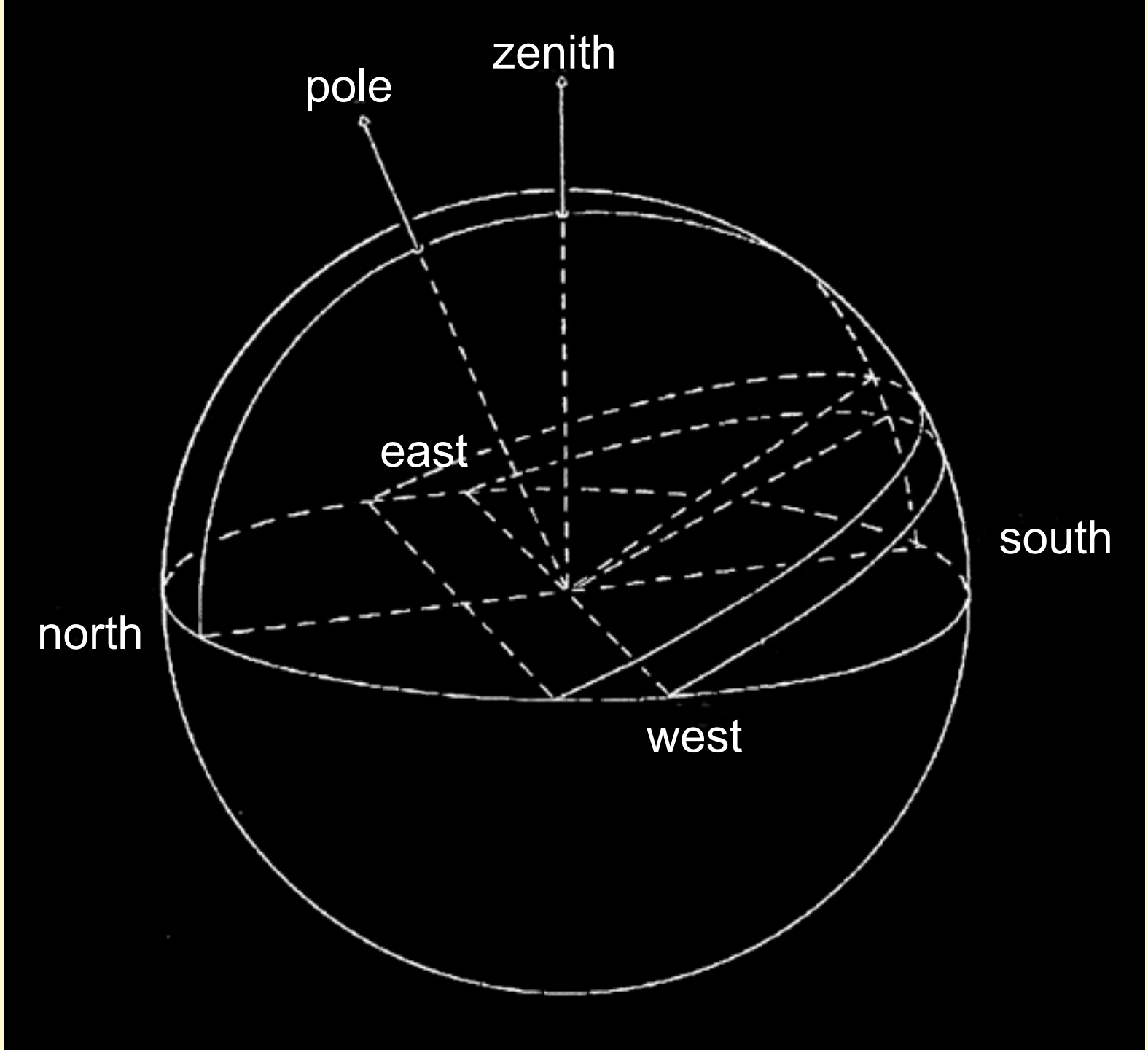
Megalithic observatories

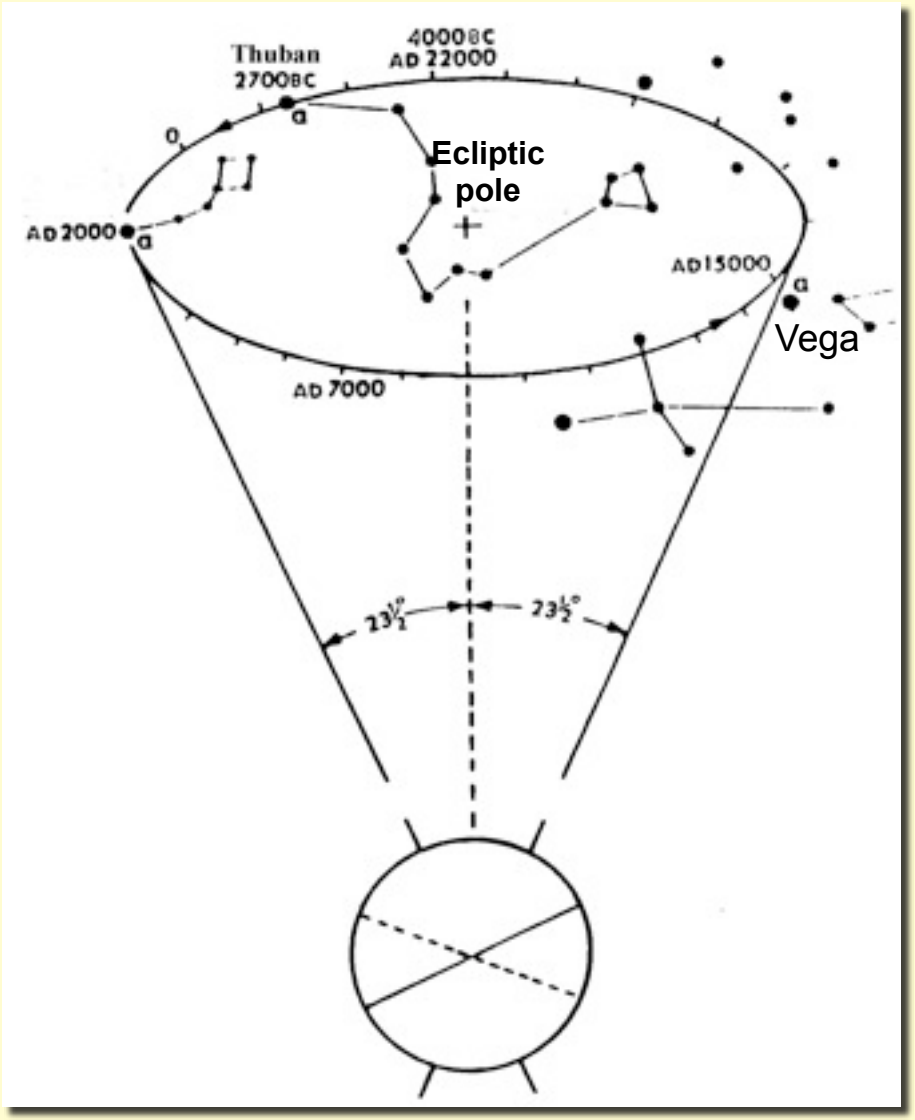
”Horizontal” astronomy

Stonehenge I
(ca. 2800 B.C.)
Stonehenge II
