INTRODUCTION

Collected and edited by Prof. Zvi Kam, Weizmann Institute, Israel

The folder contains the following Power Point Presentations:

Introduction

1. Ancient and Classical world (BC until the 5-th century)
    - 1a. Biology and Medicine
    - 1b. Chemistry
    - 1c. Mechanics
    - 1d. Optics
    - 1e. Astronomy
    - 1f. Numbers
    - 1g. Geometry
    - 1h. Algebra
    - 1i. Summery
2. Middle Ages (6-th until 15-th centuries)
3. The Renaissance (16-th century)
4. Age of reason (17-th century)
5. Age of Enlightenment (18-th century)
6. The Romantic age (19-th century)
    - 6a. Mathematics
    - 6b. Earth Sciences, Astronomy & Biology
    - 6c. Physics & Chemistry
7. The Technological Age (20-th century)
    - 7a. Mathematics
    - 7b. Earth Sciences, Astronomy & Biology
    - 7c. Physics 7 Chemistry
8. The Digital age (21-st century)

The presentations are not intended to replace science teaching materials, but rather to supply chronological lists of scientists and outline their scientific contributions, assembled according to broad scientific hierarchies. It is of course impossible to build a linear order avoiding repetitions, due to scientific contributions of the same person to different fields of science, and to contributions of each invention to different fields. In fact the multidisciplinary nature of science at all times is emphasized throughout this series, both via the broad background leading to an invention, and via the influence on future fields of science.

Science history emphasizes scientific problems, and the way they were handled by scientists at the various ages pushing forward frontiers of knowledge. It is interesting that scientists were intrigued by similar questions from the start of written history till today [1], proposing answers that were accepted at one age but later challenged and replaced (or refined) when better experimental tools and theoretical methods became available [2]. This emphasizes how incremental advancement in wide scientific fronts provide the grounds for singular breakthroughs, and how back and forth flow between technology and basic theory brings about progress and new findings [3].

[1] e.g. Description of our universe, from biblical stories to the big bang.
[2] e.g. Newtonian mechanics replaced by relativity and quantum mechanics. Simple algebra vs. differential equations. Measurements on balls and planets vs. on atoms and galaxies.
[3] e.g. Development of optics provided telescopes to astronomers and microscopes to biologists, and advancement in quantum mechanics enabled the building of transistors and lasers.

To collect the names of numerous influential scientists, mainly in the last centuries, I used lists of prize winners, such a Turing prize, Fields, Harvey, Copley, the Royal Society and obviously Nobel prize laureates in Physics, Chemistry, Medicine and Economy. These prize winners present breakthrough that were most of the times not done alone, but were supported by many of their contemporaries.

Science rely on contradictory requirement for interdisciplinary knowledge and for expertise and deep understanding in the field of research. This can only be achieved by students with broad scientific background, beyond their acquired expertise in one area, as well as with the capability of self learning, expanding and deepening knowledge in every fields that becomes relevant to their work. Although history of science can never be predictive about future scientific trends, it is a way for students to appreciate the way humanity progressed, and learn the benefits, limitations and even dangers associated with scientific progress.

A lot of images, diagrams and schematic plots are included to help anchor the rich, detailed and complex scientific stories to students memory and understanding. The collection of such images was greatly facilitated by Wikipedia !!!
The presentations are not self contained, and rely on knowledge of the reader to expand and discuss material of interest in response to raised questions stimulated by the presentations. These presentations mean to build a broad skeleton, typically not easily available on digital media, while focused Ethernet searches can readily supplement and expand missing information.

The presentations include also topics not typically required in high school matriculation curriculum, notably earth and space sciences. The first topic is increasingly important for environmental preservation, a subject of passionate interest to young people. The second topic, theoretical mathematics, is the ultimate example of a field in basic sciences that always triggered human curiosity though did not offer direct benefits to every day life (although often was later implemented in practical applications, e.g. primary numbers).

It is difficult to register sources and copy rights for material with multiple and multilayer historical citations, and very cumbersome to list credits to material included in these presentations. Fortunately, there is no need to get permissions for open-source educational material, as this is, and web searches can easily retrieve such information.

Last, due to size limitations, the pdf format is available on this web site, therefore not including dynamic presentations and movies. The original PowerPoint format is available at request, and free for modifications.

Zvi Kam, Emeritus Professor,
Molecular Cell Biology, Weizmann Institute of Science
Rehovot, ISRAEL

zvi.kam@weizmann.ac.il

SCIENCE and SCIENTISTS

Science history is tightly linked to cultural history of humanity. We shall tell them together, so that mathematics, astronomy, physics, chemistry, biology, medicine, engineering and technology will take its place within the social and cultural context of its period. It emphasizes the contribution of the “exact sciences” to social sciences, to the arts and to economy, as well as the motivation created by societies to drive scientists and engineers to solve their problems. It is unfortunate that throughout history, too many of these driving forces were created by wars and weapon developments.

Ancient science asked simple questions (as least as we find them today), and offered simple, easy to confirm and understand answers. With the progress of scientific knowledge questions (even similar ones) became more complex, and the provided answers requiring knowledge of higher mathematics and complex measurements technology. The study of science history is thus a journey from the simplest to the more complex scientific information.

It is important to state that science today (as opposed to religion) is not searching for “scientific truth”, but for a description of our world that does not conflict with any known fact about nature. Science searches to develop better and more methods of measuring the world around us, and improve the accuracy of these measurements. Scientific theories need to stand up tests by new data again and again, and the scientific community must be ready to refine or even replace theories that contradict new data. There are also fields of science where experimental data is scarce, yet scientists propose models and predictions to stimulate new measurements (e.g. astrophysics).

Moreover, the complexity of the descriptions of our world make it difficult to provide one “correct” answer to every days problems. The training exercises at school have a unique solution. But real life problems, (e.g. how to create a self sustained society that will not extinct our environment), have many solutions, and choosing the way to best shape our future world involves optimized combination of multiple possibilities, based on partial information that makes the decision a “fuzzy” problem. Our schools rarely deal with the mathematics need to work such problems. I believe that most people dealing with such fuzzy problems and statistical data for their profession (e.g. stock brokers) use ready-made software algorithms without deeply understanding their mathematics. They may be aided by big data they collect at normal times, but badly fail at financial crisis due to new factors that unexpectedly dominate stock trading (psychology: hysteria). It is claimed that deep learning will help drive our cars in the near future. I personally think that if “hand drivers” will mix with car-driving computers on the road, unpredicted accidents will be unavoidable.

But prophecies are certainly not scientifically eligible…
Niels Bohr said: “It is difficult to predict, especially the future”
Max Planck said” “Progress is hindered by capability to abort long accepted theories”
Maxwell said: “Once we believed in “corpuscular light” (light consist of particles) and now we believe in wave theory of light, because the old believers died”. He could not have predicted how fast they will revive again (Einstein photoelectric effect with photons).

Scientist skepticism is a fertile ground to new theories, but the scientific community is required to examine new proposals with matching skepticism and test all aspects before accepting it. Unlike the common image of open-minded scientists, science history demonstrated again and again highly conservative reaction to changes in scientific concepts. They were not only guided by the religious establishment [4] but also by main-stream science societies [5] which motivated the proposers of new theories to provide more and better supporting evidence, as well as data incompatible with the old theories. One can also note in this context the opposite effect of the ease of accepting wrong theories by famous scientists of great prestige [5].

[4] e.g. Copernicus heliocentric model of the planets, or Darwin evolution of species, resisted by the Church

[5] e.g. The struggle against the probabilistic nature of quantum mechanics. The acceptance of DNA as the carrier of genetic heritage in all life forms from Plants, Viruses and Bacteria to Humans.

[5] e.g. The wrong theory of muscle contraction proposed by Albert Szent-Gyorgyi.

Jewish Scientists

As an Israeli, with Jewish heritage, I have interest in the scientific history of my nation, trying to confront the stagnation of the present Jewish religious establishment, despite evidence for scientific progress documented in the bible and in Jewish literature through the renaissance. Since then, without discussing reasons here, many Jews that entered into the scientific world were excluded from the conservative Jewish congregations in Europe (less so in the Islamic worlds).

Jewish tradition glorified artists (e.g. Bezalel, the architect of the temple), medics (biblical hygiene rules, Elisha resuscitated a choked baby), and mathematicians (Raban Gamliel, who mastered calendar calculations). During the second temple, due to attempts to negate Hellenistic influence, science studies were categorized as “external wisdom”, yet Jews lived in Alexandria, the center of wisdom of the Classical world, (e.g. the translation of the bible into Greek, for the library of Alexandria). As a nation of literal people, Jews employed high level secretarial positions for rulers in the Islamic and Christian world, using the mathematics they learned for calculating calendars with Jewish holidays also for financial and economical purposes. It is worth mentioning here Maimonides in the Spanish gold era (12-th century) where Muslims, Christian and Jews shared flourishing coexistence. Maimonides was a medical doctor, philosopher (who knew Aristo ‘s writings), and maybe the last Jewish scholar to interpret Jewish laws and adopt them to the changing life style and growing cities.

There are other examples of Jewish scholars who appreciated “external wisdom”. The genius of Vilna (beginning of the 19-th century) asked his followers to translate books in Mathematics, and Chatam Sofer fought the Jewish Enlightenment movement, that promoted integration in European culture, but admitted that modern science is needed to determine the ways of the sun and the moon, and for engineering measurements.

Jews contributed the logical basis of modern judiciary laws and judicial systems not only through the bible, but mainly through the TALMUD, studied today in most law schools.

The modern era evidenced a large number of Jewish scientists, much larger than their fraction in the societies in Europe and the US. The high fraction of Jewish Nobel laureates is one evidence to their high quality as well as quantity. This can be attributed to the tradition of high appreciation for education. (I strongly resist the racial concept of “Jewish genes”…)

Are the laws of nature simple and clear?

Try to answer these questions:

We all know that earth circles around the sun. Can you prove it?

In fact we know today that at relative motion at a constant speed we cannot determine who is moving...

We know the laws of Gravity. Can you prove experimentally that heavy and light objects fall in equal velocities and times?

We saw that a feather falls slower than a metal ball !!!

We evidenced that large blocks slide faster than small ones down the slope !!!

It is difficult to set an experimental system that isolates gravitational forces from friction.

We use often our camera. Can you describe the way an image is formed?

The Greeks believed light rays exit from the eye and return to the eye, like our hands are send to sense objects around us.

Why did it take thousands of years for humanity to build microscopes and telescopes with enlarged and sharp images?

Production of clear glasses and polishing them required advanced technologies and mathematical understanding of light refraction and ray tracing in lenses and mirrors..

We fall sick and stay home with fever. Why bacteria and viruses were associated with diseases only 150 years ago?

Why plagues in Europe at the middle ages were attributed to heresy, and diseases were cured by witchcraft? Maybe because they could not see bacteria. But they couldn't also see God, and still were believers...

We are used today to graphical presentations of data. When did algebra and the mathematics of functions and their graphical plots developed?

What fields are included in natural sciences?

Basic sciences: From the exact to less exact sciences:

Mathematics, Physics, Chemistry, Biology, Medicine, Psychology.

Modern fields of science:

Statistics, Pharmacology, Computers, Construction Engineering, Architecture,

But probably not: social sciences, philosophy, painting, sculpturing and other visual arts, cinematography, music, dance, literature, economy.

Really? Find dependence of these “non scientific” fields on science and technology.

Paint colors, the print, video art, musical instruments and audio electronics, and data storage are technologies that greatly affected “non scientific” fields.

Can scientific research activities be sorted to defined fields? To basic or applied sciences, or to technology?

e.g. Computer sciences, electronics, logics?

In time basic science become applied, and turn into technology:

e.g. Thermodynamics, Mechanical engineering, nuclear physics.

Sciences present our efforts to understand our world, solve problems posed by life experience, and apply the solutions to improve our lives.

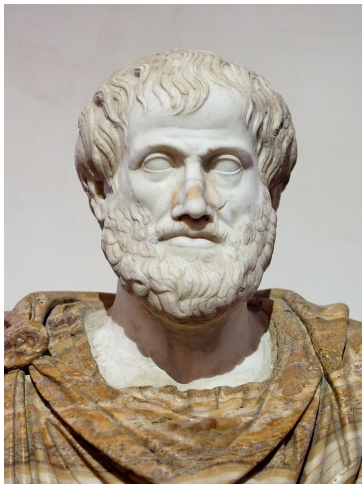
These problems do not discriminate between what we define as fields of science, and their solutions require knowledge in many fields.

This is why multi-disciplinary studies were so important all through science history, as they are today.

Contributions of great scientist in the past were multidisciplinary.

Following are a few examples:

Aristo (Aristoteles) from Athens



384–322 BC

Was a student of Plato, the teacher of Alexander the Great, and the Most influential scientist till the Renaissance. He studies Chemistry, Biology (anatomy), mechanics and astronomy. Was first to understand that plants, like living animals, need nutrition to survive, and that animals need plants to feed on, but plants do not depend on animals. However, he stated that plants need soil and water, and failed to recognize the need for air and sunlight.

He preached also other wrong theories, that nevertheless survived 2000 years: e.g.:

The sun circles around earth (only changed by Copernicus),

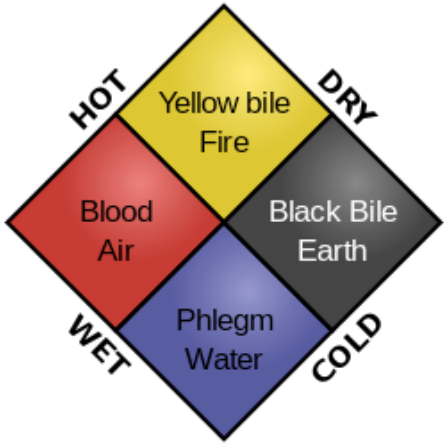
Heavy bodies fall faster than light bodies (proved wrong by Galileo),

The heart is the organ of our thinking and loving (denied only at the renaissance),

Body health and human character reflect a balance between the four body humors: blood (liver), black bile (spleen), yellow bile (gallbladder), and phlegm (brain and lungs). This theory survived till modern times, substantiated by Galen, and was the basis of blood shedding that caused thousands of wounded soldiers to die in the First world war.

