

What the Romans Knew

Piero Scaruffi

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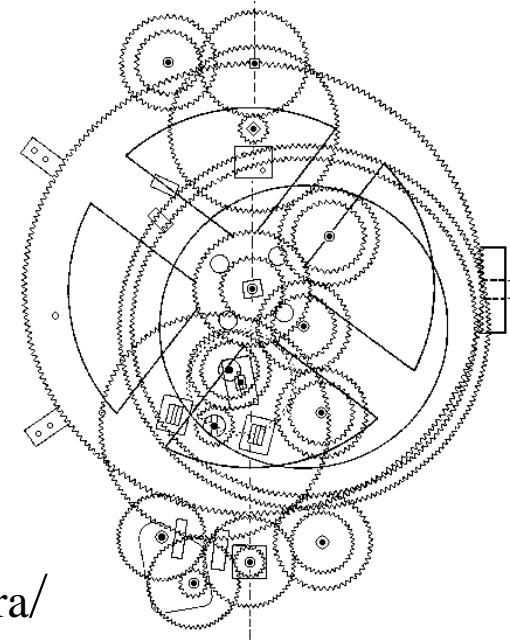
- **Technology**

# What the Greeks knew

- Hipparkhos/ Hipparchus (b146 BC) of Nicaea (Kingdom of Bithynia in 146 but part of Rome when he died)
  - Earth at the center of the universe (“geocentric theory”)
  - Catalogued 1,000 stars
  - The stars and the souls are made of the same substance (credited to H. by Pliny)

# What the Greeks knew

- Antikythera Mechanism (2nd c BC)
  - First analog computer
  - Predicted the motions of the stars and planets, the equinoxes and phases of the moon
  - It recorded the time and place of the original Olympic games

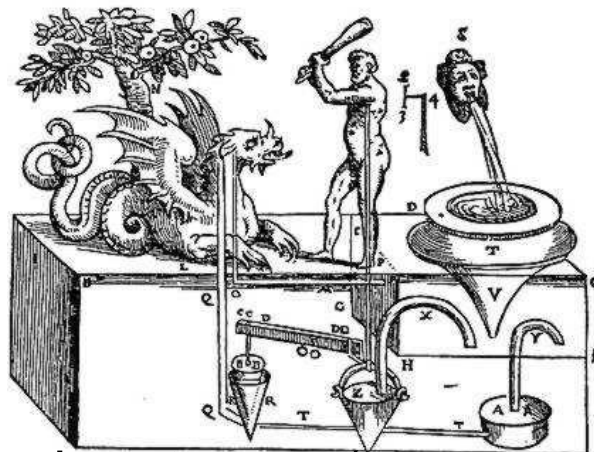


# What the Greeks knew

- Heron of Alexandria (Alexandria, 1st c AD)
  - Steam-powered engine (“aeolipile”)
  - First vending machine
  - Wind organ

# What the Greeks knew

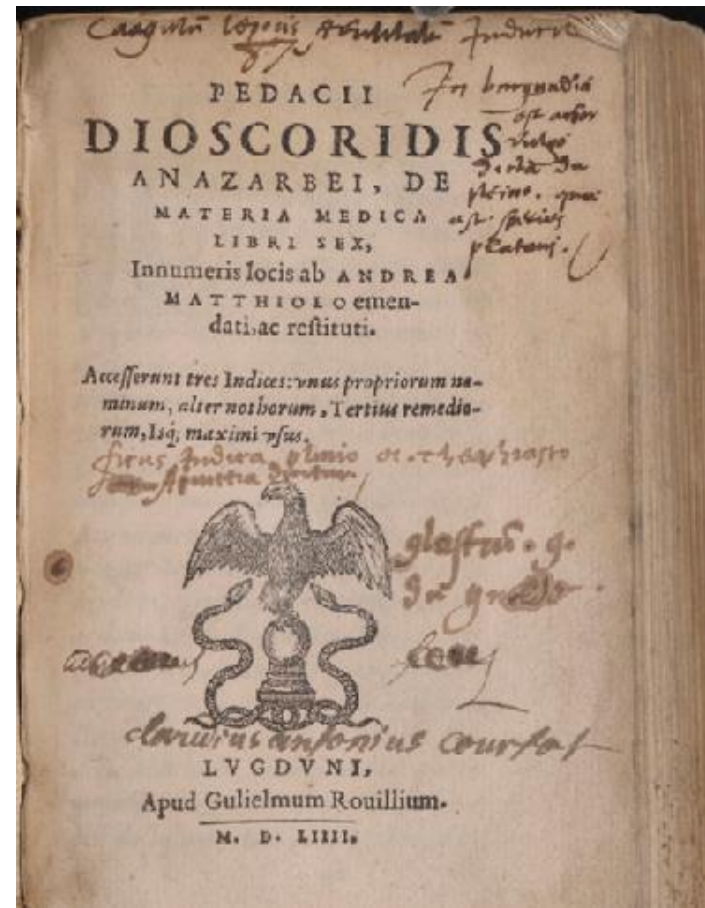
- Heron (Alexandria, 1st c AD)
  - Pneumatica (applications of steam power)
  - Dioptra (magnifying lenses)
  - Hydraulica (hydraulic lifting device)
  - Mechanica (mechanical inventions)
  - Five machines known to the Greeks to move heavy weights: wheel, lever, pulley, wedge, screw



One of Heron's automata (reconstruction)

# What the Greeks knew

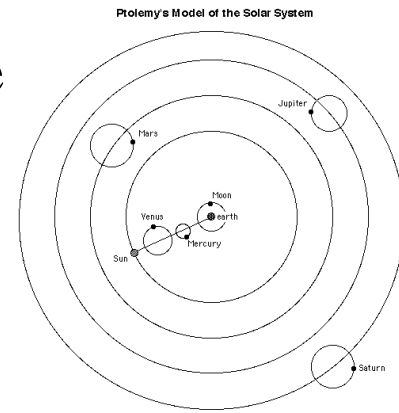
- Pedanius Dioscorides (40–90 AD)
  - Medical Botany: "De materia medica"



17<sup>th</sup> century edition

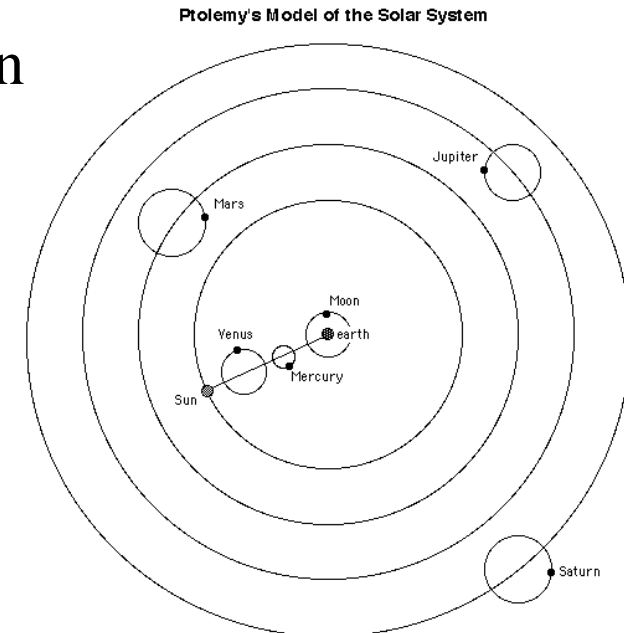
# What the Greeks knew

- Klaudios Ptolemaios/Claudius Ptolemaeus/Ptolemy of Alexandria (145 AD)
  - Earth at the center of the universe (“geocentric theory”)
  - Epicycles (planets attached to circles attached to Aristotle's concentric spheres)
  - Uniform circular motion of the planets in their orbits and of their orbits around the Earth
  - The power of mathematical analysis
  - Mathematics accounts systematically for the motion of the universe