(ca. 2200 B.C.)
Stonehenge III
(ca. 2075 B.C.)

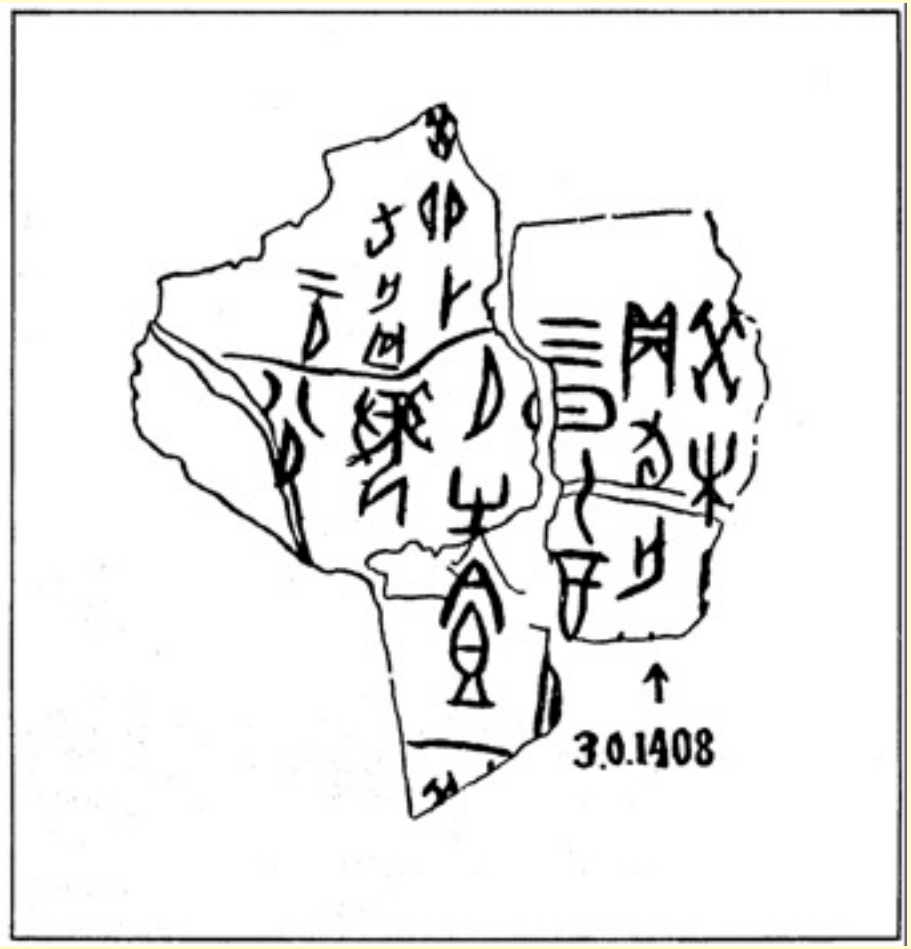


Stonehenge I (ca. 2800 B.C.)
Stonehenge II (ca. 2200 B.C.)
Stonehenge III (ca. 2075 B.C.)