Why do wrong theories survive so long?

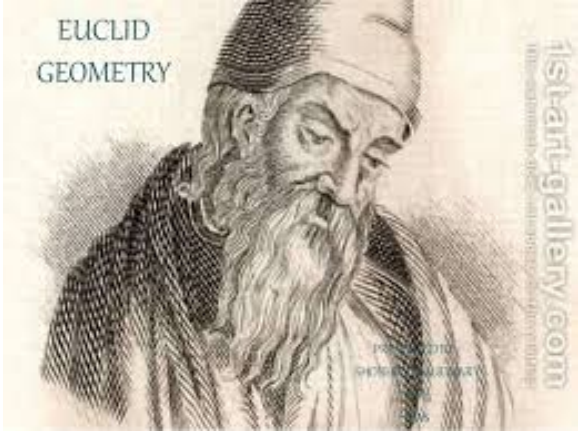
We shall see throughout science history, how difficult it is to disprove or prove scientific theories and models.



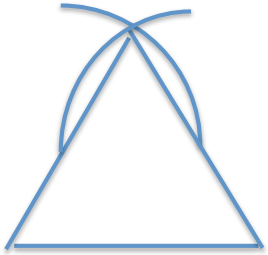
A diagram showing the four body humors and their relation to disease characteristics.

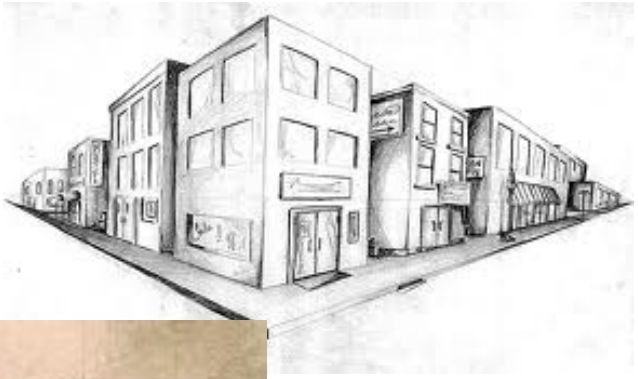
Euclid of Alexandria

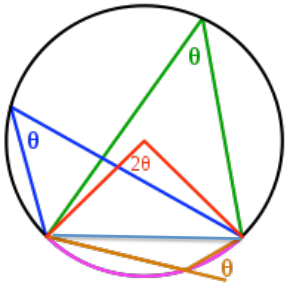
~325 – ~270 BC

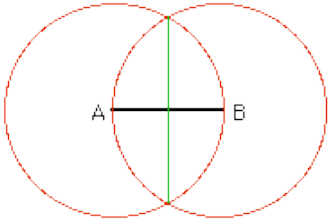


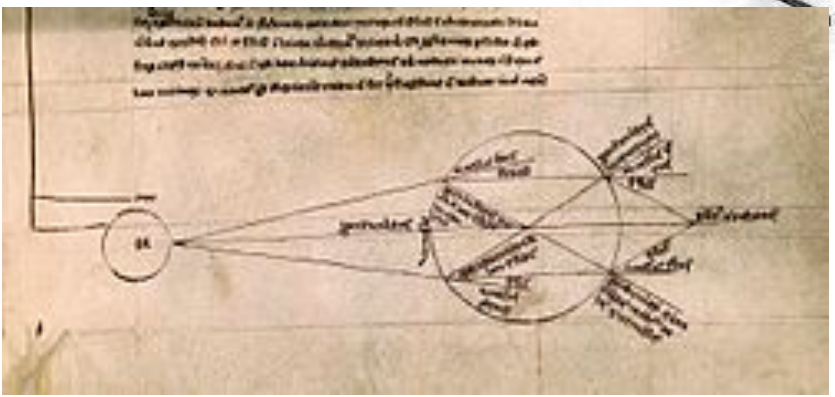
Summarized the first rigorous written composition in mathematics (13 volumes of “Elements” of geometry). Based on a set of axioms, he rigorously derived logical proofs of lemma. Although many were proposed before him, his Integral collection of knowledge in a scientific field became an example for scientific Encyclopedia assembled in following periods. Among his works: geometrical constructions with compass and ruler, projection and perspective of three-dimensional bodies, conic sections, and geometrical optics, describing refraction of light by glass spheres. These demonstrate his understanding of the relevance of geometry to other field of science

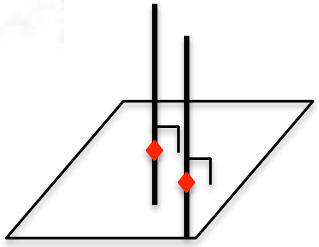


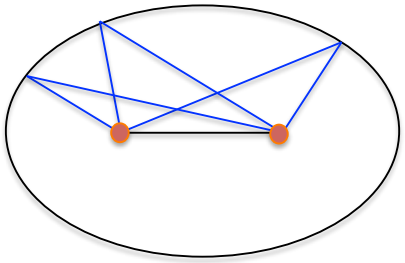






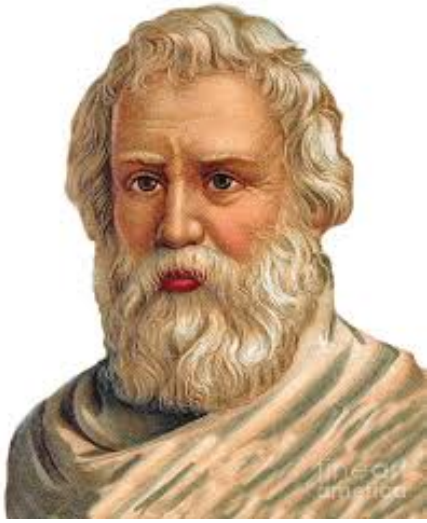






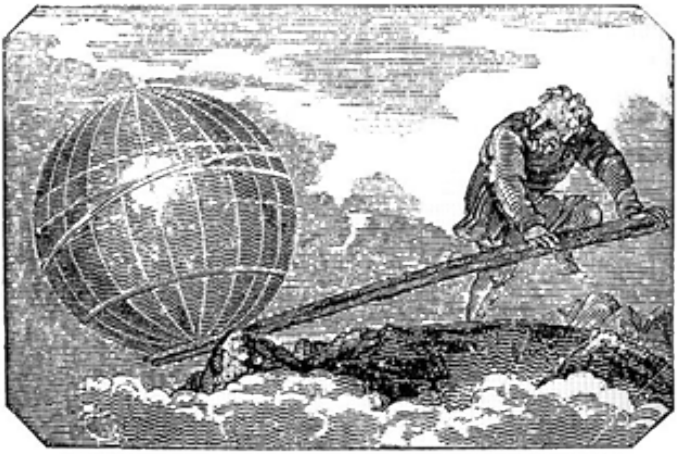
Archimedes of Syracuse

287 – 212 BC

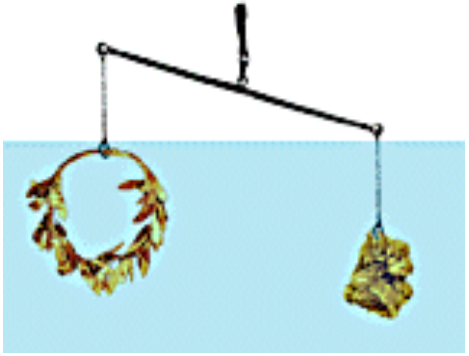


Studied in Alexandria, and was the most esteemed scientist of his time in Italy. He applied his contributions in mechanics (moments), hydrodynamics (law of floatation) and geometry (calculation of π, Volumes of geometrical bodies) to engineering (pump water: Archimedes screw) and for protecting Syracuse during the Roman siege (burnt Roman sails by reflecting sunlight from polished shields, turn over and sink Roman boats using Archimedes jaws).

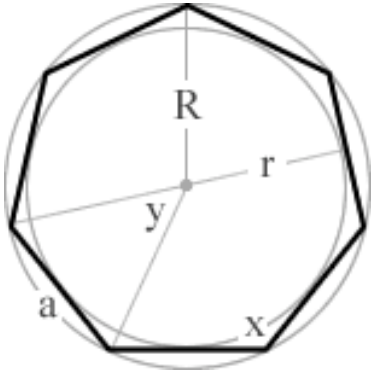
"Provide me with a support and I will lift the earth"



EURECA, king Hero's Crown is not made of pure gold !!!



The perimeter of a circle Approximated by polygons

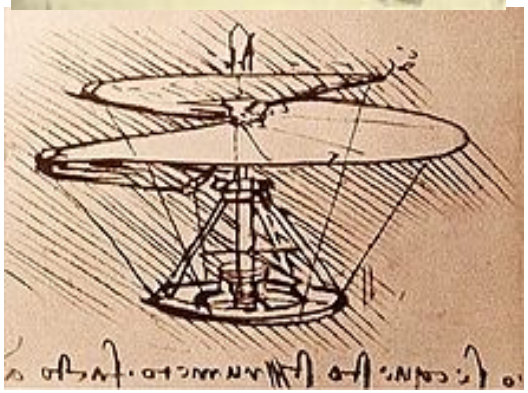


The volume of a sphere bound in a cylinder

Leonardo da Vinci

1452 –1519

The renaissance man, who was a painter who studies human and animal anatomy, inventor of machines, (helicopter, triggered arc) and engineer of city fortifications.



Karl Fridrich Gauss

1777-1855

One of the greatest mathematician and physicist of all times. He was a child prodigy, who solved in a flash the sum of 1 to 100 at the age of 7 responding to teachers quiz. He lived all his life in Göttingen, Germany. Due to his shy character he carried all his work from home. He only agreed once to Alexander von Humboldt Request to visit him in Berlin, since he admired his urge for investigating the world with his own feet.

Among the many areas of his contributions: Number theory, Geometry, Topology, Graph theory, Algebra, Statistics, Astronomy and Physics.

Worth noting here:

Linear best fit by least square minimization (which he applied to fit the parameters of Kepler equations to predict the positions of Ceres and Pallas, the new “small planets”, and for the geodesic survey he conducted for the state of Hanover).

Gauss-Jordan **matrix inversion**.

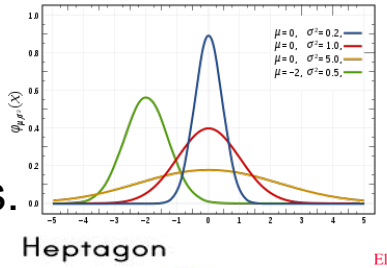
Fast Fourier analysis for interpolation.

Gaussian distribution of errors.

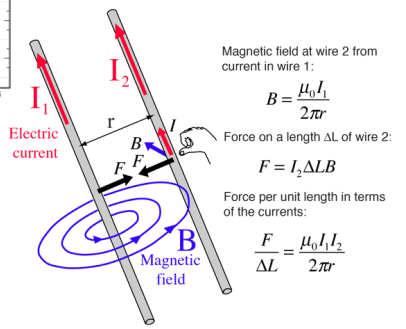
Gauss laws of **magnetic flux** by electric currents.

Construction of **Heptagon** by compass and ruler (an open problem since Euclid)

and many more…



Heptagon



**You will find in this website,
at the front page for each era,
more of such “teaser” slides
devoted to famous scientists
with brief pictorial presentations
of their scientific work.**

What is the significance of natural sciences?

Satisfies our curiosity for knowledge: The aspiration to understand laws of nature and the world around us:

Sort and order animals and plants in families – botany and zoology.

Mathematics, high-energy particle physics, astronomy.

Finds solutions to practical problems and apply them to helpful technologies:

Geometry help design buildings, map cities.

Astronomy sets our calendar and tell us in agriculture when to prepare lands for seeding and harvest.

Offers personal prestige and national pride:

Science advances quality of living of our societies.

Regrettably, science also advances technology of war:

The iron age provided swards and war chariots

Explosives for mining was used for guns.

Ballistic studies were used to design longer-range cannons (Napoleon)

Relativity enabled the construction of the atomic bomb.

Today specialized education is common, why?

Unlike ancient times, it is difficult to cover all of the modern knowledge.