# What the Greeks knew

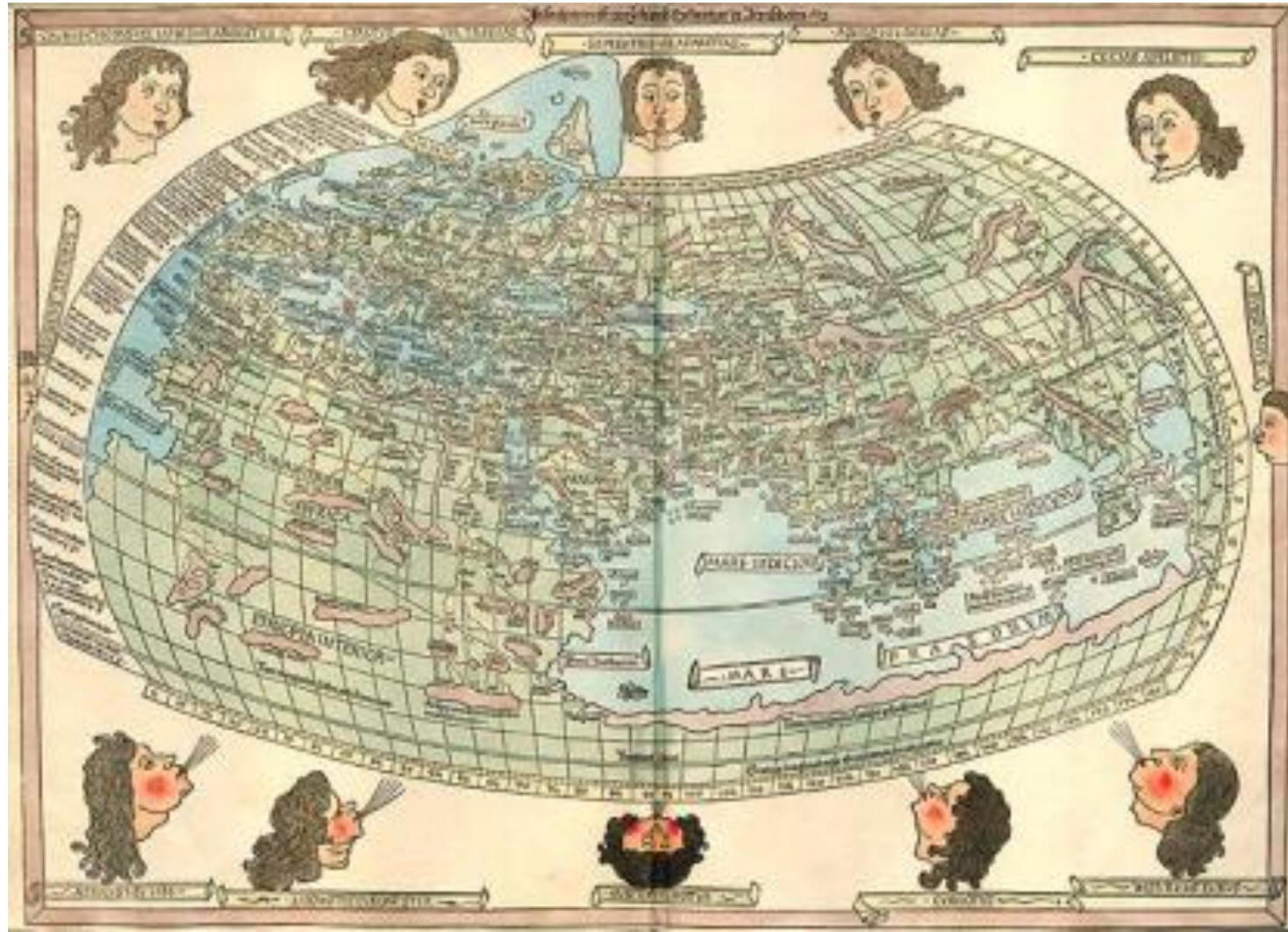
- Klaudios Ptolemaios/Claudius Ptolemaeus/Ptolemy of Alexandria (145 AD)
  - Ptolemaic model of nesting spheres
  - Planetary spheres: the spherical stationary Earth at the center, the sphere of the Moon, of Mercury, Venus, Sun, Mars, Jupiter, and Saturn.
  - Eighth sphere: the stellar sphere containing the fixed stars





# What the Greeks knew

- Ptolemy: "Cosmographia" (160 AD, printed 1478)



# What the Greeks knew

- Diophantus of Alexandria (250 AD)
  - The "Arithmetica"
- Achilles Tatius (Alexandria, 3rd c AD): "The Adventures of Leucippe and Cleitophon", erotic romance

# What the Romans Knew

- Imported technology
  - Stone Age
    - Pottery making
    - Cloth making
    - Tool making
  - Early civilizations
    - Wheel
    - Metallurgy
    - Writing
    - Mathematics
    - Astronomy
    - Shipbuilding
    - Food preservation
    - Grape and oil cultivation

# What the Romans Knew

- Engineering
  - Roma's technological mastery of the environment
    - Roads: 70,000 kms
    - City walls
    - Sewer (cloaca) and aqueduct
    - Multi-story buildings
- But...
  - Vertical waterwheel (1st c BC) used for grinding flour but no need to use it for "industrial" works because of surplus of free slave labor
  - No horses for agriculture
  - Little irrigation, relying on the sea for fishing and its colonies for agriculture

# What the Romans Knew

- Engineering
  - Rivers not fully exploited for transportation and travel because it is safe and rapid to travel by road and by sea
  - The great rivers (Danube and Rhine) provide the border, not a waterway

# What the Romans Knew

- Communication
  - Roads: 70,000 kms
    - Originally paved for military movement
    - Facilitates trade and administration
    - Travel becomes relatively easy and unexceptional
  - Postal delivery system serving the whole Mediterranean world ("cursus publicus")
  - Riders could cover about 270 kilometers in a 24-hour period
  - The speed with which mail could be carried about the Mediterranean was not equaled again in Europe until the 19th century

# What the Romans Knew

- Communication
  - Via Appia (312 BC)
  - Via Valeria (303 BC)
  - Via Aurelia (241 BC)
  - Via Clodia (3rd c BC)
  - Via Flaminia (220 BC)
  - Via Aemilia (187 BC)
  - Via Annia (158 BC)
  - Via Cassia (154 BC)
  - Via Postumia (148 BC)
  - Via Popilia (132 BC)
  - Via Domitia (121 BC)

# Viae

The Roads of Rome



Peutinger's Tabula (12th c copy of a Roman map)



# What the Romans Knew

- Engineering
  - Urban planning
    - Sewers and aqueducts made enabled larger cities
    - Paved roads and multi-story buildings

# What the Romans Knew

- Engineering
  - Greek architecture, that was mainly religious, was applied by the Romans to political (palace), public (theaters, baths, basilicas) and domestic (villa) architecture

# What the Romans Knew

- Engineering
  - Technology of the curve: arch, vault, dome (a 360 degree extension of the arch)
  - The vault over a square bay made possible the abolition of the wall and enables large windows
  - Two fundamental structures: vaulted hall of the thermae and long-aisled basilica
  - Tall buildings: multi-story houses, bridges, aqueducts, theaters, basilicas, baths, triumphal arches

# What the Romans Knew

- Engineering
  - Theme: enclosing large volumes of space and organizing complex combinations of various types of structures
  - Arches, vaults and domes allow to cover huge spaces
  - Vaulting first used for practical purposes (3rd/2nd c) for warehouses and depots
  - Warehouses, basilicas, sanctuaries/temples, palaces, thermal baths, cisterns
  - Cement from Pozzuoli used to build the Appian Way, baths, the Colosseum, the Pantheon, and the Pont du Gard aqueduct in France

# What the Romans Knew

- **Engineering**
  - **The invention of concrete (3rd c BC) allows the erection of huge buildings in the center of town, with no need to transport huge boulders from mountains or countryside**
  - **Concrete also spurs construction of aqueducts, that bring freshwater to remote towns (eg garrison towns)**
  - **Concrete requires lower skills than stone, therefore slaves replace craftsmen**

# What the Romans Knew

- Engineering
  - 326 BC: the Circus Maximus
  - 313 BC: the Basilica of Maxentius
  - 179 BC: the Porticus Aemilia
  - 2nd c. BC: the sanctuary at Praeneste (Temple of Fortuna: 80 )
  - 55 AD: Pompey's theater in Rome, first permanent theater in Rome, and temple complex
  - Gaius Julius (Caesar, 49-44 BC), transformation of Rome into an imperial capital: Julian forum (54), Basilica Aemilia, Basilica Julia, Curia Julia
  - Gaius Octavius (Augustus, 27-14 BC): Augustus' forum (20), gates, theater of Marcellus, temple of Mars, Ara Pacis (“I found Rome brick and left it marble”)

# What the Romans Knew

- Engineering
  - Nero (54 AD - 68 AD): Rebuilding of Rome after the fire of 64 in revolutionary forms
    - Nero's architects abandon the parallel lines and the right angles of Greek architecture
    - An architecture of curves, vaults and domes
    - Domus Aurea (octagonal hall, grotto/"grotesque")