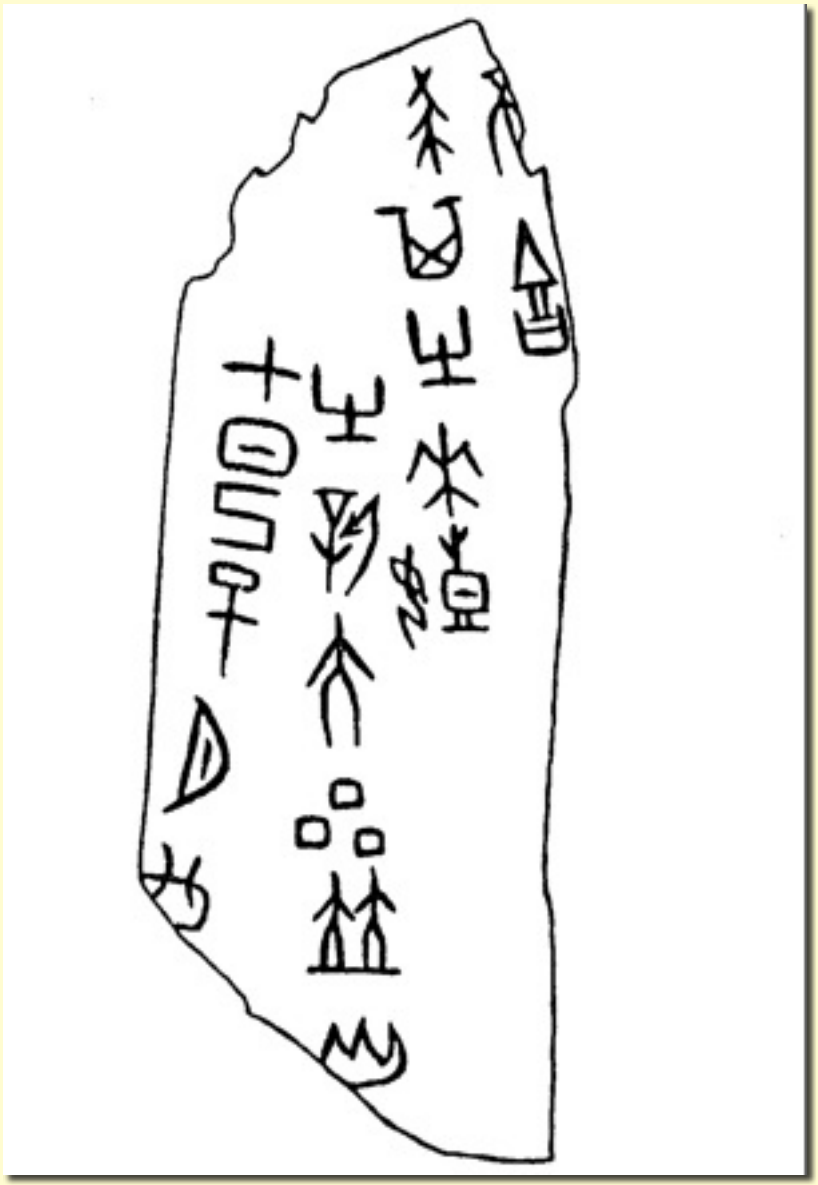

zenith
pole
east
south
north
west



Astronomical precession



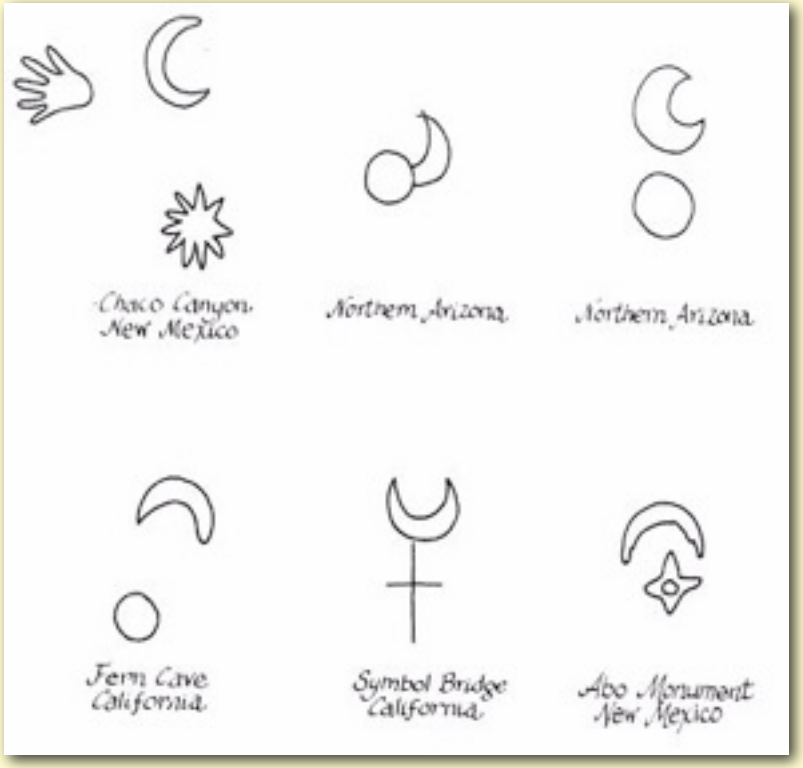
An oracle bone with the record of
the lunar eclipse
on September 2, 1279 B.C.



The oldest Chinese record
of a nova from about 1300 B.C.

Supernova explosion of 5 July, 1054
("Guest" star from Chinese chronicles)

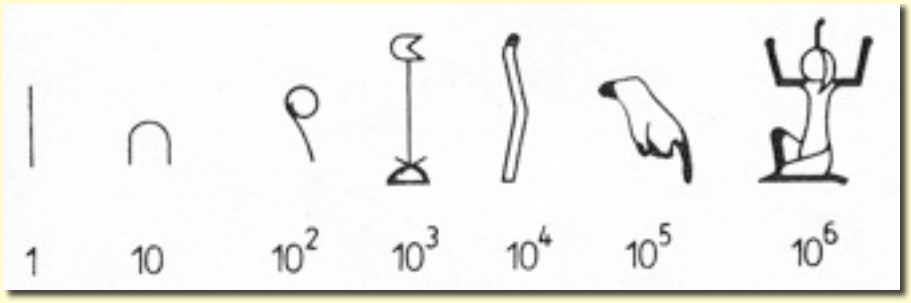
Computer simulation



Indian pictographs

Crab nebula today

Mathematics in Egypt



non-positional decimal system,
multiplication through addition,
division through subtraction
fractions of numerator = 1
high level of geometry