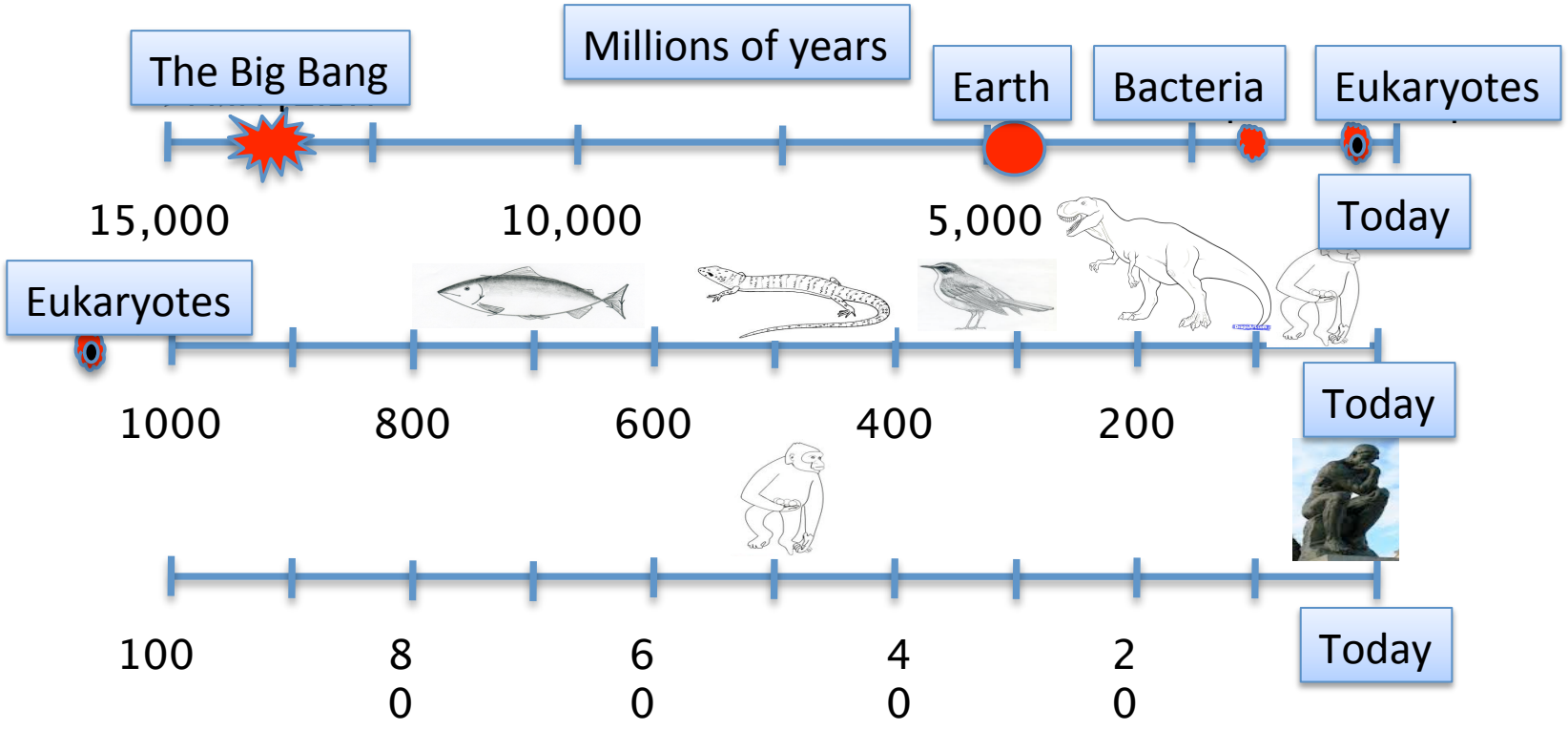
On the other hand, solving typical real-life problems require competence in several fields.

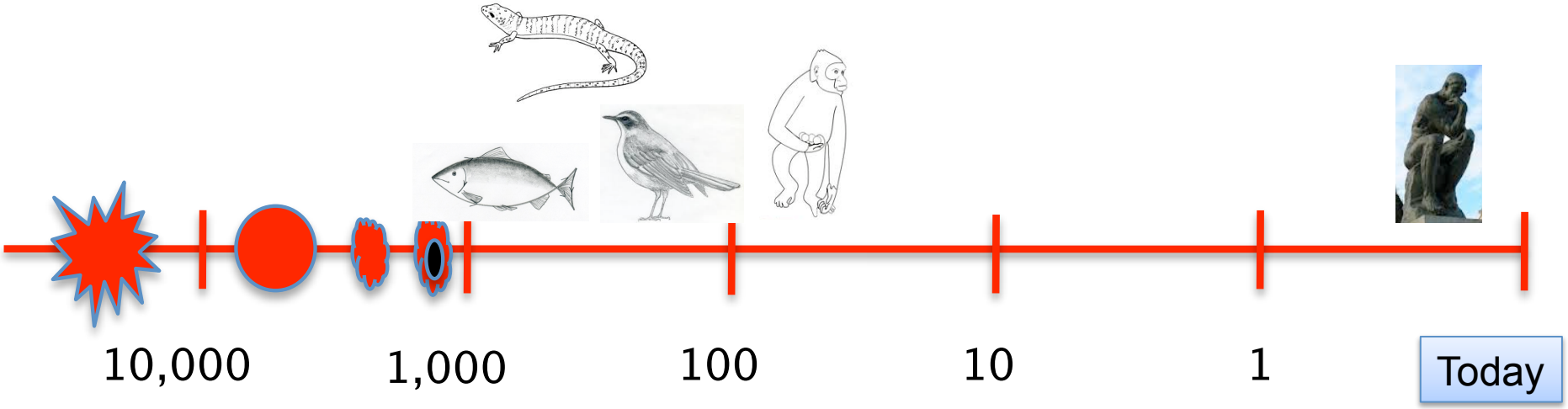
The solution is to acquire broad background in science and technology, experience methods of scientific thinking via thorough and deep learning in one defines field, while keeping awareness of developments in other fields, maintain good capability to independently study topics that become relevant to emerging tasks, and work in teams with supplementary specialization.

The history of science may demonstrate how scientists working together (whether physically interacting, or just learning colleague's work) advanced slowly but steadily our understanding of the world around us and its laws, and provided the knowledge underlying modern sciences.

WORLD TIME SCALES

If the big bang would have happened one day ago, The first man on earth would have happened about a second ago. To plot vastly different time scales we can display several plots with different scales:





Instead of setting, say, 100 million years for each unit tick, we can set every unit time length to be 1/10 of the time length of the previous unit. Thus the first unit is 10,000 billion years, the next 1,000 billion years, etc. The whole time scale is the same, but the events are better spread along the plot for later times. This is called “Logarithmic scale”, while the previous is “linear scale plot”.

The development of scientific knowledge is also not linear. Why?

Clue: The incremental knowledge is proportional to the amount of present knowledge.
Also: information about scientific progress is better documented in later times.

We shall start with ancient history of human knowledge, from the cave man, as documented in wall paintings, through scientific inventions in old civilizations, preserved in archeological constructions as well as in scripts. We shall try to understand what were the technologies human developed to achieve progress in the old era.

We start with biology and medicine, the more descriptive sciences then, discuss chemistry, mechanics, optics and astronomy, and find out the difficulties human faced in ancient and classical era when they attempted to discover laws of nature, and last, how mathematics was developed to help all these efforts.

Two important landmarks in the development of Knowledge: speaking and writing.

When spoken language start to be used?

We do not know for sure, but probably 10,000 years ago people started to use speech similar to spoken languages of today, for social communication and organized distribution of tasks such as hunting of large animals. There are scientists that show evidence of a common structural origin and basic principles to all spoken languages (Noam Chomsky from MIT, Boston).

And writing?

That we know better from old scripts from 5,000 years ago, that were written for administrative purposes of rulers and kings.

There were minor genetic and physiological alterations in humans since the emergence of documented history. On the other hand, the “mental evolution” of humans is very fast. Much faster than the biological evolution, and is mainly dependent on the accumulation of knowledge made possible by speech and writing, and its applications, resulting with huge changes in our life style and every day habits.

It is interesting that one finds during human history many events of destruction of knowledge:

Christians burnt the library in Alexandria.

The Chinese emperor Shih Huang Ti from the Qin dynasty burnt all books of mathematics and killed scientists in his “educational reform”.

The Catholic Inquisition banned and destroyed books of the Classical Greeks.

The Nazis burnt Jewish literature

The Taliban extinguished all written documents and artwork other than the Koran.

The power of knowledge and of free thinking endangers tyrannies. But science can be also employed by tyrants to gain power and suppress freedom (e.g. James Bond movies).

Landmarks in development of enabling technologies

Stone age – 25,000 years ago

Based on findings in the ancient man caves.

Nutrition: Gatherers of Fruits, seeds, roots.

Hunters of animals.

The development of wooden spears, flint stone cutting tools, bows and arrows with sharp stone arrow-heads, and the capability to communicate and organize groups to cooperate in hunting of larger mammals. They offered rich foods, and provided skins and wool for clothes and shoes, threads from tendons for better bow strings (birds hunting), etc.

Fishing. With nets from palm tree fibers, and harpoons for hunting larger fishes.

Cooking: with the lighting of fire from flint stone sparks or wood rubbing.

Controlling fire allowed migration to colder lands, with richer vegetation and wildlife.

The technologies for cutting was not only used for the meat, but to curve handy pots and plates, as well as figurines and jewelry from colored stones, teeth, shells and bones. Free time at night beside the fire was used to paint on the cave walls, and to create spiritual world, with burial ceremonies, religious habits and leaders that were typically the elderly priests.

Prehistoric flint tools. What are the uses for these tools?

Not only necessary tools, but free time activity:
Cave man wall painting from India. What are the colors made off?

Cave man paintings from Lasco, France from 13-25,000 BC

What are the colors made off here? (clue: charcoal, why not in Indian paintings?)

A horse painted in Lasco caves.
Note the black sketch lines with the brown painting: really a modern style.

Middle Stone age – Mesolithic period – 20,000-10,000 years ago

Domesticated animals: Hens, Ducks, Sheep, Cows, Donkeys, Camels and Horses
in China: Pigs, in South America: Lama
Villages of homes such as tents made of wood and skin tents, straw and mud houses,
later ice Igloos, Paper and Bamboo (China).

New Stone age – Neolithic period -10,000 years ago

Agriculture: Land plowing, selective improvement of plant species (e.g. wheat grains).
Yearly seeding cycle,
Irrigation: Control riverbed flooding, Irrigation with buckets, water channels,
pumping wheels.
Storage of excess products: silos for wheat seeds (Egypt), bread baking, dried lentils,
cooking in clay pots, milk and cheese in skin bottles.
beers and wines (yeast primers for bread and wines).

The agricultural revolution:

Wheat and other grains preserved after harvest for a year.
Rice in China, Potatoes, Tomatoes Corn and pumpkins in Americas,
Sugar and Banana in Guinea.

8-7,000 BC: Grains and lentils stored and distributed by organized city states:
in Sumer (in the Perth and Tigris deltas), Egypt
(on the Nile), China (on the Yang-Tse yellow river),
the Amazonas and the Indus.

Dependence on irrigation and transportation on rivers by barges pulled by animals.

An interesting counter example of the development of advanced cultures that were not linked to rivers: Greece, Maya & Inca. Maybe the reason is the more rainy climates and development of transportation by wagons in Greece and Lamas in Central America.

Plowing by mules in Egypt, 1200 BC. Wooden plow preceded the iron age.

What is common to buildings around the world 4000 years ago?

The structures that survived today are stone-built palaces and temples. Their building required huge stones manufactured by large human resources for digging in stone-quarries, for transportation and for the constructions.

e.g. The pyramids were built by thousands of workers, using larger stones that were practically piles in huge mass to conceal a tomb.

Cities contained also simple people's homes, but only walls constructed from piles of small stones and "glued" together by mud can be sometimes revealed. They were covered by wooden ceiling made of branches and straw.

What was the technology of quarrying large stones prior to the iron age?

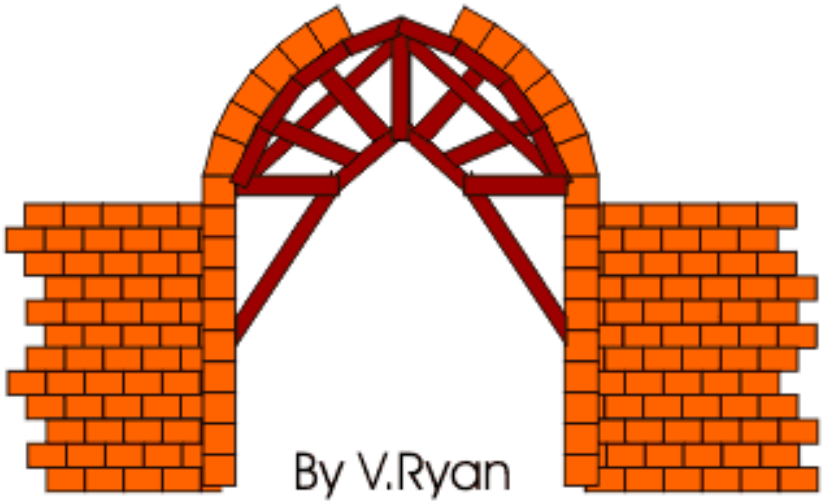
Wooden sticks (maybe with flint tips) were used to drill series of parallel holes in lime stone rocks. The holes were filled with dry branches and sucked wet. The wood expanded and cracked the rock. The remains of these holes is evident in queries as late as the Roman empire.

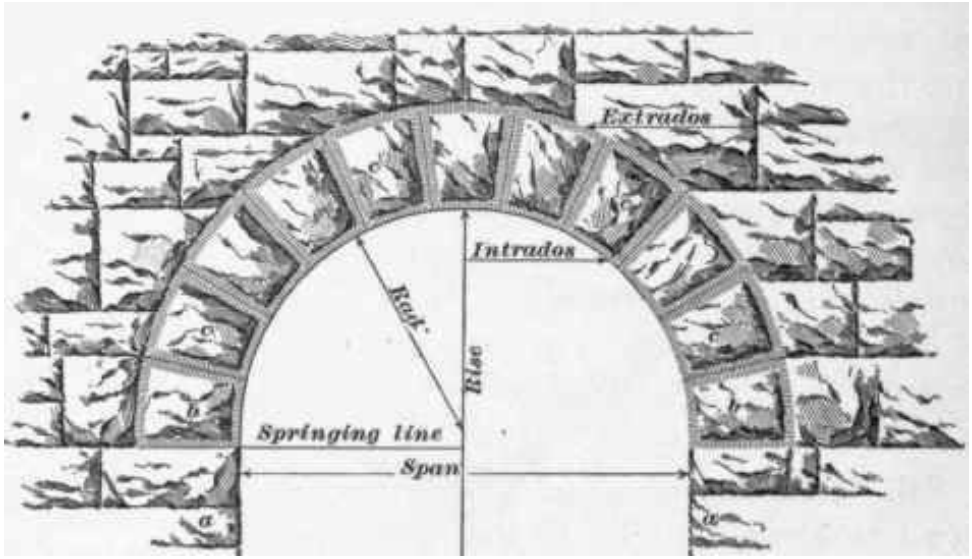
The entrance to a temple in Malta: Large stones are needed to support the top of the gate

Stonehenge: England, 4-5,000 ago: A monumental structure using large stones.