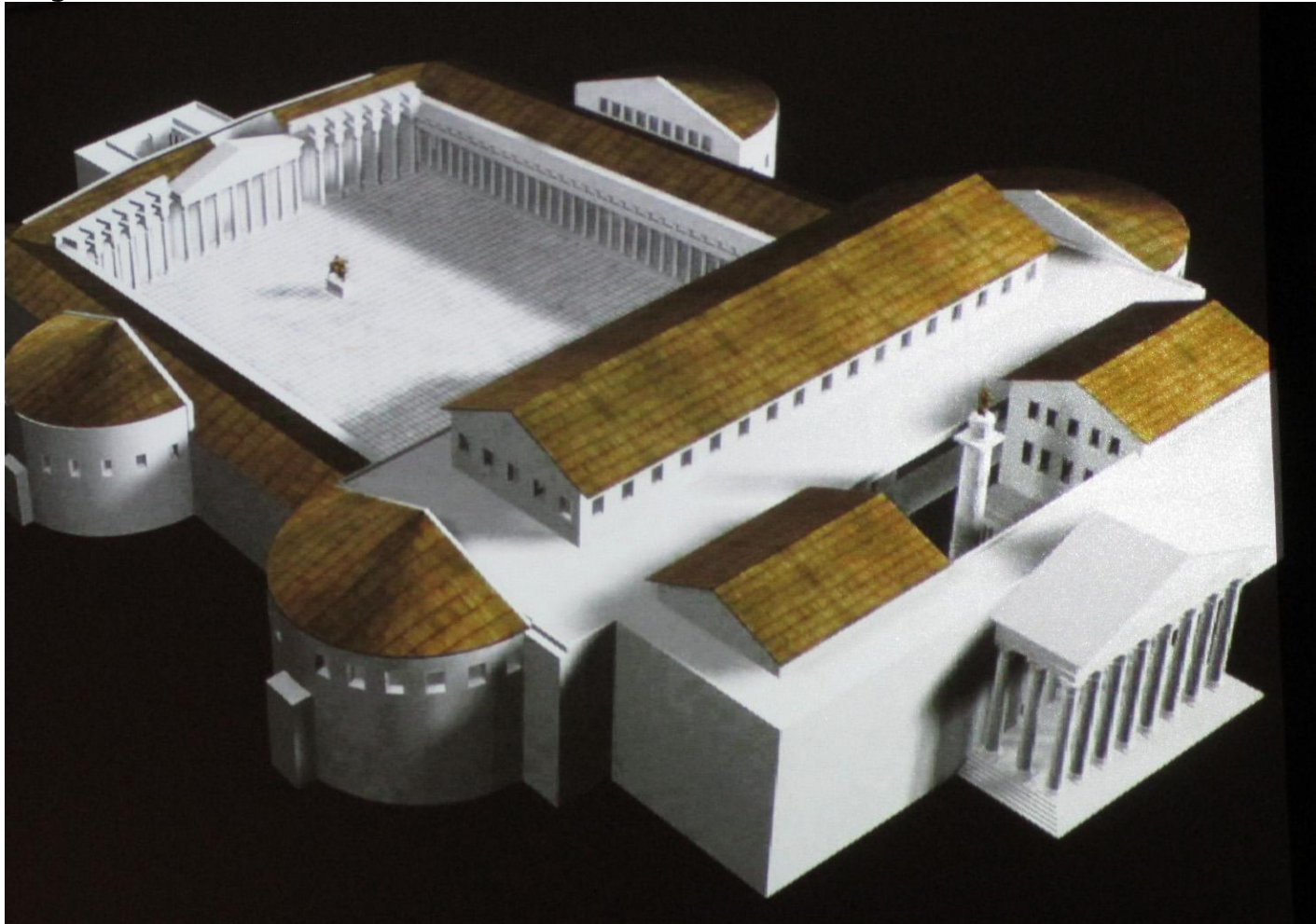
# What the Romans Knew

- **Engineering**
  - **Vespasianus (69-79): Colosseum (79 AD)**
  - **Titus (79-81): Arch of Titus (81 AD)**
  - **Trajanus (98-117): architect Apollodorus of Damascus designs the Trajan Forum (107 AD), Trajan's Column (113) and the bridge over the Danube**
  - **Domitian's Palace (92): apotheosis of curved architecture**



# What the Romans Knew

- **Engineering**
  - Trajan Forum



# What the Romans Knew

- **Engineering**
  - **Hadrianus (117-138):**
    - **Inspired by Greece, does for Greece what Greece could never do:**
      - **Creates the first federation of Greek cities in history**
      - **Codifies Athenan law**
      - **Completes the Temple of Olympian Zeus**
    - **Creates the Jewish diaspora**
      - **Dissolves Judea and creates Palaestina**
    - **Villa of Hadrian, comprising 30 buildings, including three theaters and a stadium (118 AD), apotheosis of curves, vaults and domes**
    - **Pantheon, a circular temple made of brick and concrete (121 AD)**
    - **Mausoleum (138)**
    - **Wall of Hadrian in Britain**

# What the Romans Knew

- **Engineering**
  - **Marcus Aurelius (161-180): Marcus Aurelius' column (176)**
  - **Caracalla (188-217): Termae of Caracalla (216)**

# What the Romans Knew

- **Engineering**
  - **Greece focused on the exterior, Rome focuses on the interior**
  - **Greek monumental architecture was dedicated to the gods (Parthenon of Athena, Temple of Olympian Zeus, Sanctuary of Apollo, etc)**
  - **Roman monumental architecture is dedicated to the emperors who built it (Trajan Forum, Hadrian's Pantheon, Flavian Amphitheater, Caracalla Baths, etc)**
  - **Roman architecture is secular even when it is dedicated to a god**

# What the Romans Knew

- **Imperial Roma**



(Museo della Civiltà Romana, Roma)

# What the Romans Knew

- **Imperial Roma**

Marcellus



(Museo della Civiltà Romana, Roma)

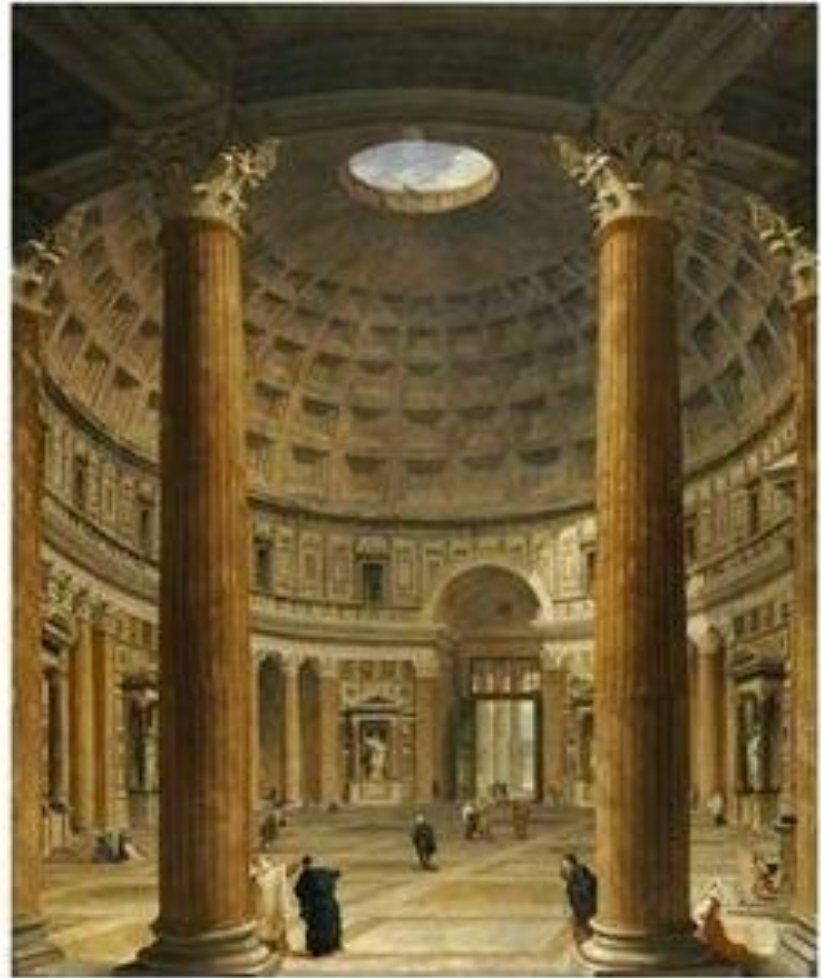
# What the Romans Knew

- **Imperial Roma**
  - **Pantheon**
    - **Temple to all deities**
    - **A cosmic building**
    - **Opening in the dome: the sun**
    - **Deified Caesar among the deities**
    - **Analogy between cosmos and empire**