$S_{circle} = (8d/9)^2$; $S = \pi(d/2)^2 \Rightarrow$

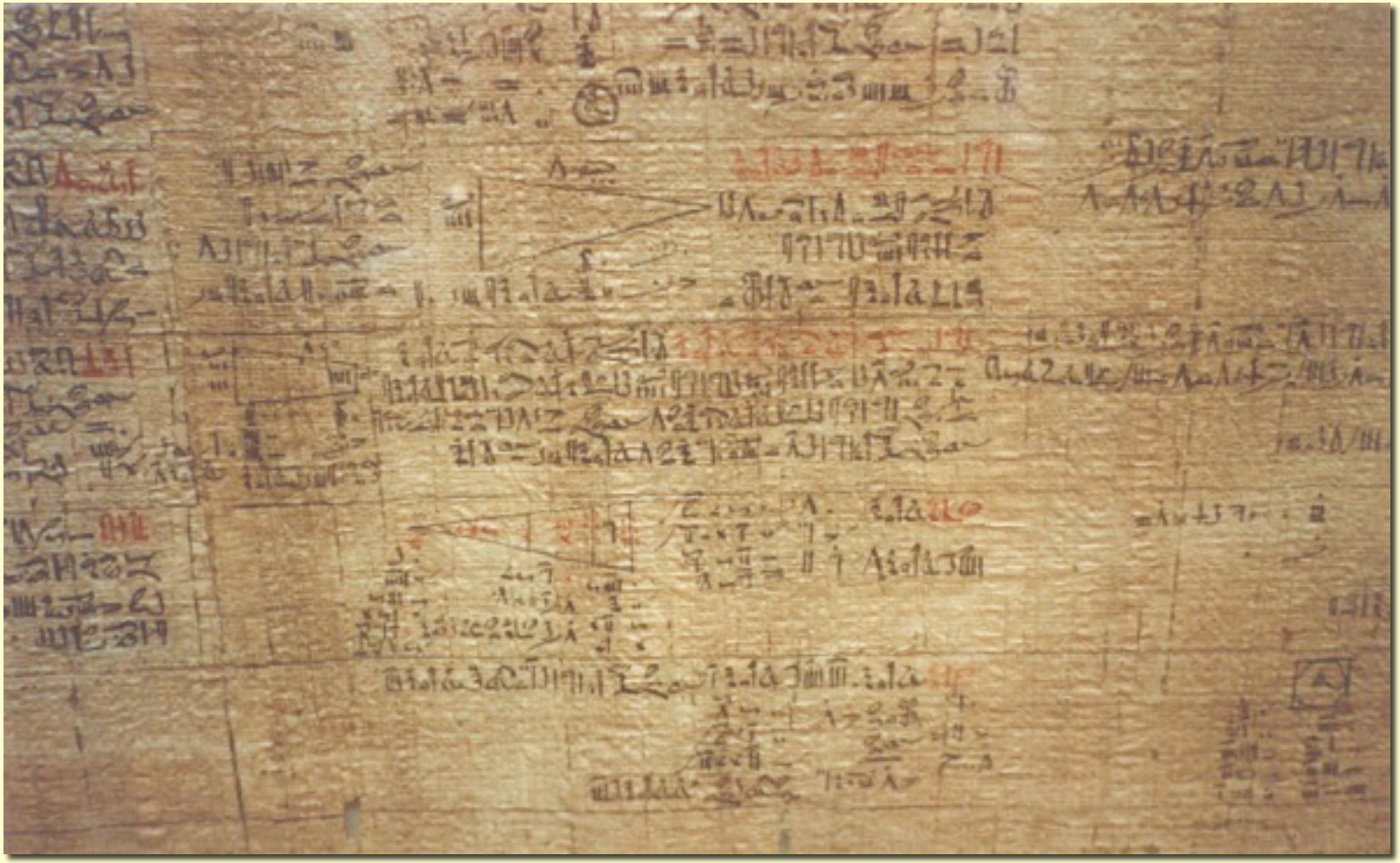
$\pi \approx 4(8/9)^2 = 256/81 \approx 3{,}1605$

Mathematics in Mesopotamia

= 1, 60, 60^2, also 1/60, 1/3600 etc.

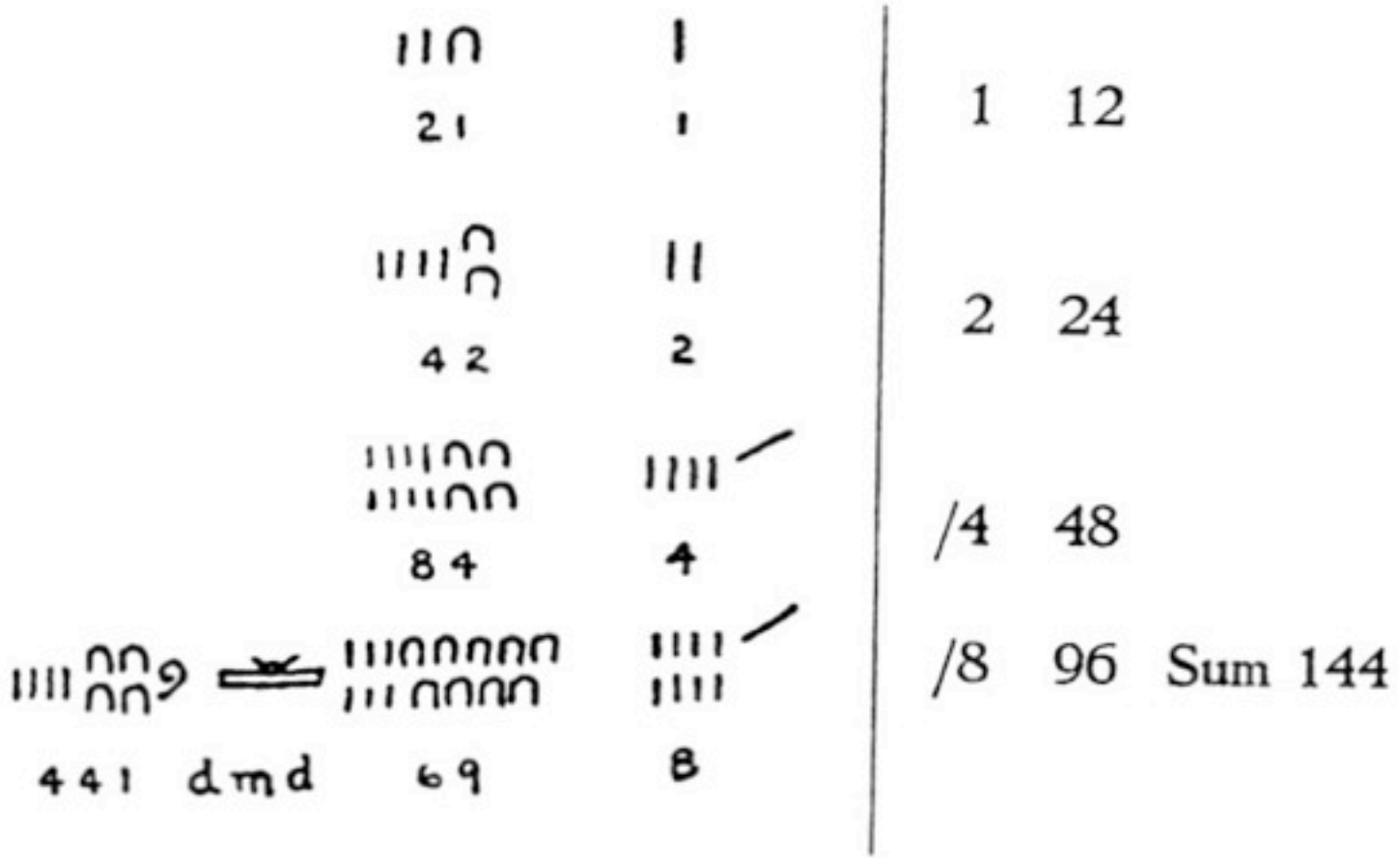
= 10, 10•60, 10•60^2 etc.