From light homes (tents and brick walls with wooden ceiling) to all stone buildings :

Building methods with gates and ceilings made all from small stones and modest working teams: A wood skeleton supported the positioning of small stone arches. The insertion of a headstone locked and stabilized the whole structure, and the wood support could be removed. Arches also supported ceilings of large halls (e.g. middle ages churches and crusades halls). They were typically built on sand that was cleared after inserting the headstones.





Bronze age 3000 BC

Alloy of copper and lead melts at 900^0C, lower temperature than pure copper (1084^0C), and is harder than lead (melting temperature of 232^0C).
Ores rich with copper sulfate salts ($CuFeS_2$ Cu_2S) have typical greenish color. When heated with silicates, they become oxides then release the oxygen to form molten metal.
Early bronze age tools have similar uses as stone-age tools, (arrow heads, knives, needles, cups, decorative beads) yet they can be made finer (e.g. the comb), lighter, and better decorated.

Iron age, 1200 BC

Iron melts at 1536^0C. Its purification requires hotter furnaces. This was achieved by better heat isolation and by more efficient air blowers (see following presentation in Chemistry).

Iron is stronger than bronze. It was first used for wheels and axels, plows and hammers for stone quarrying and to sharpen bronze tools. Later, by adding carbon to molten iron during its production, steel was prepared with even higher strength and ability to better sharpen knife blades and unfortunately also swards for fighting.

Transportation technology

On land:

Push, pull and carry of loads by one or several man.
Baskets and sacks loaded on donkeys, camels, mules and lama. No need for roads.
Slide loads on rounded wooden trunks (probably used to build the Pyramids).
Wagons with axels and wheels, pulled by animals on paved roads.
Today: tires, ball-bearings, bicycles: what are the advantages over solid wheels?

In rivers and sees:

River barges (pulled from the shores), row-boats, sail-boats.
Engine-propelled boats.

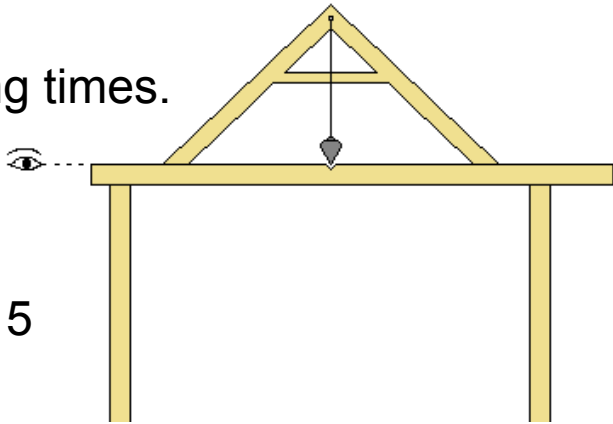
And in the air:

Kites, Parachutes, Wings, Gliders, Hot balloons, Hydrogen and Helium Balloons
Propelled airplanes, Jet planes, Rackets.
Nuclear Ion engines (in space).

Numbers and Measurements!

Integer numbers: counting.
Length units: need fractions.
Area: need formulae to calculate area from length and width for land surveys.
Volume: e.g. number of stones needed to build a pyramid of a given width & height.
The volume of wine or oil to determine the cost in the market.
Weight: standards for fare trade. e.g. compared to the number of olive seeds.
Geometry: generates irrational numbers.
e.g. the diagonal of a triangle (Pythagoras)
the circumference of a circle/
Time: from short durations, up to months of the year (for agricultural planning)
History of many years.

Measuring tools:
Length: Ruler, with repeated length unit, and fractional units.
Weight: Scales to balance unknown with standard weights.
Time: Hourglass (Sand clock) for short times,
movement of the sun, moon and planets for long times.
Volume: Measuring cup for liquids.
Angles: Water level and plumb for horizontal
and vertical building.
Right angle: triangle with edge lengths of 3,4 & 5



Volume of wines:

Archeologists discovered many clay jars with similar sizes. They believe that merchants in early times realized that the volume of a sphere is determined by its circumference, thus used spherical shape jars with standard circumference of 1 forearm (ancient unit length) to measure volume of liquids for sale.

Development of tools for every-day uses was associated with mental tools:

Spoken languages: allowed to organize communal efforts, as well as cultures

Dance, Singing, Music playing, at the basis of religious ceremonies

Written language and numbers: Records of property, food storage, taxes to the emperor.

Record history and glorify the emperor.

Embedding pegs in clay (3500 BC - cuneiform in Sumer)

and ink on papyrus (3200 BC Egypt – hieroglyphs)

Later during iron age: carving scripts on rocks using a chisel.

Babylonian writing (2000 BC)

Chinese writing (1200 BC)

Rope knot number system (1000 BC, central America)

Arabic number system (900 BC, originated in India)

Today: Binary number presentation.

But also “Written Art”: Drawing on walls, Painting clothes with colors.

Jewelry, body painting for beauty and rituals.

Mathematics and Geometry:

Provides quantitative tools for calculations.

At the same time around the world

Probably without communications…

The biblical profit Isaiah, the early Greek philosophers Thales, Anaximander & Heraclitus, Buddha in India, Confucius in China.

Does it indicate similar rate of intellectual development of humans ?

After the defeat of the Persian king Xerxes at 480 BC by the association of Greek Cities, academic prosperity in Athens: Socrates, Plato, Aristo and spread of their followers to small Asia (todays Turkey) and Egypt (Alexandria under the Ptolemaic rulers).
The library in Alexandria was the first international home of wisdom, collecting scripts and commissioning of compositions of encyclopedia e.g. of geometry (Euclid) and religion (the translation of the bible to Greek).

Hammurabi's stele
1750 BC
Cuneiform script listing state laws.
Displayed in the Louvre, Paris.

Scripting systems from around the world

Two main types:
Pictographic scripts: Signs for words:
e.g. Egyptian Hieroglyphs, Maya, Chinese & Japanese (mixed with phonetic letters)
Logographic scripts: A sign for each phonetic vowel: most written languages today.

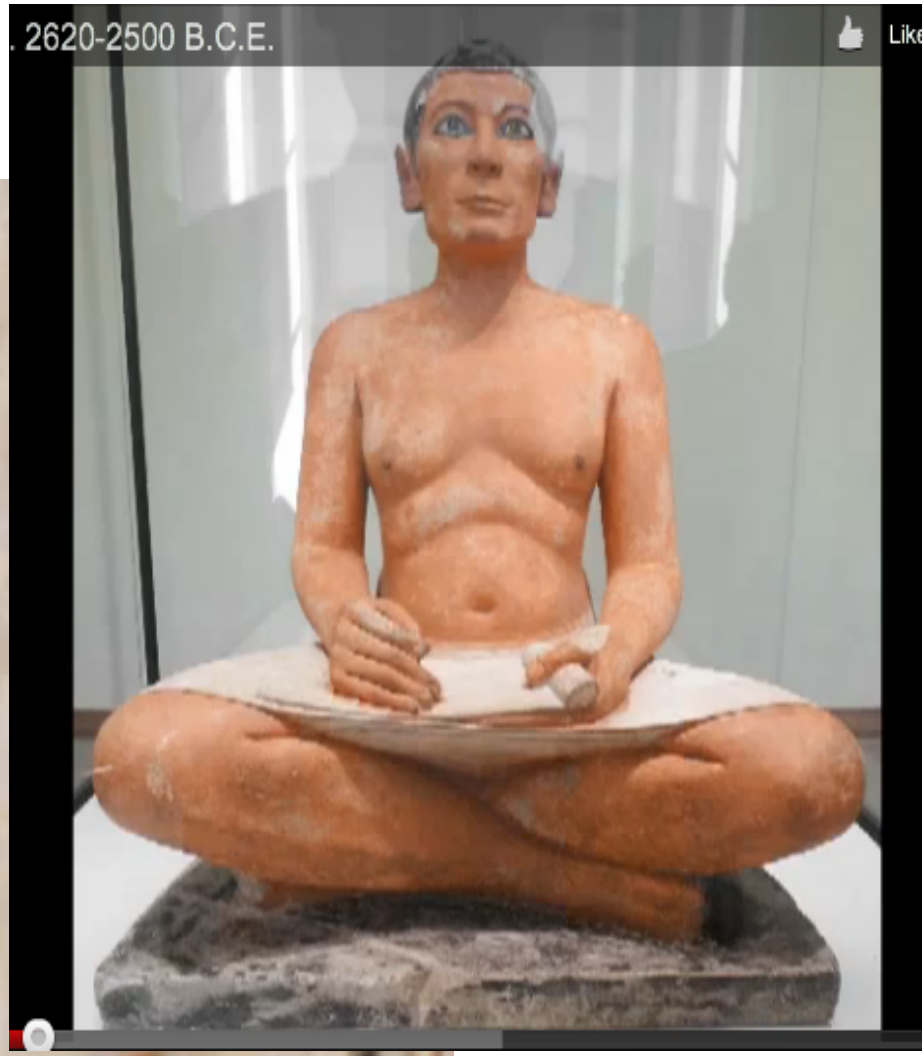
Alignment: Left-to-right, Right-to-left (Arabic, Hebrew), Up-to-down (Chinese)

Numbers: Basis of 60 (Babylon) or Decimal basis (with fewer signs)
Roman number system,
Positional system with Zero (India, Arabic. Europe since late middle-ages).

Relation between the writing media and the scripts:

Pegs on soft clay (Sumer), Chisel on stone, tips and ink on papyrus (Egypt), brush on paper (China):
e.g. squared or rounded letters, direction of writing, uniform thickness etc.

Egyptian wooden statue of a clerk writing on Papyrus
and a wall painting depicting
Egyptian sorcerer / wise adviser to Pharaoh



Egyptian hieroglyphs:
Chiseled onto lime-stone or marble

Hieratic script
Written on papyrus
with reed-tip (calamus)
dipped in ink.
A fast writing method.

Sumer – peg script

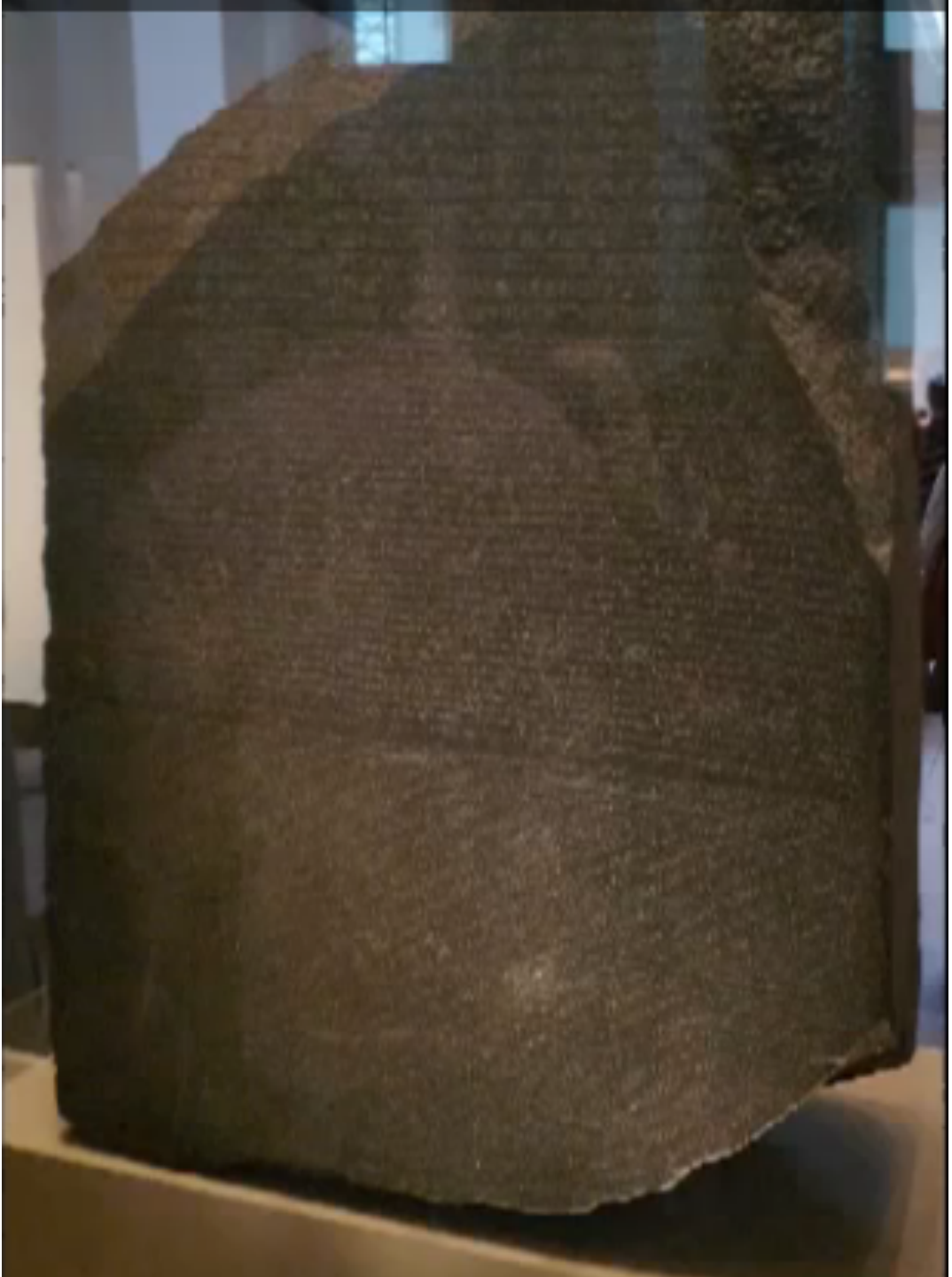
Greek

αβγδηεκλμνυθψφφωϖρστιοπζξχ

Latin

ABCDEFGHIJKLMNOPQRSTUVWXYZ

Indian Sanskrit



The Rosetta stone

Discovered by a soldier in
Napoleon's army
In Memphis.