# What the Romans Knew

- **Imperial Roma**
  - **Pantheon**



(Giovanni Panini)



# What the Romans Knew

- Imperial Roma
  - Marcus Aurelius' column
    - The plight of ordinary people



# What the Romans Knew

- Vitruvius (1<sup>st</sup> c BC): "De Architectura" (1<sup>st</sup> c BC)
  - Oldest surviving treatise on architecture
  - The application of mathematics to architecture
  - Three essential attributes of architecture: "firmitas, utilitas, and venustas" (firmness, commodity, delight)
  - Architecture as imitation of nature
  - Architecture as imitation of the human body
  - Cosmic order founded on geometry
  - Beauty is mathematics
  - A building is an organism

# What the Romans Knew

- **Crane**

A tread wheel crane based on a design by Vitruvius (Relief on a 100 AD tomb)



# What the Romans Knew

- **Forum**
  - **Compromise between the civic center of the Etruscans and the agora of the Greeks**
  - **Large open space in the central part of town, surrounded by arcades**
  - **Originally an open space with no buildings for people to gather on market days, during religious festivals, for political events, games and theater**
  - **Later the site of administrative buildings and state temples, surrounded by shops and often including a covered market**
  - **First courthouse: the Basilica Porcia (184 BC), followed by basilicas Aemilia, Sempronia, Opimia**

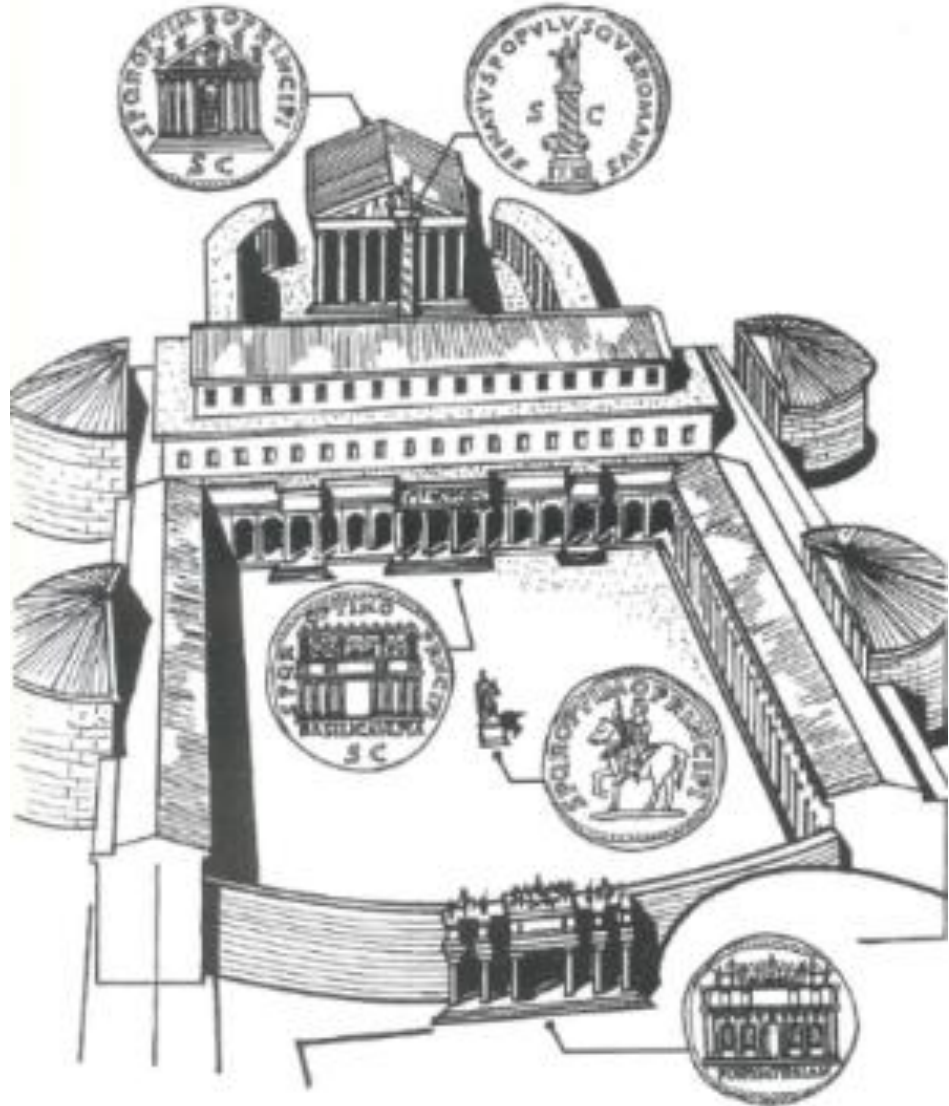
# What the Romans Knew

- **Forum**

- **Julius Caesar's forum (54 BC): first alternative to the Forum Magnum**
- **Augustus' Forum (20 BC)**
- **Two more imperial fora and finally Trajan's Forum, the most magnificent (basilica Ulpia, Trajan's column, Trajan's temple)**
- **All five imperial fora communicated with the Forum Romanum Magnum**
- **Mostly destroyed in 1084, during a Norman invasion**

# What the Romans Knew

- **Forum**
  - **Trajan's Forum**



(Marvin Tameanko)

# What the Romans Knew

- **The sanctuary at Praeneste (80 BC)**
  - Inspired by the temple of Athena at Lindos
  - Sanctuary as total reorganization of the landscape
  - New architectural vocabulary:
    - Ubiquitous curvilinear and circular forms
    - Unifying plan based on symmetrical and axial organization
  - Association of temple and theater



# What the Romans Knew

- **Theater**
  - **Greek theater, but on open ground (no need for a hill to support the steps) and multi-story**
  - **Hemicycle framed by tiers of arched galleries**
  - **Amphitheater = two theaters**



# What the Romans Knew

- **Pompey's Theater (55 BC)**
  - **The world's largest and most important stage**
  - **The first permanent theater built in Rome (only wooden amphitheaters were legal, so Pompey added a temple to "Venus Vincitrix")**
  - **First theater in the world to have a back wall that enclosed both the audience and actors on all sides (Greek theaters were carved into a hill)**
  - **Backed with a giant square portico (quadriporticus)**
  - **Temple at the top of the cavea**
  - **Symbolism of the square (the human world), the semicircular tiers of the theater (celestial spheres) and the dominating temple (the gods)**
  - **Caesar assassinated here**



Santa Maria Capua Vetere



rs

- **Flavian amphitheater or “Colosseum” (80 AD)**
  - **Multilevel system of vaults made of concrete**
  - **50,000 spectators**
  - **Similar size:**
    - **Verona**
    - **Siracusa**
    - **Pozzuoli**
    - **Capua Vetere**
    - **El Djem, Tunisia**
    - **Tarragona, Spain**



# What the Romans Knew

- **Circus**
  - **Greek stadium**
  - **Made of wood**

# What the Romans Knew

- **Thermae**
  - Roman invention
  - Amusement park with rooms for the recreation of both body and mind
  - Central heating system

# What the Romans knew

- **Terme di Caracalla (Caracalla's Baths): 217 AD**
  - **Open to every citizen of both sexes**
  - **Men and women bathed at different times**
  - **Free of charge**
  - **Capacity: 1,600**
  - **Statues, fountains, mosaics**
  - **Why: hygiene**
  - **How: hot bath in calidarium, lukewarm bath in the tepidarium, cold bath in the frigidarium, swim in the natatio (pool)**
  - **What: bath, pool, gardens, libraries, gymnasium, stadiums, lecture halls, stores, brothels**