positional system,
sexagesimal
high level of algebra

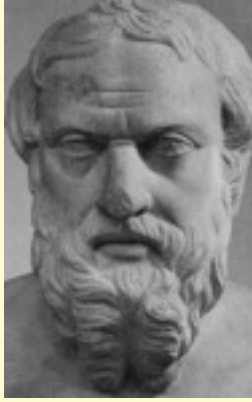


”Rules for enquiring into nature, and for knowing all that exists, [every] mystery... every secret. Behold this roll was written in Year 33, month 4 of the inundation season...[under the majesty of the King of Upper] and Lower Egypt Aauserrē, endowed with life, in the likeness of a writing made in the time of the King of Upper and Lower Egypt Nemarē. It was the scribe Ahmōse who wrote the copy.” (*Rhind Papyrus*, ca. 1900 B.C.)

Egyptian multiplication (Problem no. 32 from the Rhind Papyrus)



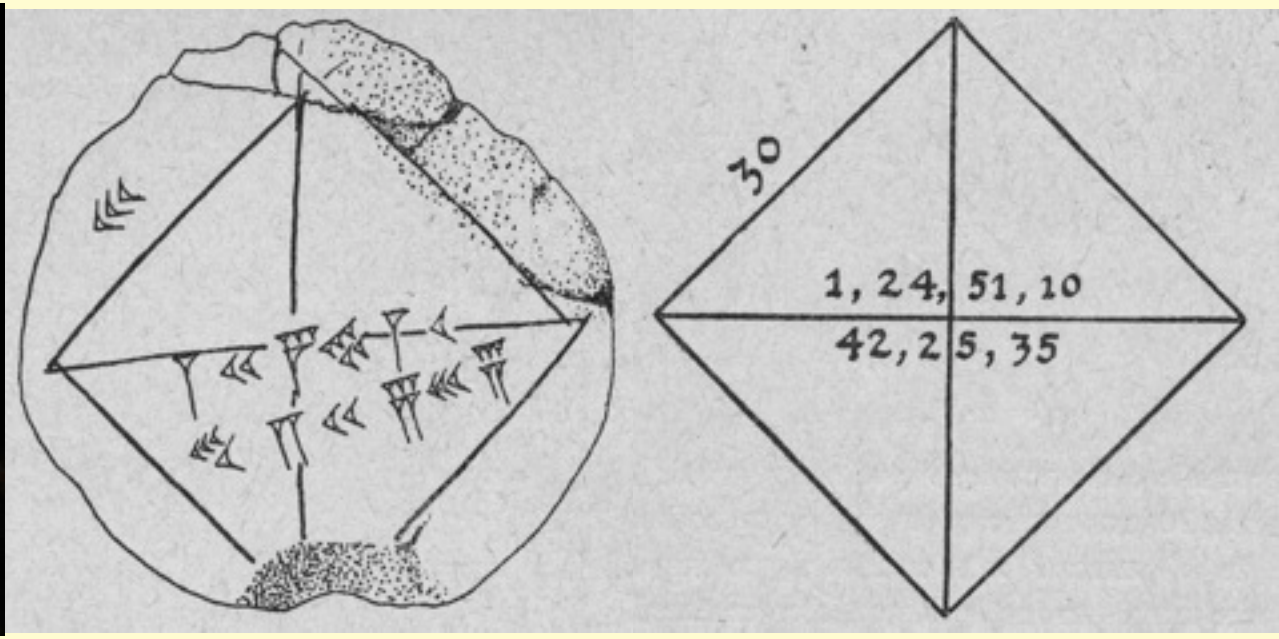
Herodotus on the origin of geometry



”Sesostris also, they declared, made a division of the soil in Egypt among the inhabitants, assigning square plots of ground of equal size to all, and obtaining his chief revenue from the rent which the holders were required to pay him year by year. If the river carried away any portion of a man's lot, he appeared before the king, and related what had happened; upon which the king sent persons to examine, and determine by measurement the exact extent of the loss; and thenceforth only such a rent was demanded of him as was proportionate to the reduced size of his land. **From this practice, I think, geometry first came to be known in Egypt,** whence it passed into Greece. The sun-dial, however, and the gnomon with the division of the day into twelve parts, were received by the Greeks from the Babylonians.”