Written by the Ptolemaic
rulers, to exempt priests
from taxes in order to gain
their loyalty.

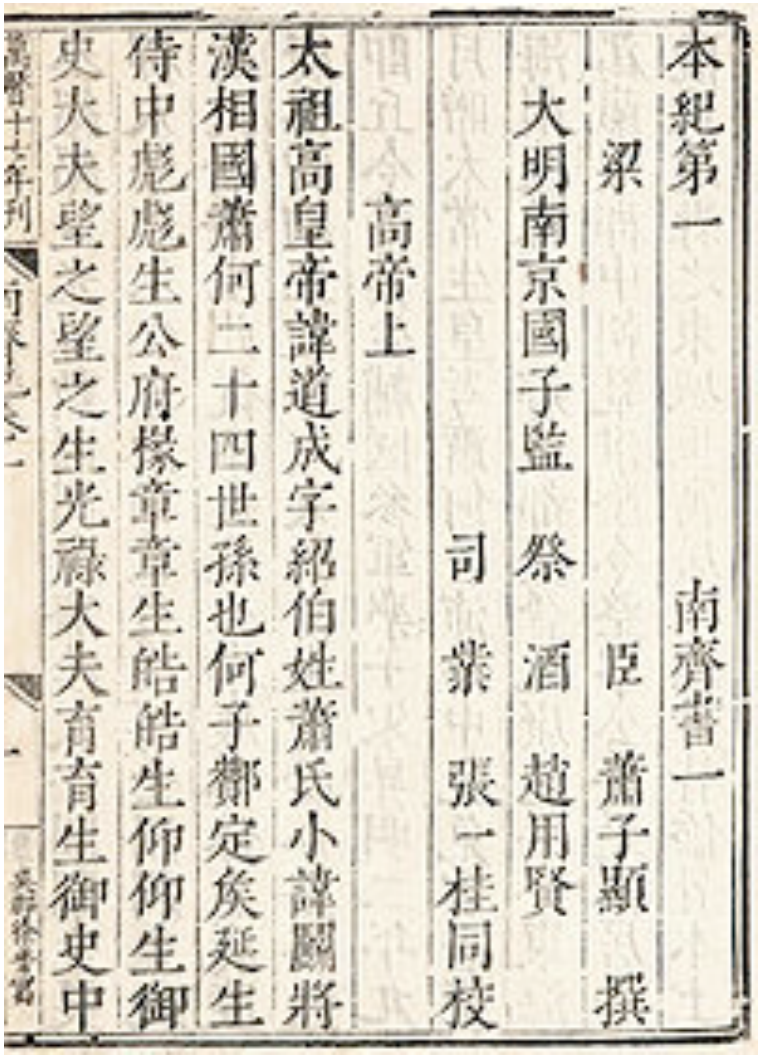
Inscribed in three versions:
Hieroglyphs
Late Egyptian script
And old Greek

Enabled to decipher
Hieroglyphs
by Yang & Champollion

Now: in the British Museum

THE HAAB - month signs from the 365 day calendar

Maya script:
Sculpturing in soft lime stone


本紀第一　南齊書一

梁　臣　蕭子顯　撰

大明南京國子監　祭　酒　趙用賢

司　業　張一桂同校

高帝上

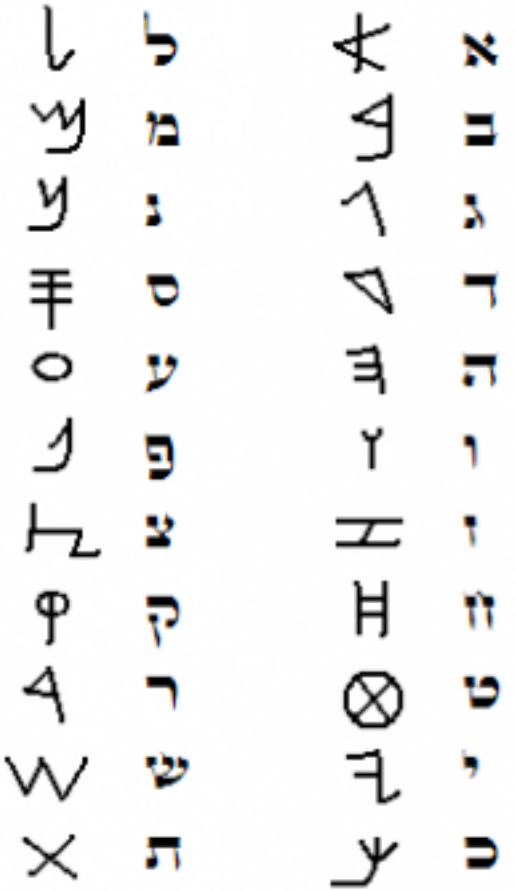
太祖高皇帝諱道成字紹伯姓蕭氏小諱闍將漢相國蕭何二十四世孫也何子鄰定侯延生侍中彪彪生公府掾章章生皓皓生仰仰生御史大夫堅之堅之生光祿大夫育育生御史中

China

Writing with
soft hair paintbrush
on rice paper.
The thickness indicates
Start and end
of the written lines.

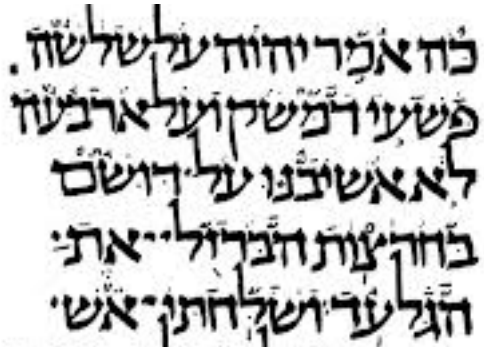
為此所能無

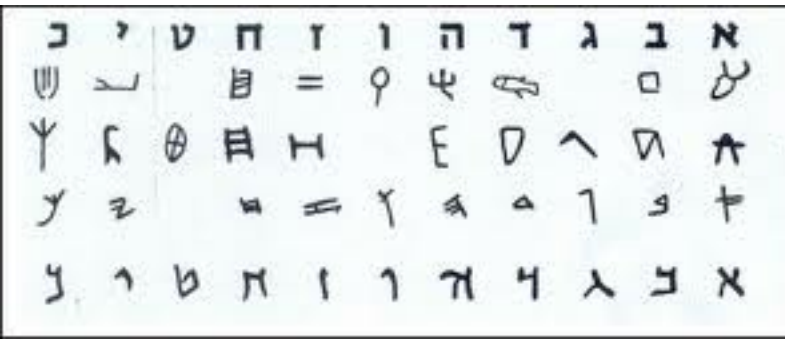
Canaanite / Modern



Hebrew Bible script

Written with calamus on cow skins, and include accents.



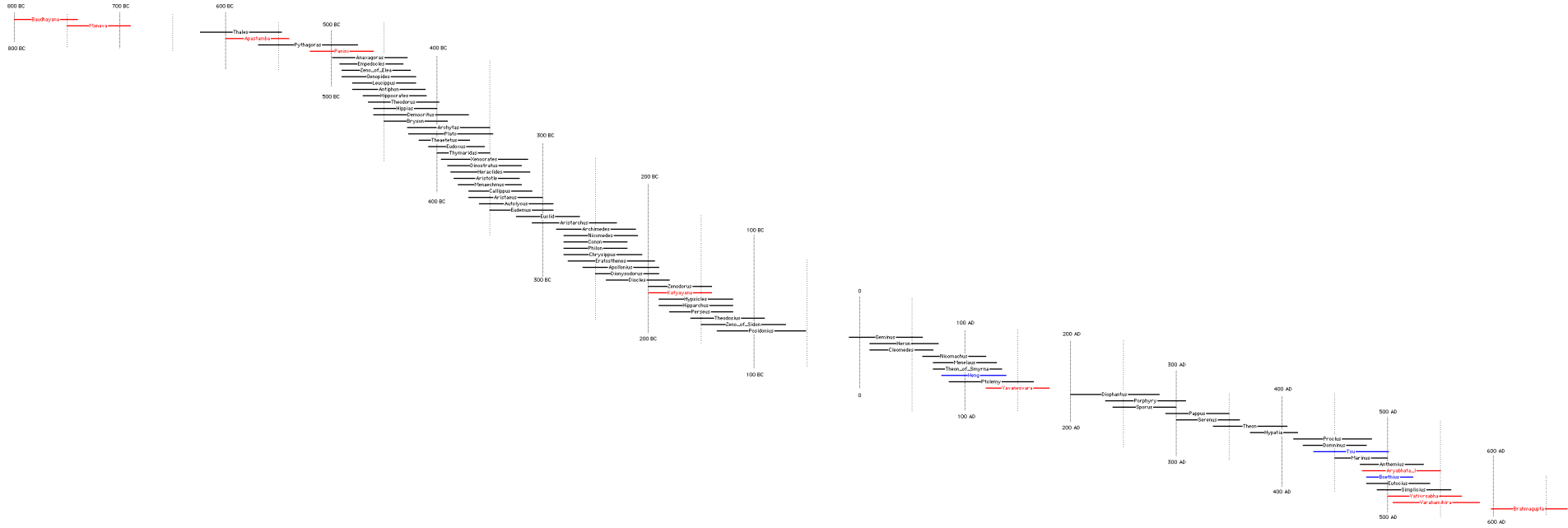


Modern
Canaanite
Proto-Canaanite
Hebrew seals
Rashi (Medieval)

Scientists Time Line

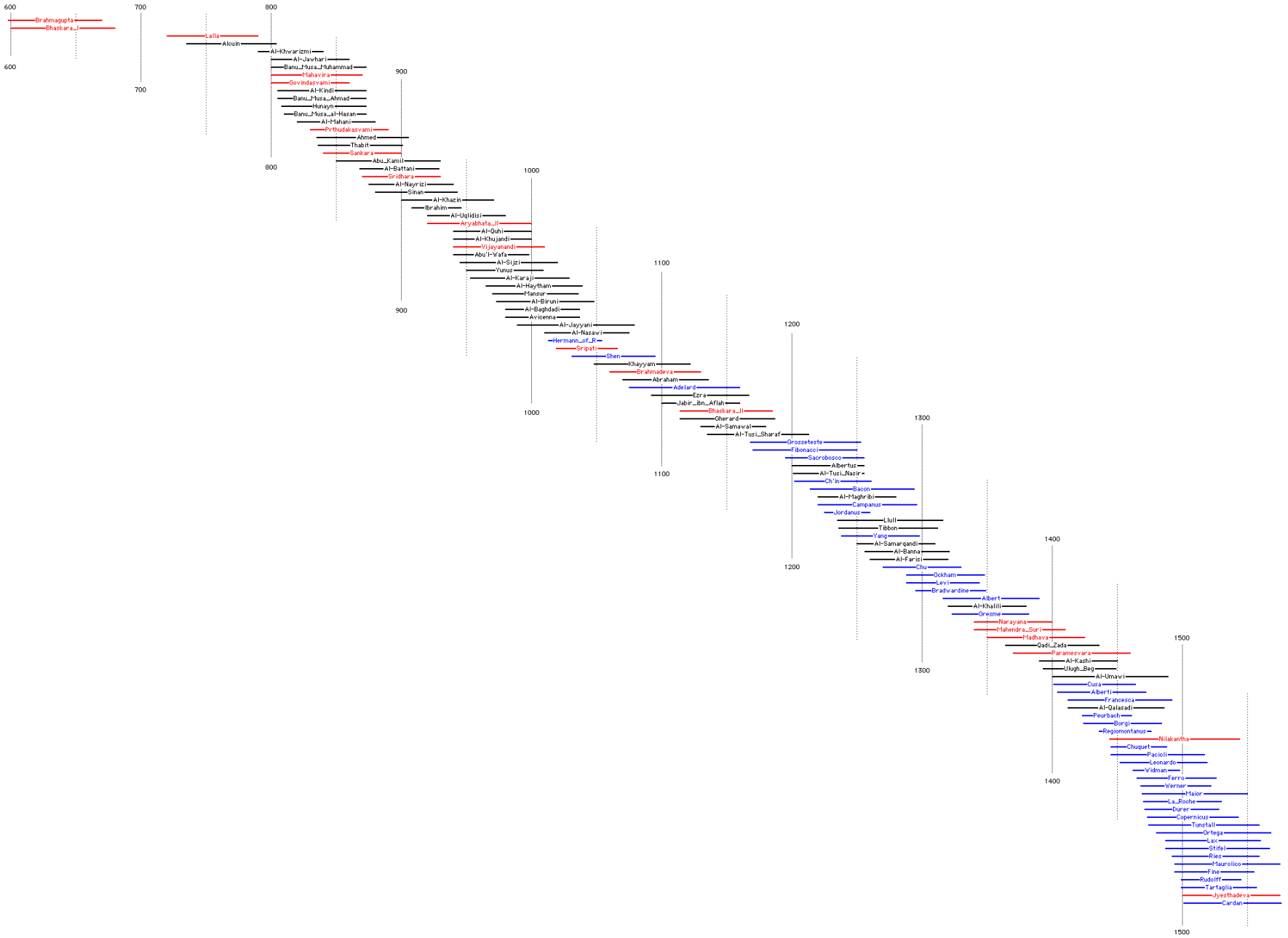
We plot a line for each scientist we know about from birth to death on horizontal time scale. The scientist lines are in equally spaced vertically.