# What the Romans Knew

- **Baalbek (60 AD)**



# What the Romans Knew

- **Ceremonial buildings**
  - **Memorial column**
  - **Triumphal arch**

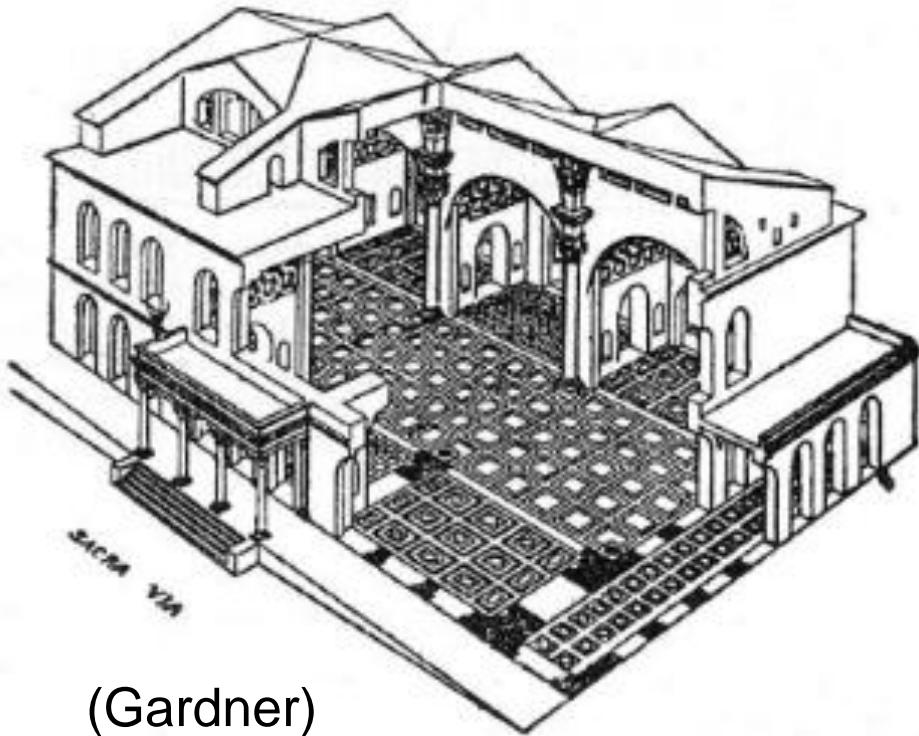
# What the Romans Knew

- **Basilica**
  - **Nave + aisles + apse**
  - **Covered market or exchange or court of law**
  - **Eastern origin**



# What the Romans Knew

- **Basilica of Maxentius (312 AD)**



(Gardner)



# What the Romans Knew

- Reconstruction by Chiffot of the House of the Centenarian, Pompeii, 79 ad



- Hadrian's Villa, 118 AD



# What the Romans Knew

- Split, Croatia: Diocletian palace



# What the Romans Knew

- **Refinements of old technologies:**
  - **Swape (to raise water)**
  - **Wine and olive press**
  - **Crane**
  - **Water clock**
  - **Flour mill**
  - **Hodometer**
  - **Revolving mill for grinding**

# What the Romans Knew

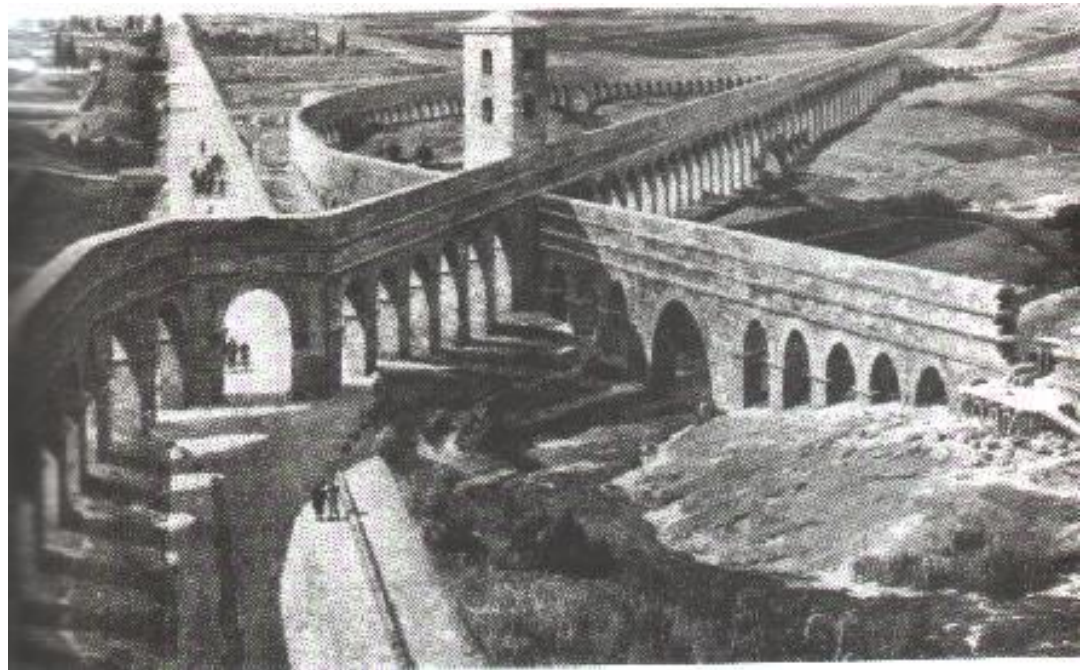
- **Water power**
  - **Noria (to raise water to higher terrain)**
  - **horizontal water wheel attached to millstone**
  - **geared mill (water wheel with gears)**
  - **4th century peak of the (horizontal) water mill in Rome**
  - **Water power is mostly used for grinding grain**
- **Limited use of animal power**
  - **Mediterranean climate is not favorable to raising stock animals**

# What the Romans Knew

- **Aqueduct**
  - **Superimposed rows of arches**



(Nimes)



(H.Hodges)

# What the Romans Knew

- **Nourias (Hama, Syria)**



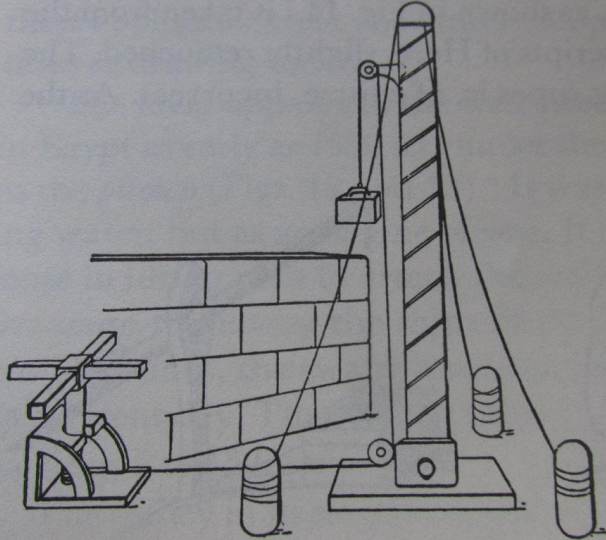


Fig. 14. Crane with a single mast.

Fig. 34. The water clock.

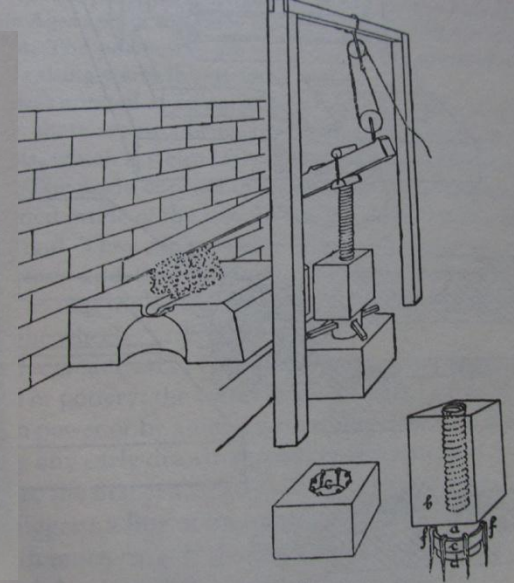
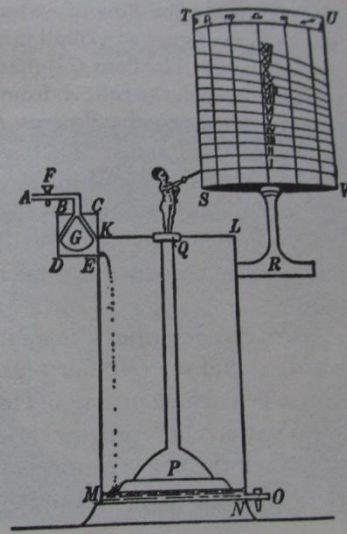


Fig. 19. Beam press with screw.