History, Book 2, § 109

Babylonian tablet (XVIIIth century B.C.)



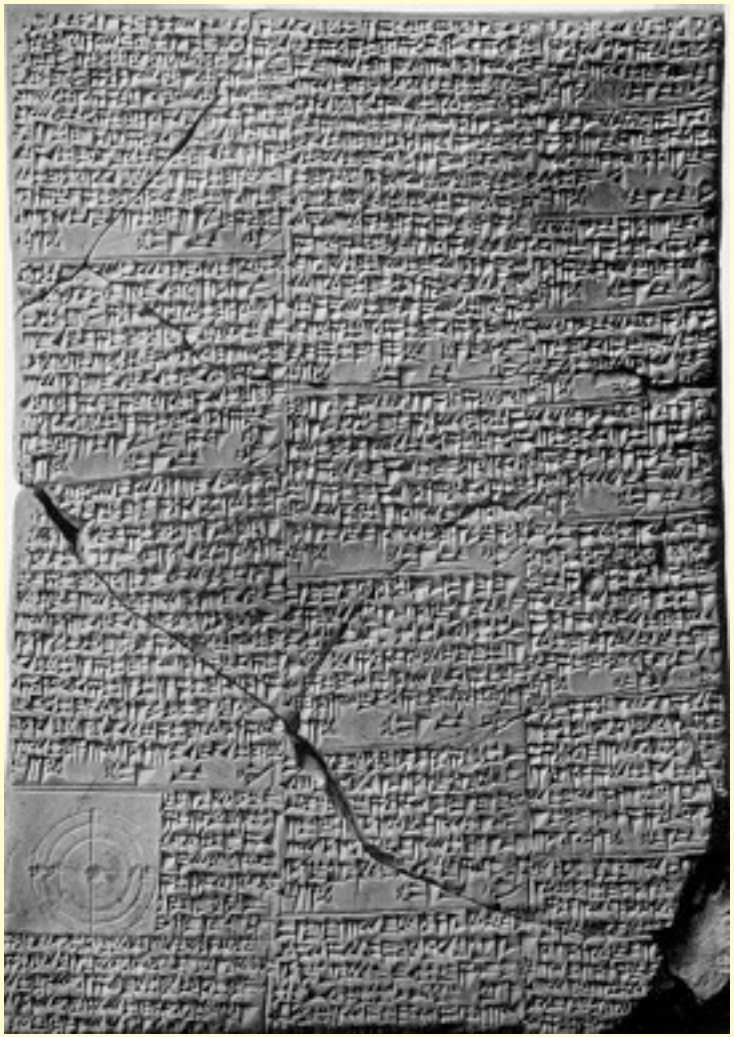
$\{42 + 25/60 + 35/60^2\}/30 = 1 + 24/60 + 51/60^2 + 10/60^3 =$

$= 1,41421296...$

$\sqrt{2} = 1,41421356...$

$(1,24,51,10)^2 = 1,59,59.59,38,1,40 = 1,9999983...$

Mathematical documents from the Near East

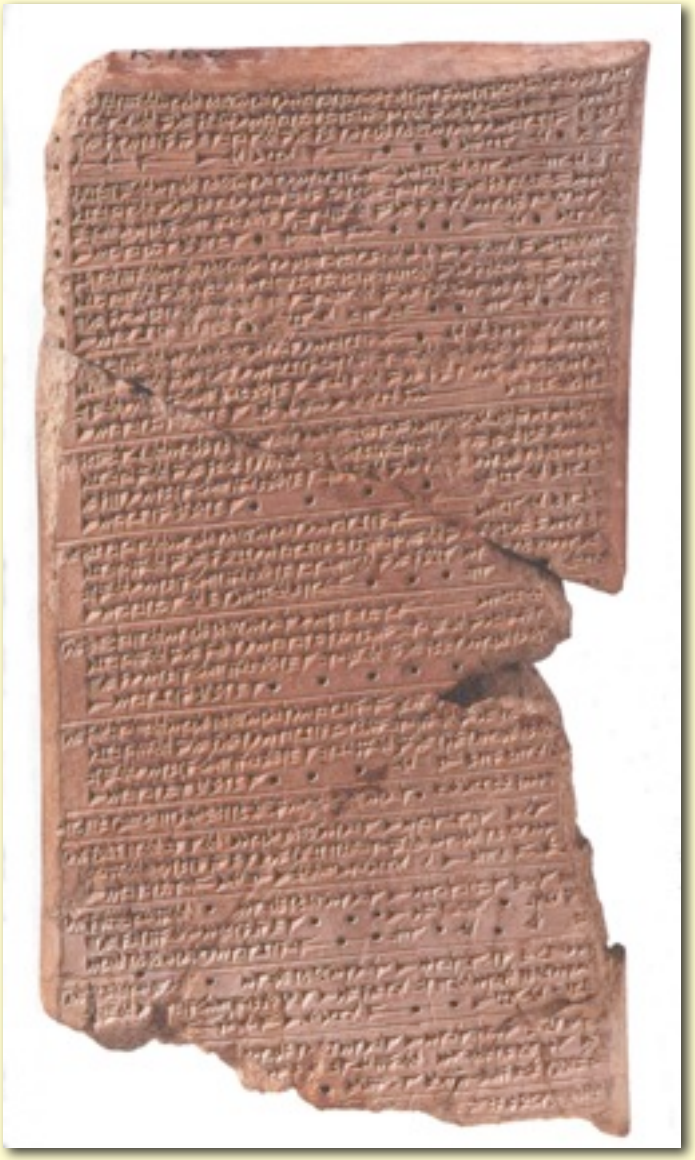


Babylonian tablet
(ca. 1600 B.C.)