http://www-history.mcs.st-and.ac.uk/Timelines



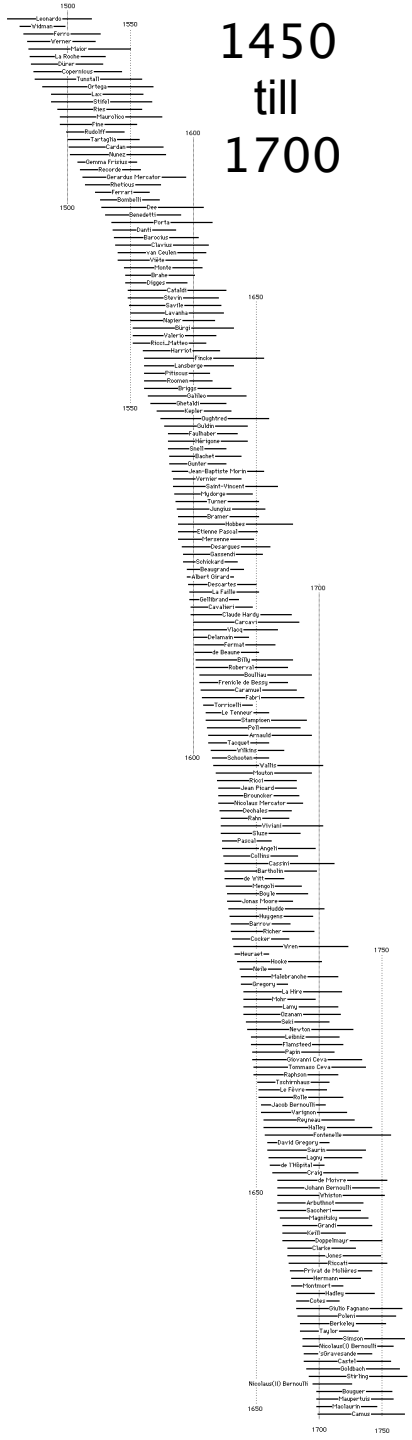
700 BC – 800 AC

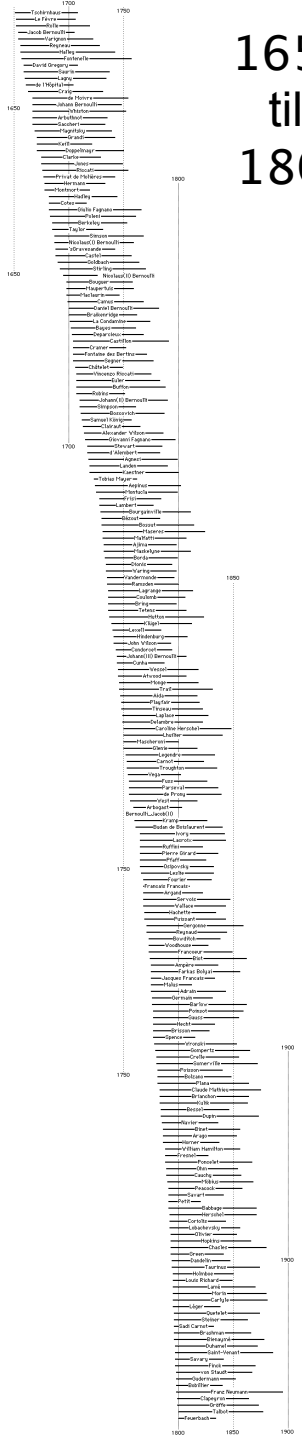
Red- Indian mathematicians Blue-Non-Greek mathematicians

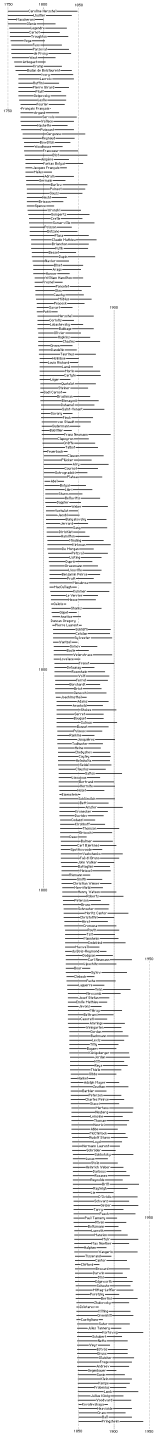


600 AC – 1500

Red- Indian mathematicians Blue-Non-Muslim mathematicians


1450
till
1700


1650
till
1800

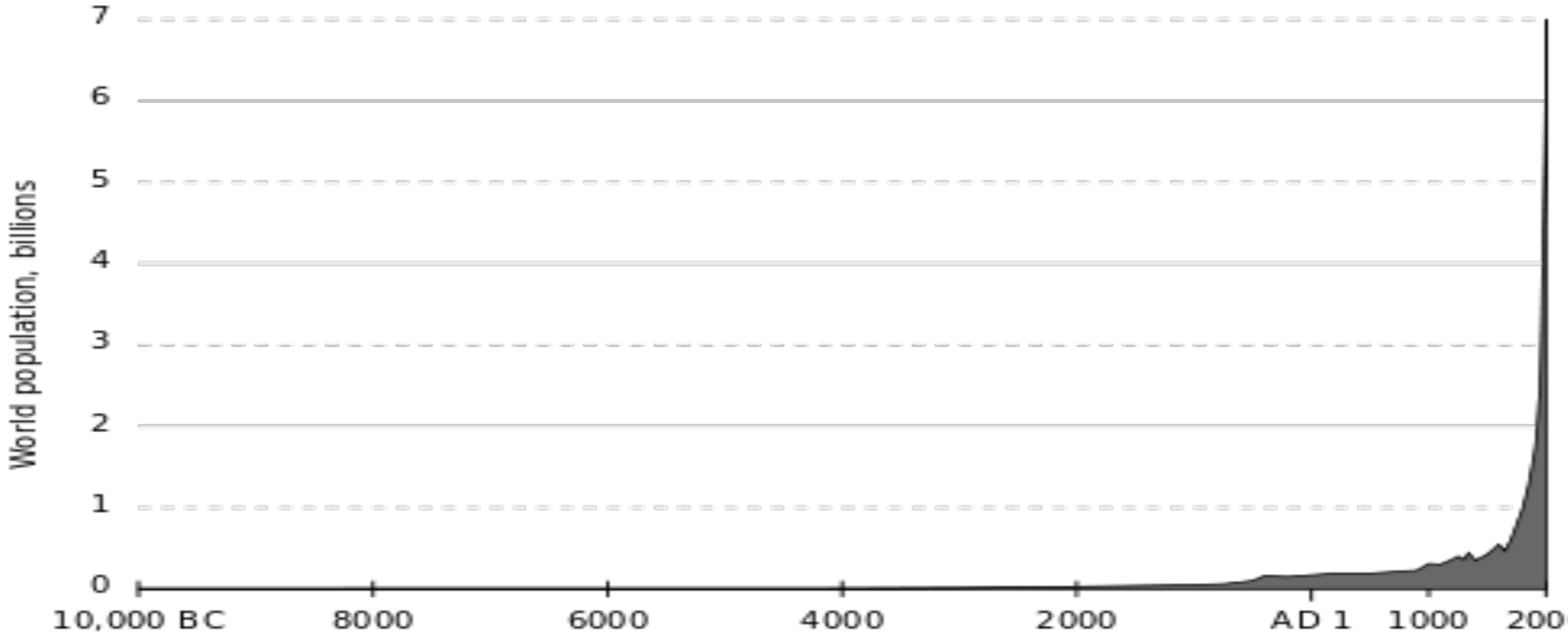

1750
till
1850


1825
till
1960

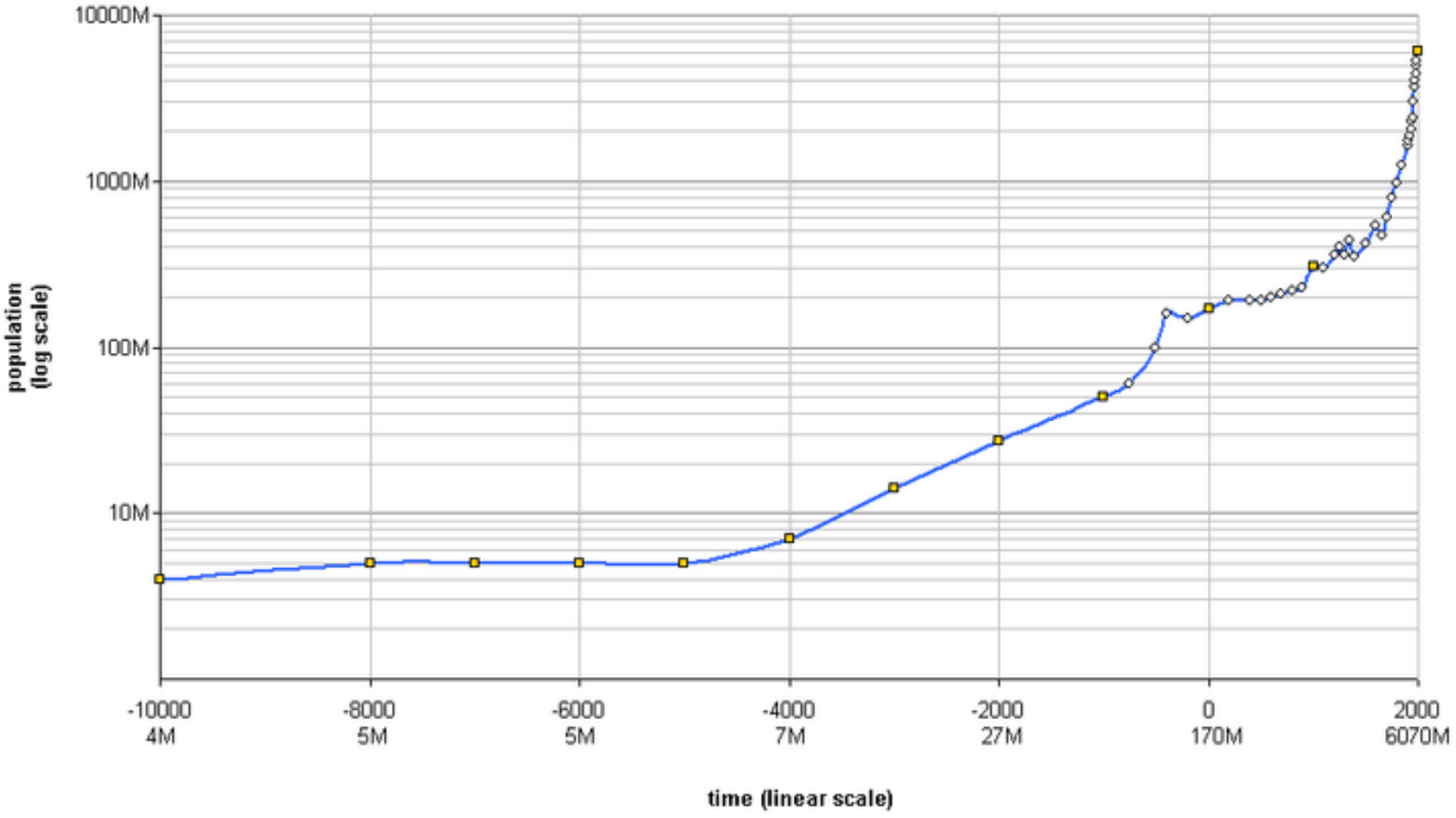
Why is the pattern becoming steeper ?

More scientists in later times
We know about more scientists in recent times
More available documentation preserved more scientific compositions
The spreading of books facilitated science knowledge accumulation,
and amplified scientific discovery events based on known science.

Number of scientists rise exponentially,
Even relative to the exponential growth of the human population.

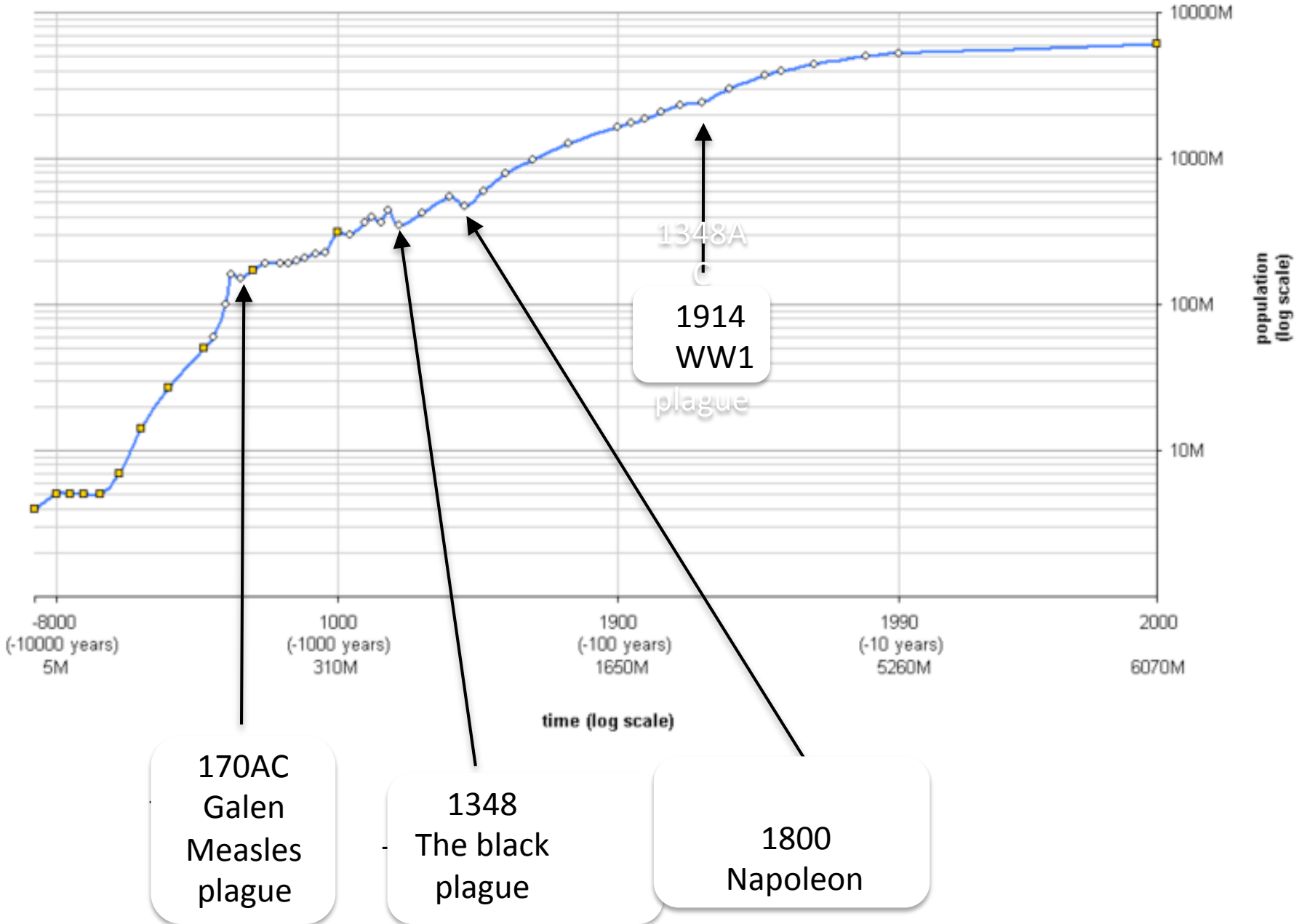


Number of people on earth in Logarithmic scale, versus linear time scale.