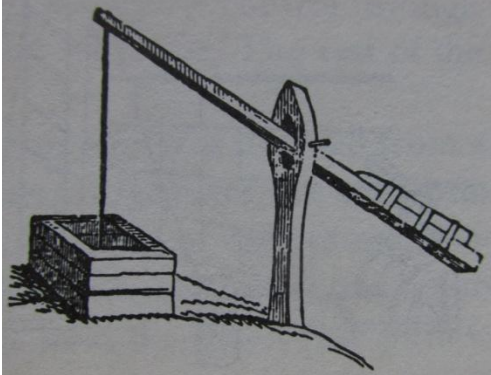


Fig. 13. A swape.

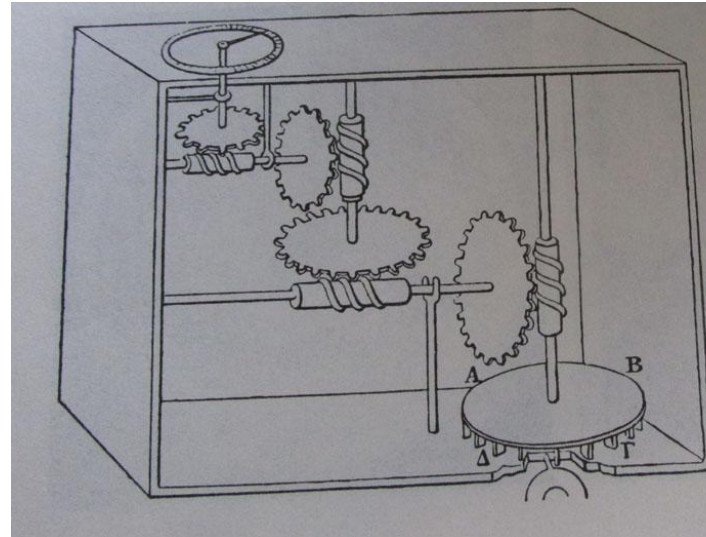


Fig. 36. Hodometer (cyclometer).

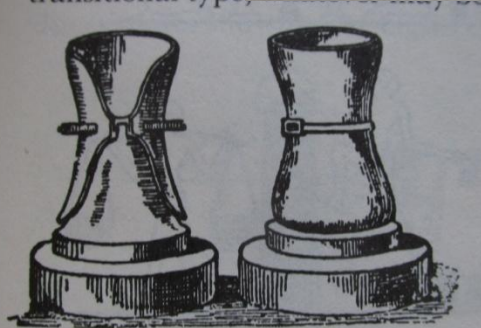


Fig. 39. Great quern, Pompeii.



# What the Romans Knew

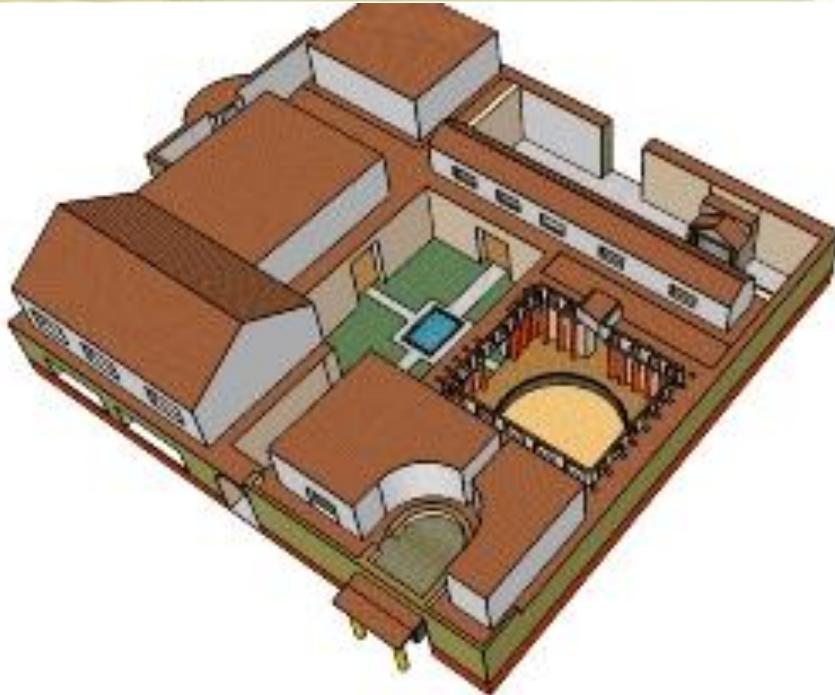
- **Domestic architecture**
  - **Blocks of apartments**
  - **Villas**
    - **Greek house (rooms around a garden surrounded by columnnade) + Etruscan house (atrium, offices, public rooms)**



(Museo della Civiltà Romana, Roma)