Egyptian papyrus
(ca. 1700 B.C.)

A stone axe from Moravia
(neolithic)

Ephemeris of Venus
(ca. 1640 B.C.)



We may expect further findings concerning ancient science

HISTORY OF SCIENCE

Ancient Babylonian astronomers calculated Jupiter's position from the area under a time-velocity graph

Mathieu Ossendrijver*

The idea of computing a body's displacement as an area in time-velocity space is usually traced back to 14th-century Europe. I show that in four ancient Babylonian cuneiform tablets, Jupiter's displacement along the ecliptic is computed as the area of a trapezoidal figure obtained by drawing its daily displacement against time.This interpretation is prompted by a newly discovered tablet on which the same computation is presented in an equivalent arithmetical formulation.The tablets date from 350 to 50 BCE.The trapezoid procedures offer the first evidence for the use of geometrical methods in Babylonian mathematical astronomy,which was thus far viewed as operating exclusively with arithmetical concepts.

from *Science*, 29 January 2016

Science, and in particular physics, is not limited to empiricism or the know-how of transporting heavy objects, constructing large buildings, measuring land and time, etc.

It is first of all an endeavour to recognize the laws which govern phenomena in the world around us

A part of the Egyptian pantheon

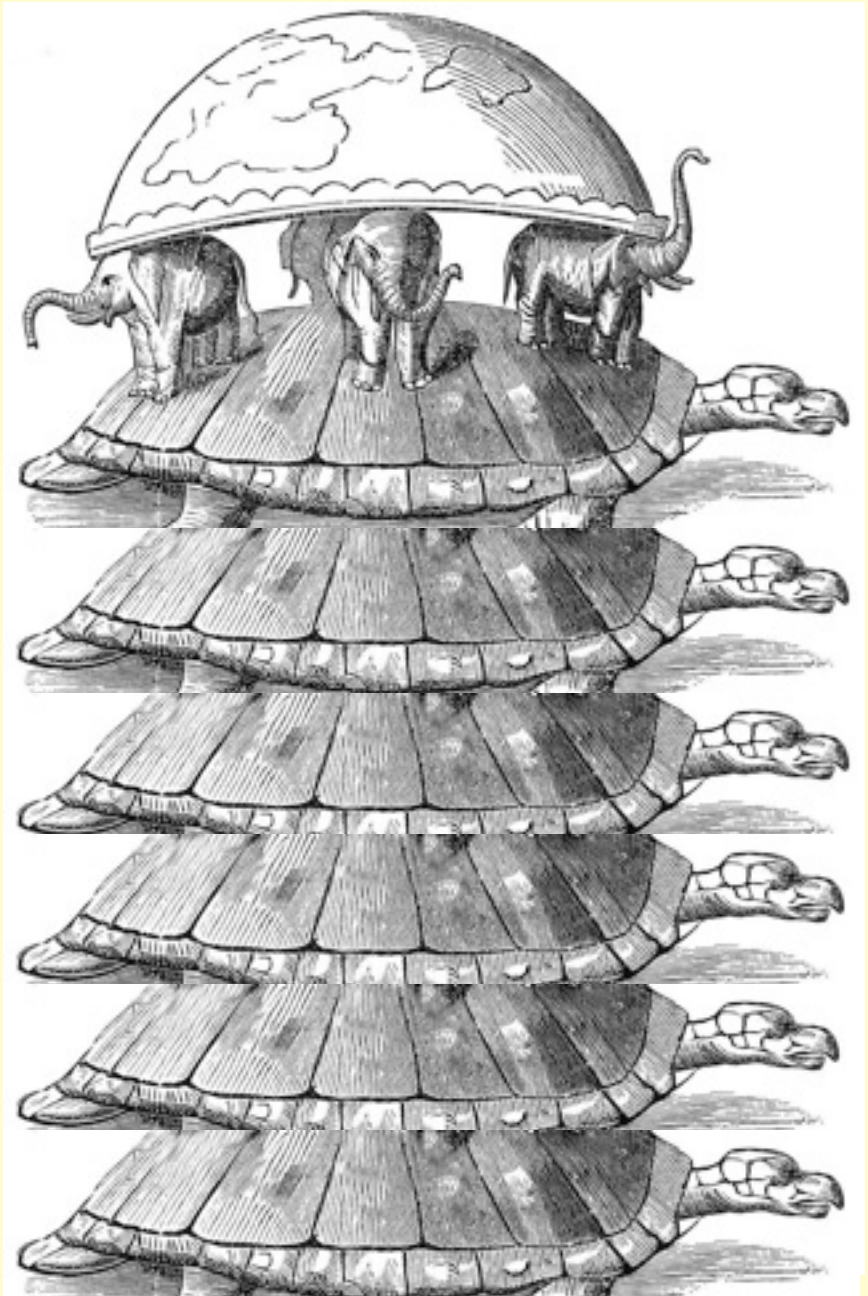
Ra
god of the Sun

Ged - goddess of the earth
Nut - goddess of the heavens

Thoth
god of the Moon

A part of the Mesopotamian pantheon

The ancient Hindu world



„There are turtles all way down...”