Number of people versus time in double logarithmic scale:

Note the better-presented bumps in the curve, indicating global catastrophes.



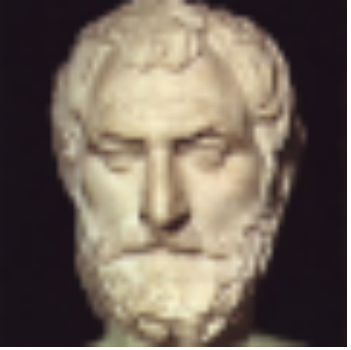
APPENDIX:

The names of scientists at the ancient and classical era

2650 BC Imhotep, Architect of the Pyramid of Djoser (3rd pharaoh dynasty)

750 BC Baudhayana Author of one of the earliest Sulbasutras: documents containing some of the earliest Indian mathematics.

Manava 750-690BC Author of the Indian geometric text of *Sulba Sutras*



625-547 BC Thales of Miletus, the 1st Greek philosopher who proposed that the Earth is a disc which floats on water. Did not discriminate between magnetic and electrical forces (rubbed amber [electron in Greek] attracts pieces of feather) .
Thales was a geometer, military engineer, astronomer, and logician. Probably influenced by Babylonians and Egyptians, Thales **discovered the solstice and equinox**, and is credited with predicting a battle*-stopping eclipse thought to be on 8 May 585 B.C. He **invented abstract geometry**, including the notion that a circle is bisected by its diameter, and that the base angles of isosceles triangles are equal.

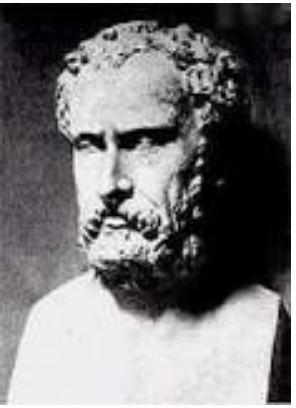
610-545 BC Anaximander of Miletus, book of prose, a treatise about nature. Gnomon: Sun dial, Map of earth, Celestial globe
The Greeks had a water clock or klepsydra that kept track of short periods of time. Anaximander invented (or took from the Babylonians) the **gnomon on the sundial**, providing a way to keep track of time, and he **created a map of the known world**.

Apastamba 570 BC Author of Dharmasūtra: 30 "questions" of geometry needed in ritual ceremonies.

605 to 562 BC - Nebuchadnezzar creates the Hanging Gardens of Babylon - one of the 7 wonders of the old world: Light house of Alexandria, Status of Zeus at Olympia, Temple of Artemis in Ephesus (Asia minor), The great Pyramids of Egypt, The Mausoleum at Halicarnassus, Asia minor (tomb of king Mausolus), The colossus of Rhodes (large statue at the port entrance)

Anaximenes of Miletus 585-525 BC

Archelaus of Athens 5th BC



Xenophanes of Colophon 570-480BC Greek philosopher poet, and social and religious critic

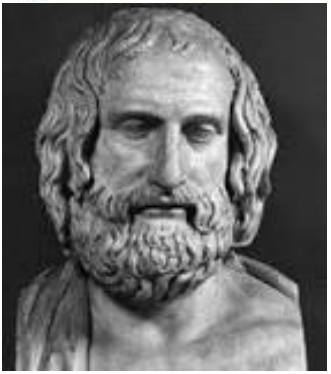
569-475 BC - Pythagoras of Samos, student of Tales. Nature is all of numbers. In addition to discovering the famous property of right triangles, he proposed that the Earth is a sphere and that planets move in circles. Related pitch to string length.

Pythagoras realized that the earth and sea are not static: where once was land is now sea and where once was sea is now land; valleys are formed by running water and hills are eroded by water. He stretched string to produce specific notes in octaves after having **discovered the numerical relations between the notes of the scale**.

In the field of astronomy, Pythagoras may have thought of the universe as rotating daily around an axis corresponding with the axis of the earth. He may have thought of the sun, moon, planets, and even the earth as spheres. He is credited with being **the first to realize the Morning Star and Evening Star were the same**. Presaging the heliocentric concept, Philolaus, a follower of Pythagoras, said the earth revolved around the “central fire of the universe”.

Alcmaeon of Croton (6th BCE) contemporary or student of Pythagoras

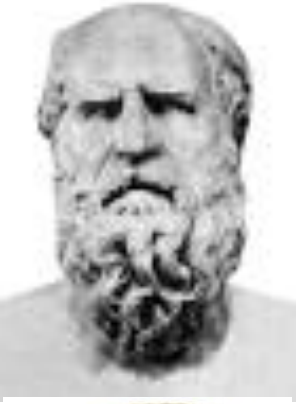
Panini 500 BC Author of Ashtadhyayi, a Sanskrit grammar book, a way to understand spiritual knowledge



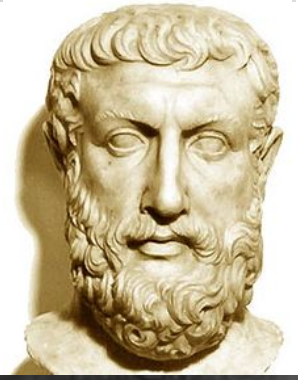
Anaxagoras of Clazomenae 500-428BC

Anaxagoras was the first philosopher to bring philosophy from Ionia to Athens. Influenced by Thales. Anaxagoras made important contributions to astronomy. Moon reflects sun light. He saw valleys, mountains and plains on the moon. He determined the **cause of an eclipse** -- the moon coming between the sun and earth or the earth between the sun and moon depending on whether it's a lunar or solar eclipse. He **recognized that the planets Jupiter, Saturn, Venus, Mars, and Mercury move**. Agathemerus refers to his world map. He saw particle matter as moving in infinite ether (atomism).

Empedocles 495-435BC
Greek pre-Socratic philosopher, Cosmo-genic theory of the four Classical elements: fire, water, air & earth. A myth tells he perished under the flames of an eruption of mount Etna

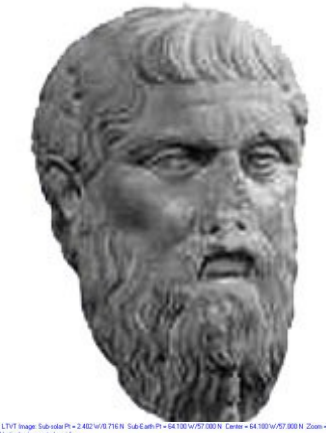


Heraclitus of Ephesus 535-475BC pre-Socratic Greek philosopher



Parmenides of Elea 515 / 540 BC pre-Socratic Greek philosopher founder of the Eleatic school of philosophy. Wrote a poem about nature

Zeno of Elea, 490-430BC Inventor of the dialectic. His paradoxes preceded infinitesimal mathematics.



Protagoras 490-420BC One of the Sophists (teacher of virtue)

Oenopides of Chios ~490-420BC A moon crater on his name. Determined the angle of 24° between the plane of the celestial equator, and the zodiac (the yearly path of the sun in the sky, and the Great Year: the shortest interval of time that is equal to both an integer number of years and an integer number of months. As the relative positions of the sun and moon repeat themselves after each Great Year, this offers a means to predict solar and lunar eclipses.

Socrates 470-399 BC Philosopher, teacher of Plato. Lived in Athens during the Peloponnesian war with Sparta. The oracle at Delphi told him he was the wisest man, which he denied until he realized other man were stupid but believed they were wise, unlike him… He was accused of corrupting the minds of young Athenians and not believing in Athens gods, and sentenced to death, drinking poison.

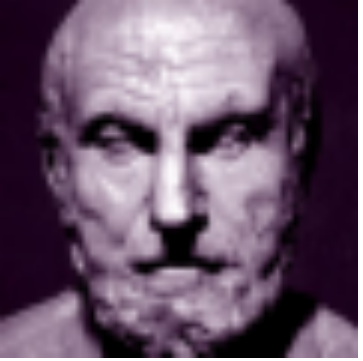
Leucippus, (475 BC) 1st theory of atomism

Democritus 460-370 BC Atomic theory

Democritus believed **the Milky Way was composed of millions of stars**. He was the author of one of the earliest parapegmata (sg. παράπηγμα) tables of astronomical calculations. He is said to have written a geographical survey, as well. Goldstein and Bowen say that Democritus thought of the earth as disc-shaped and slightly concave. Burch ["Counter-Earth,' by George Bosworth Burch; *Osiris* (1954), pp. 267-294] says Democritus thought the sun was made of stone.

Pythagoras Leucippus & Democritus Athens school - atomism. Fled with his brotherhood from Greece to Italy.

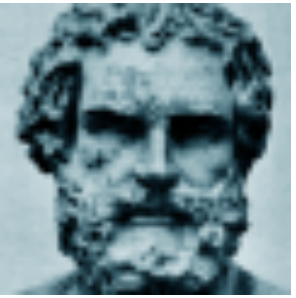
Antiphon



460 BC - 380 BC Hippocrates of Kos, the father of Medicine
Previously, illness had been thought to be a punishment from the gods. Medical practitioners were priests of the god Asclepius (Asculapius). Hippocrates studied the human body and **discovered there were scientific reasons for ailments**. He told physicians to watch especially when fever peaked. He made diagnoses and prescribed simple treatments like diet, hygiene, and sleep.

Theodorus of Cyrene 5th century BC
Greek mathematician. Quoted in three of Plato's dialogues: the Theaetetus, the Sophist, and the Statesman.

Hippias 6th century BC
Tyrant of Athens, succeeded his father, Peisistratus in 527 BC. His son is Hipparchus



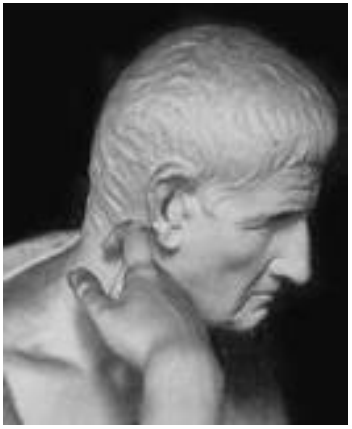
460 BC - Democritus of Abdera, suggested that the world is made up of only vacuum and atoms - an infinite number of tiny, hard, indestructible particles which combine in different ways to produce the variety of everything in the world, both living and non-living.

Archytas 428-347 founder of mathematical mechanics. Designed and built the first artificial, self-propelled flying device, *The Pigeon,* a bird-shaped model propelled by a jet of what was probably steam, and suspended on a wire or pivot for its flight. Archytas' theory of proportions (book VIII of Euclid's *Elements*) where is the construction for two proportional means, equivalent to the extraction of the cube root, was the first in which geometry was studied with concepts of mechanics. The Archytas curve, which he used in his solution of the doubling the cube problem, is named after him.

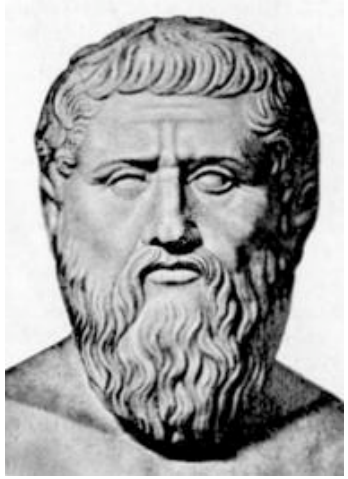
Herodotus of Halicarnassus 490-430 BC Persian-Greek war history - First historian

Antisthenes 445-365BC

Greek philosopher and a pupil of Socrates in Athens. First learned rhetoric under Gorgias before becoming an ardent disciple of Socrates.



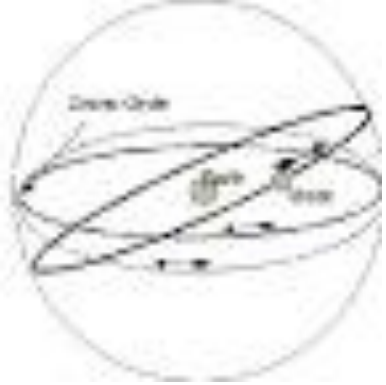
Aristippus of Cyrene 435-356BC
Founder of the Cyrenaic school of Philosophy. He was a pupil of Socrates, but adopted a very different philosophical outlook, teaching that the goal of life was to seek



427-347 BC - Plato, Greek philosopher who proposed that all objects in the Universe moved in perfect circles around the Earth. "Academy". True exists prior to experiment.