# What the Romans knew

- **Housing**



# Domestic Architecture

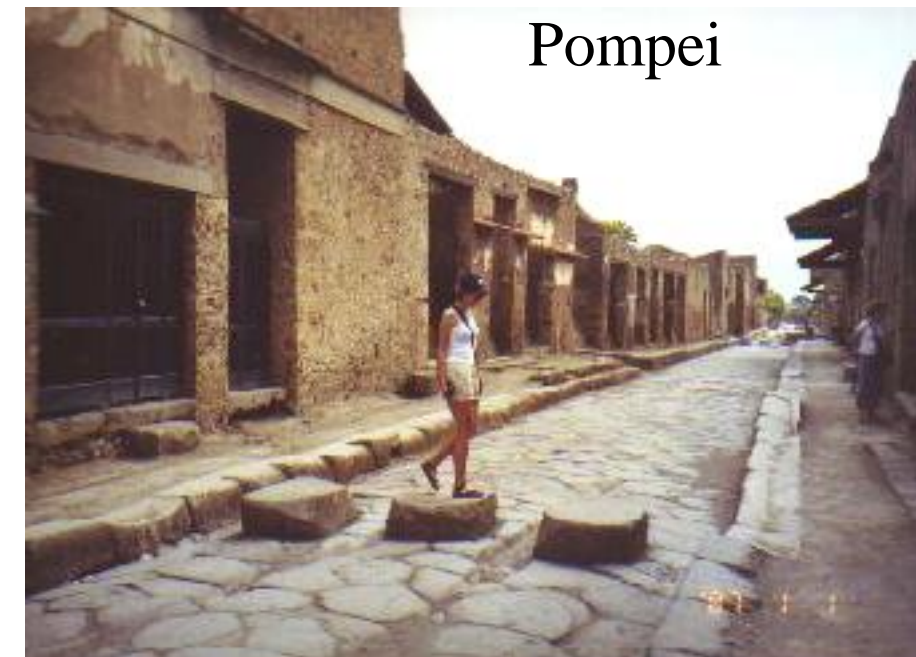


Herculaneum

Forum



Pompei



Ostia



# What the Romans Knew

- **Jerash (2nd c AD)**



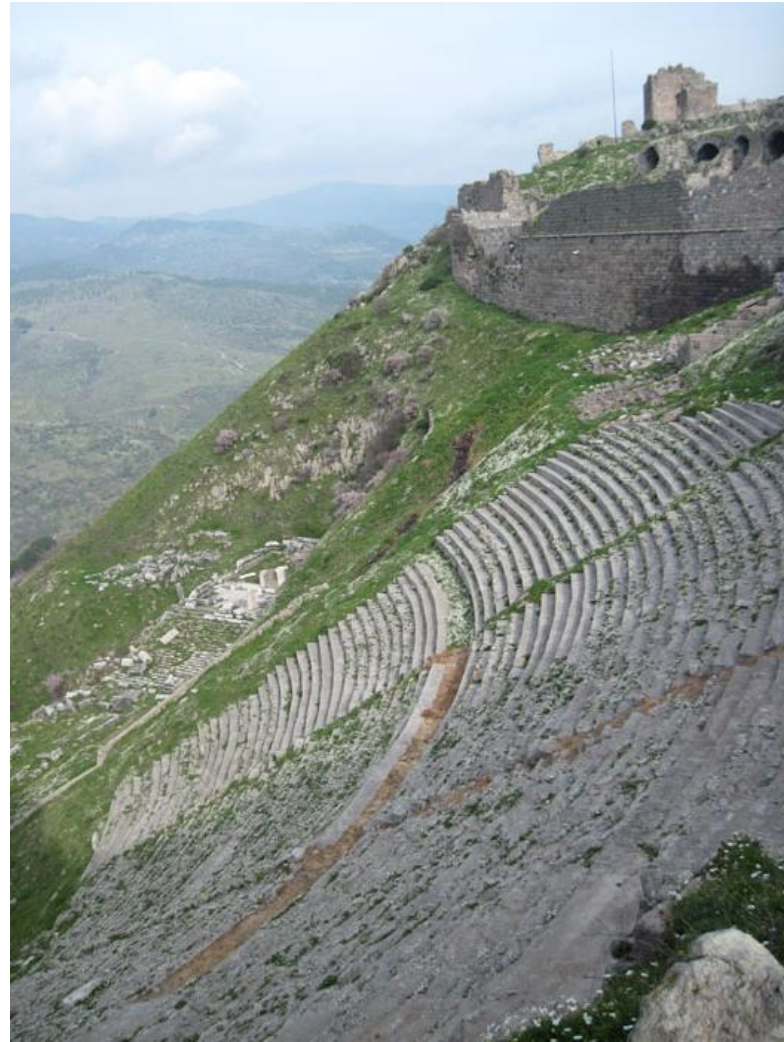
# What the Romans Knew

- **Afrodisias (2nd c AD)**



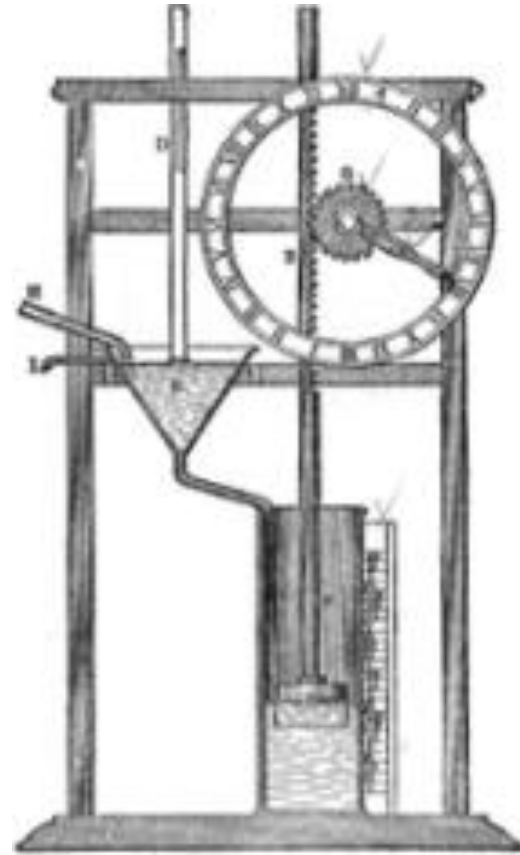
# What the Romans Knew

- Pergamon (2nd c AD)



# What the Romans Knew

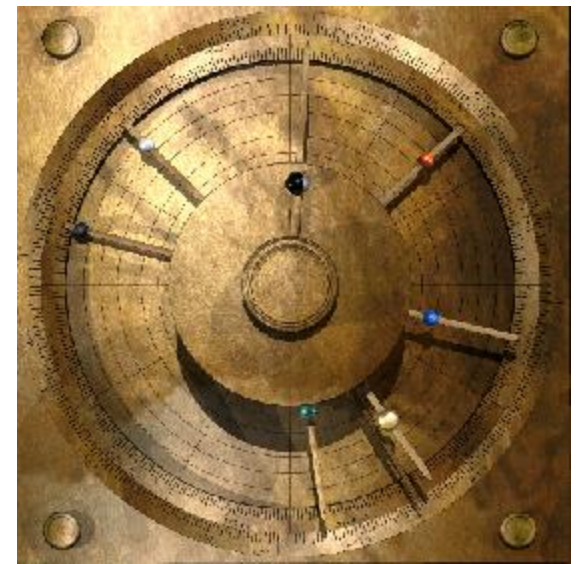
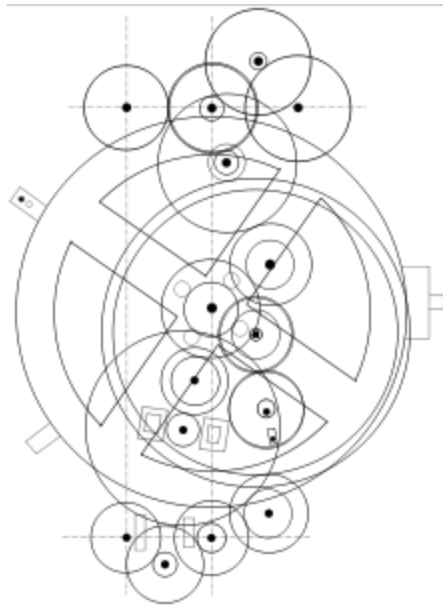
- **Time keeping**
  - **Water-clocks**
  - **Sundials**





# What the Romans Knew

- **Computing**
  - **Antikythera mechanism (30 bronze gears)**



# What the Romans Knew

- **Glass blowing**
  - **Glass: sand + soda + lime**
  - **Invented in Mesopotamia in 2,500 BC but glass objects rare until 1st c BC, when Roman Phoenicia invent blow-pipe, that allows infinite variety of shapes and mass production**

# What the Romans Knew

- Communication/ writing
  - Acta diurna (59 BC): daily "newspaper" posted on wooden boards in the forum
  - Slaves copied news for aristocrats on tablets
  - Excerpts were circulated to the provinces on papyrus rolls
  - Books written on papyrus rolls
  - Roman books don't use punctuation nor spaces: only specialists can read them

# What the Romans Knew

- **Spare-time activities**
  - theaters
  - amphitheaters
  - hippodromes
  - gymnasia
  - thermae (public baths)

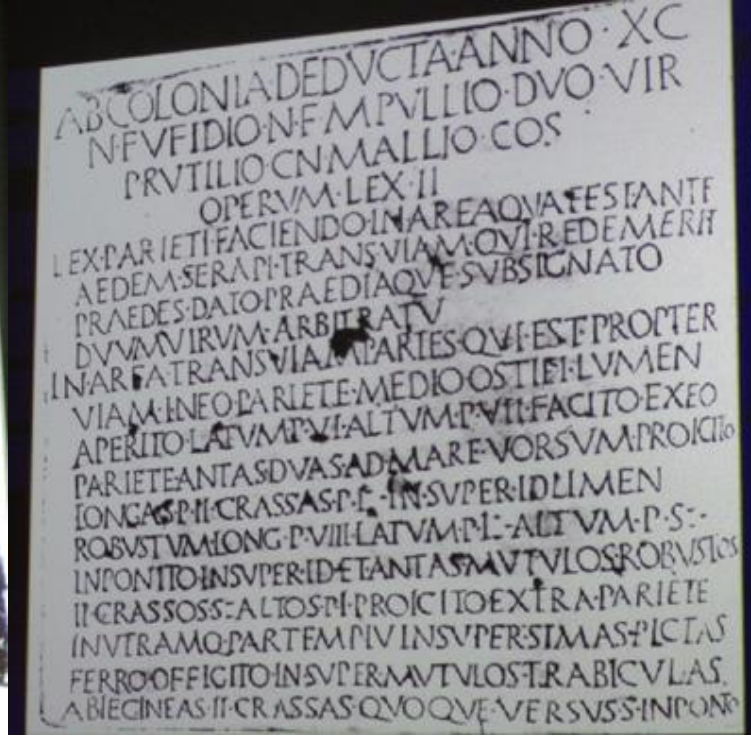
# What the Romans Knew

- **Epigraphic evidence (technology and public life)**
  - **Vipasca: mining**
  - **Pozzuoli/Puteoli: construction**
  - **Agon: irrigation**
  - **Copaic Lake (125 AD): dikes and aqueduct (text 1)**
  - **Lambasis: aqueduct and tunnel**
  - **Neisa (134 AD): timber transportation (text 2)**
  - **Cevlik: tunnel**
  - **Patara (70AD): aqueduct (text 3)**
  - **Turos Mountains: highway**
  - **Sip (101 AD): canal (text 4)**
  - **Nile Delta (87 AD): canal (text 5)**

1. Official documents

Vipasca

lex metallis dicta and  
lex territorio metalli  
Vipascensis dicta  
(end of 1<sup>st</sup> / beginning of  
2<sup>nd</sup> cent. )



lex parieti  
faciundo  
Puteolana  
(105 BC)