From myths to science

Myths help to form notions such as objectivization of natural phenomena, their necessity, explanation through hypotheses, and also unselfish curiosity; it's a path which leads to science

1. Nontrivial time ordering of events in myths
   (it *was*, it *is*, it *will be*)
2. Myths help to realize that all natural phenomena occur independently from us
3. Myths explain phenomena, even the origin of the world and the gods; myths help to develop curiosity which does not lead to immediate material profit
4. Myths teach to frame hypotheses and conjectures in order to explain events and phenomena

Aristotle on the beginnings of science

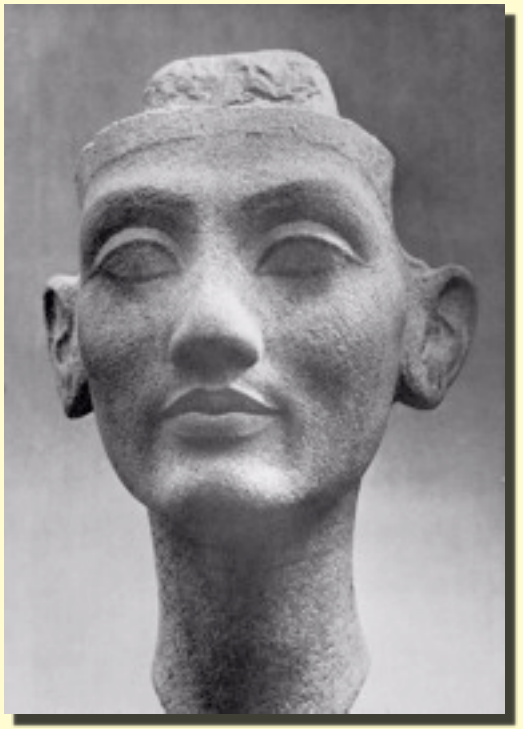
”At first he who invented any art whatever that went beyond the common perceptions of man was naturally admired by men, not only because there was something useful in the inventions, but because he was thought wise and superior to the rest. But as more arts were invented, and some were directed to the necessities of life, others to recreation, the inventors of the latter were naturally always regarded as wiser than the inventors of the former, because their branches of knowledge did not aim at utility. Hence when all such inventions were already established, the sciences which do not aim at giving pleasure or at the necessities of life were discovered, and first in the places where men first began to have leisure. This is why the mathematical arts were founded in Egypt; for there the priestly caste was allowed to be at leisure.”

Metaphysics, Book A

Egyptian art from Amarna

XVIIIth Dynasty (ca. 1360 B.C.)

Heads of
queen Nefertiti
by Tuthmosis



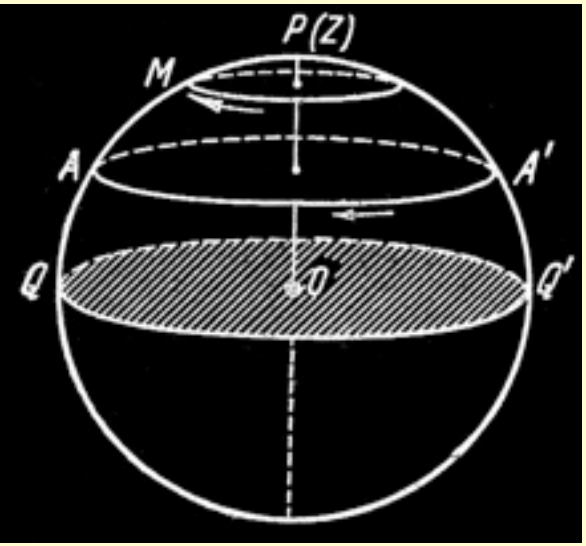
”We owe to Egypt some of the most individualized and the most moving portraits of ancient times... There was everywhere a great love of beauty, which is immortalized in the models, the reliefs, the paintings and drawings...”
(Sarton, *A History of Science,* vol. I)

Summary

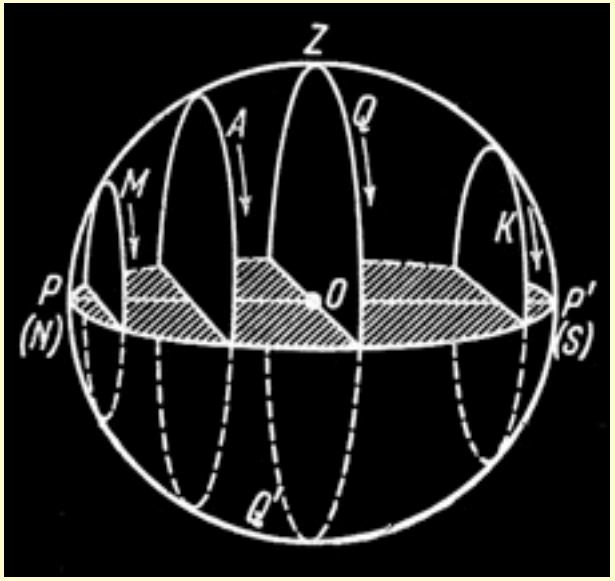
- Science before the Greeks was purely empirical
- No distinction between pure and applied science because it all originated from practical needs
- First attempts of scientific classification of data (e.g. astronomical tables, medical papyri)
- First attempts of scientific predictions (e.g. positions of celestial bodies)
- Continuing strong links of science to magic and mythology

Additional explanatory slides

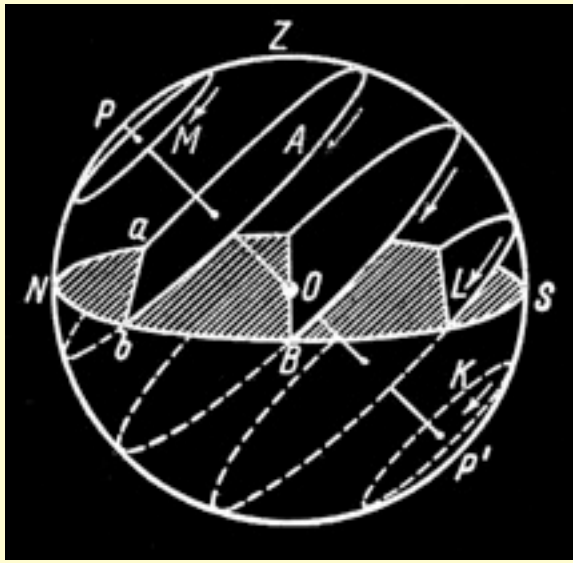
Tracks of the stars in the sky



North Pole



Equator



Latitude of 45^{o}

Path of the sun in the sky in various seasons at our latitude