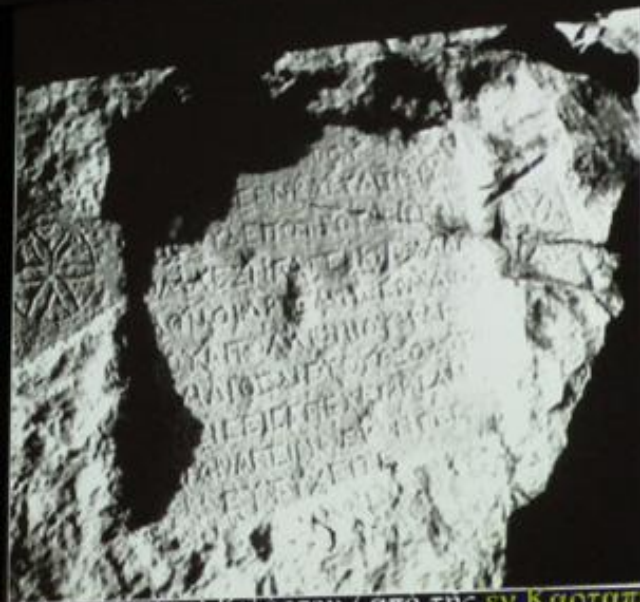
Lex Rivi Hiberiensis, bronze de Agón, 50 km northwest of  
Caesaraugusta/Zaragoza, Spain

2. Funerary, honorary and votive inscriptions

Lambaesis

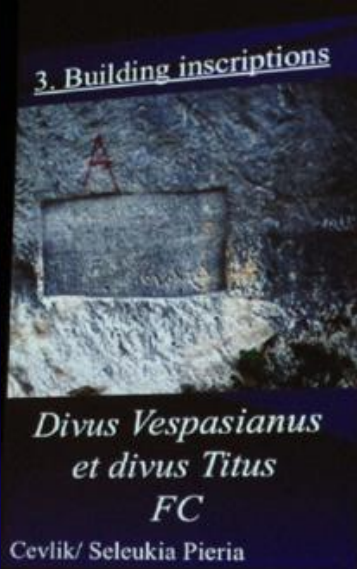
Lucius Nonius Datus





Under the archiereus Kilortos. No one has ever brought sawn timber out of the forest in the (canyon of) Kartapis before; only Artemes, son of Hermaios, grandson of Apollonios, and Hermaios, son of Hermaios, grandson of Theodotos, citizens of Neisa, have achieved this. You who read this, farewell!

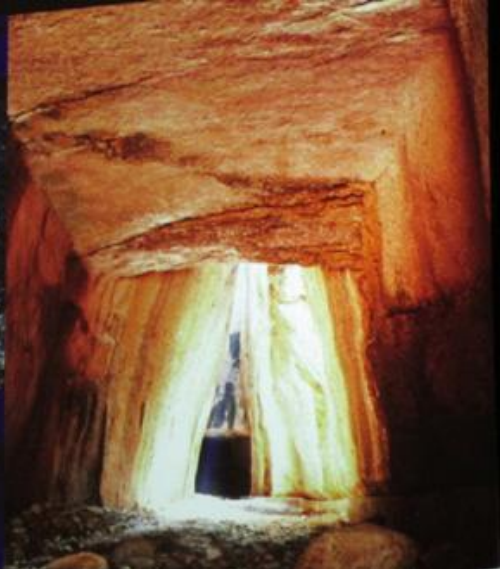
επι αρχι(ερεως) Κιλορτου / απο της εν Καρταπιδι υ/λης ουδέποτε ουδεις  
 πρι/ωμα εξηγαγε<ν> ικρι<α>, αλλα / μονοι Αρτεμης Ερμαιου / του  
 Απολλωνιου (vac.) και / "Ερμαιος δις του Θεοδοτο/υ Νεισεις  
 επεχειρησαν. / οι αναγεινωσκοντες / ευτυχειτε.



3. Building inscriptions

*Divus Vespasianus  
 et divus Titus  
 FC*

Cevlik/ Seleukia Pieria



Patara



*Imp(erator) Caesar / Marcus Au/relius [[Antoninus  
 pi]]us / felix invictus Augu/stus montibus caesi[s] /  
 viam latiore[m] fecit. ὄροι Κιλικῶν*

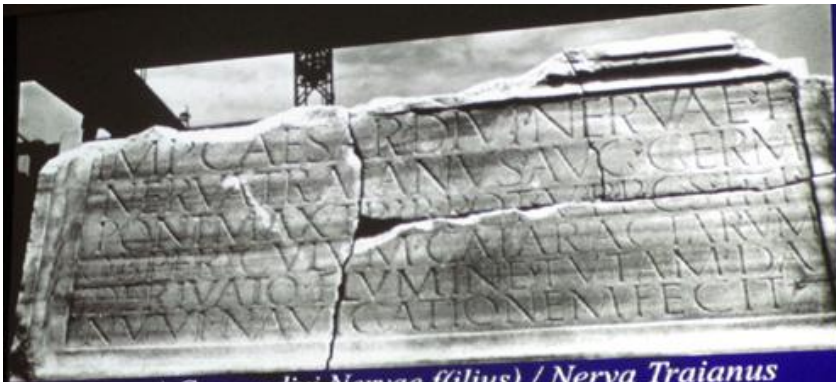
To Good Fortune. Emperor Caesar Trajan Hadrian Augustus, son of deified Trajan Parthicus, pontifex maximus, tribunician power for the ninth time, thrice consul, to the archons, council, and demos of the Coroneans, greetings. I ordered dikes to be made for the Cephissus and the Hercynne and the other rivers along the section where they now flow together before emptying into the Copaic Lake. Construction shall occur as soon as possible so that they flow along their banks and be not diverted from their course, nor, as now happens, flood most of the cultivable land. I shall construct an aqueduct for you too. The money will be given by me, 65,000 (*denarii*), which the experts in such matters say will be necessary. You are to elect the men who will be in charge. (Transl. Oliver, Greek Constitutions, p. 264).

Under the archiereus Kilortes. No one has ever brought sawn timber out of the forest in the (canyon of ) Kartapis before; only Artemes, son of Hermaios, grandson of Apollonios, and Hermaios, son of Hermaios, grandson of Theodotos, citizens of Neisa, have achieved this. You who read this, farewell!

After the wall of the water line had been destroyed by an earthquake, the emperor Imperator Caesar Flavius Vespasianus Augustus had it rebuilt together with the water line made of stone blocks on top of it. In addition, he ordered a pressure line to be built in three rows along the wall with earthenware pipes of a



Imperator Caesar Nerva Trajanus Augustus Germanicus, son of the deified Nerva, pontifex maximus, tribunician power for the fifth time, pater patriae, four times consul, has, by diverting the river because of the dangerous cataracts, provided for safe navigation on the Danube.



*Imp(erator) Caesar divi Nervae f(ilius) / Nerva Traianus Aug(ustus) Germ(anicus) / pont(ifex) max(imus) trib(unicia) pot(estate) V p(ater) p(atriciae) co(n)s(ul) IIII / ob periculum cataractarum / derivato flumine tutam Da/nuvi navigationem fecit.*

AE 1973, 475 = ILJug 2, 468 (Sip, Moesia superior, 101 AD)



*Anno VI Imp(eratoris) [[Domitiani]] / Caesar(is) Aug(usti) Germanic(i) / sub C(aio) Septimio Vegeto praef(ecto) Aeg(ypti) / foditu(m) est flumen Philagrianu(m) / at tria soldu(m) usque ad petra ἔτους Ϛ' Αὐτοκράτ[ορος] Καίσαρος [[Δομιτιαν(οῦ)]] / Σεβαστοῦ Γερμανικοῦ / ἐπὶ Γαῖου Σεπτιμίου / Οὐεγέτου ἡγεμόνος / ὠρύγη ποταμὸς / Φιλαγριανὸς ἐπὶ τὰ / γ' στερεὰ ἕως τῆς πέτρας.*

In the sixth year of Imperator Domitianus Caesar Augustus Germanicus, under the *praefectus Aegypti* Septimius Vegetus, the *Philagrianum* channel was dug out in all its three dimensions / three sterea/soldum deep down to the rock.

# What the Romans Knew

- **Gold coins**
  - **Aureus (from 50BC, but used only by administrators and traders)**
  - **Solidus (from 300AD, used by ordinary people)**

# What the Romans Knew

- **Beginning of Christian architecture**
  - **The catacomb (subterranean cemetery)**

What the Romans Knew

Piero Scaruffi

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