Diogenes of Sinope (Laertius) 404-323BC
A Greek philosopher and one of the founders of Cynic philosophy. Also known as Diogenes the Cynic, he was born in Sinope, an Ionian colony on the Black Sea, and died at Corinth

Theaetetus of Athens ~417-369BC
Quoted by Plato: First to construct the so-called five solids, and by Pappus: square roots, proportions in geometry etc.



Eudoxus of Cnidus ~408-347BC

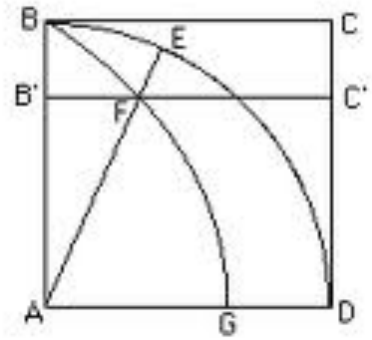
Greek astronomer, mathematician, scholar and student of Plato. Using only uniform circular motions, Eudoxus was able to "save" the rather complex planetary motions with some success. His theory required four homocentric spheres for each **planet** and three each for the Sun and Moon. Eudoxus improved the sundial (called an arachne or spider), made a map of the known stars, **devised a theory of proportion, which allowed for irrational numbers, a concept of magnitude, and developed a method for finding areas and volumes of curvilinear objects**. Eudoxus used deductive mathematics to explain astronomical phenomena, turning astronomy into a science. He developed a model in which the earth is a fixed sphere inside a larger sphere of the fixed stars which rotate around the earth in circular orbits.

Thymaridas of Paros 400-350BC

Greek mathematician and Pythagorean noted for his work on prime numbers and simultaneous linear equations.

Xenocrates 396-314BC

Greek philosopher, mathematician, and leader of the Platonic Academy from 339/8 to 314/3 BC. His teachings followed those of Plato, which he attempted to define more closely, often with mathematical elements.



Dinostratus 390-320BC

mathematician and geometer, and the brother of Menaechmus. He is known for using the quadratrix to solve the problem of squaring the circle.

Heraclides of Pontus 387-312BC

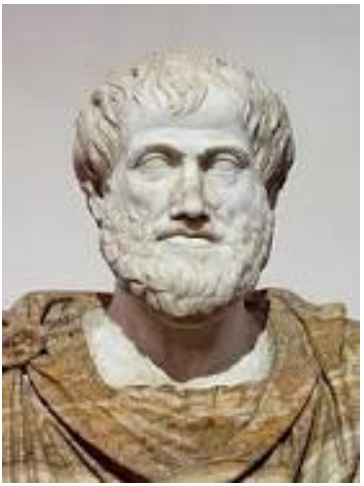
Proposed that the earth rotates on its axis, from west to east, once every 24 hours. He is also frequently hailed as the originator of the heliocentric theory, although this is doubted.

Crates of Thebes 365-285BC

Cynic philosopher. Crates gave away his money to live a life of poverty on the streets of Athens. He married Hipparchia of Maroneia who lived in the same manner that he did.

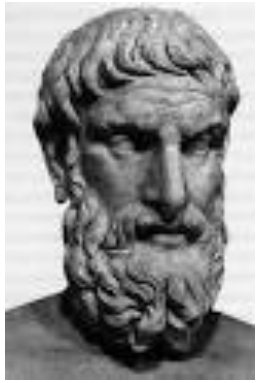
350 BC Pytheas Merchant and explorer of Massilia (Marseille) and great Britain

388 BC - Heraklides of Pontus, Greek philosopher and astronomer who taught that the Earth turns on its axis once every 24 hours.

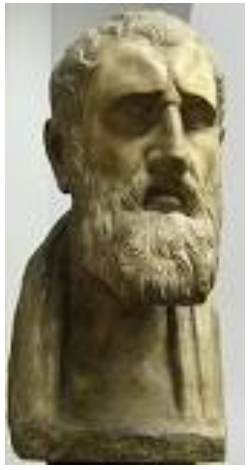


384 BC - 322 BC Aristotle (of Stagira), Greek philosopher studied under Plato. Taught that everything in the material world is composed of four elements - fire, earth, air, and water.
Plato & Aristotle were teachers of Alexander the Great, 356-323 BC Plato's "Academy" True exists posterior to experiment. "Lyceum" training by research (not thinking only…).
Aristotle **decided the earth must be a globe**. The concept of a sphere for the earth appears in Plato's *Phaedo*, but Aristotle elaborates and estimates the size. Aristotle **classified animals and is the father of zoology**. He saw a chain of life running from the simple to more complex, from plant through animals.

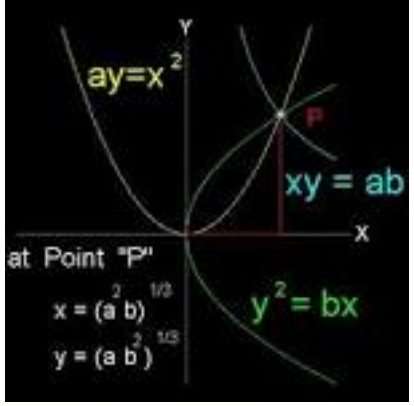
Alexander the great of Macedon 356-323BC
king of Macedon, a state in northern ancient Greece. Alexander was tutored by Aristotle until the age of 16. Established an empire spanning from Greece and Egypt to the Indus river in India, after overthrowing king Darius III from Persia. Preached for religious and cultural plurality, he was gladly accepted by the Jews who opened the gates of Jerusalem to him and showed him the book of Daniel and a prophecy of his success. Spread Hellenism. Built 20 cities on his name, most notably Alexandria in Egypt.



Epicurus 341-269BC Philosopher founder of the school of philosophy called Epicureanism

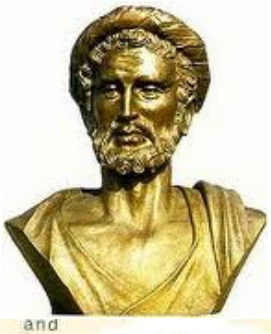


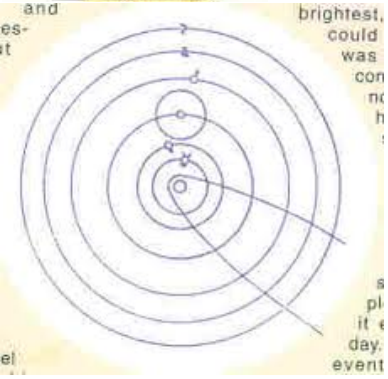
Zeno of Citium 334-262BC
Greek thinker from Citium, Cyprus. He was probably of Phoenician descent. Zeno was the founder of the Stoic school of philosophy, which he taught in Athens from about 300 BC.



Menaechmus 380-320 BC

Friend with Plato Discovery of conic sections and his solution to the then-long-standing problem of doubling the cube using the parabola and hyperbola.





Callipus of Cyzicus 370-300BC

Greek astronomer and mathematician. Studied under Eudoxus of Cnidus at the Academy of Plato. Extended Eudoxus model of plenary motion with more spheres.

Aristaeus 350-330 BC

Pythagorean philosopher, who succeeded Pythagoras as head of the school, and married his widow. Further developments in conic sections.

Autolycus 360-290BC

Astronomer quoted in the Almagest. Great circles, including meridian circles and latitudinal parallels. Visible and invisible areas produced by a light source shining on a rotating sphere. Propositions and proofs. Supported Eudoxus homocentric spheres theory, tried to explain the variability in brightness of Venus and Mars and eclipses, with no real success.

Eudemus of Rhodes 370-300BC

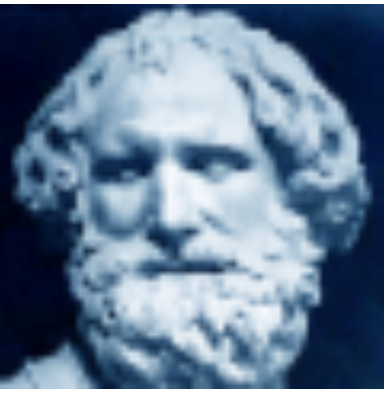
The first historian of science**.** Aristotle's most important pupils, editing his teacher's work and making it more easily accessible.

Theophrastus of Eresus (371-287BC)

Theophrastus was the first botanist we know of. He described about 500 different types of plants and divided them into trees herbs and shrubs.

325 BC - 265 BC Euclid of Alexandria, established Euclidean geometry. Euclid thought that **light travels in straight lines or rays**. He wrote a textbook on algebra, number theory, and geometry that is still relevant.

310-230 BC Aristarchus of Samosis, 1st to suggest heliocentric model
Aristarchus is held to be the **original author of the heliocentric hypothesis**. He thought the sun was immovable, like the fixed stars. He knew that day and night were caused by the earth turning around on its axis. There were no instruments to verify his hypothesis, and evidence of the senses -- that the earth is stable -- testified to the contrary. He was not believed by many.



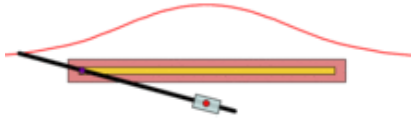
287-212 BC Archimedes of Syracuse discovers the law of buoyancy and specific gravity. Lever.
Archimedes **discovered the usefulness of the fulcrum and lever**. He began the measurement of the specific gravity of objects. He is credited with having **invented what is called the screw of Archimedes for pumping up water or so they say, as well as an engine to throw heavy stones at the enemy**. A work attributed to Archimedes called *The Sand-Reckoner*, which Copernicus probably knew, contains a passage discussing Aristarchus' heliocentric theory. During the Renaissance, Petrarch and Leonardo credited Archimedes with creating the cannon.

Apollonius of Prega 235 BC

Eratosthenes 276-195 BCE

Nicomedes 280-210BC BC

criticized Eratosthenes' method of doubling the cube. Apollonius of Perga called a curve of his creation a "sister of the conchoid," suggesting that he was naming it after Nicomedes' already famous Conchoid curve.

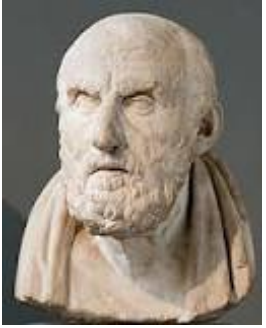


Conon of Samos 280-220BC

A friend of Archimedes whom he probably met in Alexandria. Probably discovered the spiral of Archimedes. Astronomer - constellation "Bernice's Hair" named after Ptolemy II wife who sacrificed her hair in exchange for her husband's safe return from the Third Syrian War, which began in 246 BC.

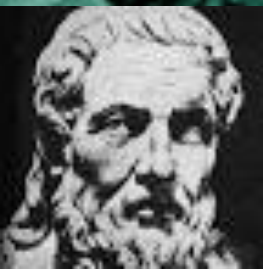
Philon (Philo Judaeus) of Alexandria (of Byzantium) 260-180 BCE

Attempt to fuse and harmonize stoic Greek philosophy with Jewish philosophy.

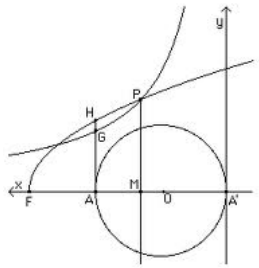


Chrysippus of Soli 280-207BC
Greek Stoic philosopher. Pupil of Cleanthes in the Stoic school of Athens. Logical propositions (if … then …, and, either … or …, because …, more/ less).

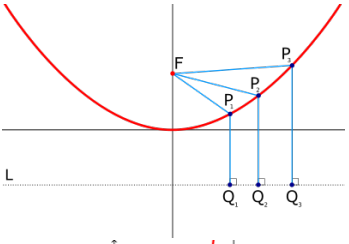
Erastosthenes of Cyrene 275-194 BC director of the library, measured earth diameter

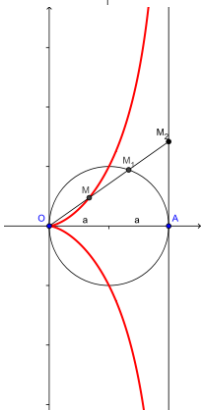


Appolonius of Prega 262-190BC
Greek geometer and astronomer noted for his writings on conic sections. Parabola connects with the area of a square rectangle



Dionysodorus 250-190BC
Solved the cubic equation by means of the intersection of a rectangular hyperbola and a parabola.





Diocles 240-180BC

first person to prove the focal property of the parabola: The distance from any point on the parabola to the focus (P_nF) equals the perpendicular distance from the same point on the parabola to the directrix (P_nQ_n). His name is associated with the geometric curve called the Cissoid of Diocles, which was used by Diocles to solve the problem of doubling the cube.

Zenodorus 200-140BC

Find a mirror surface such that when it is placed facing the sun the rays reflected from it meet a point and thus cause burning. Studies isometric figures enclosed in circles and spheres.

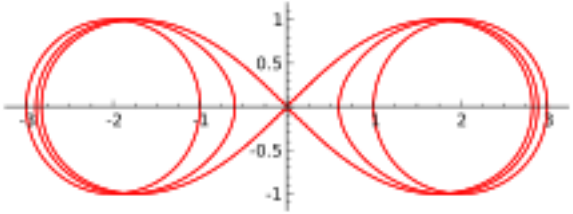
Katyayana, 3rd century BC

Sanskrit grammarian, mathematician and Vedic priest who lived in ancient India.

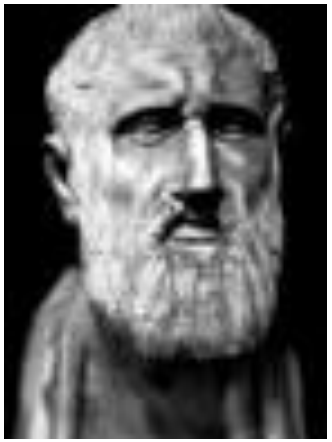
Hypsicles, 190-120BC
Greek mathematician and astronomer known for authoring On Ascensions and the spurious Book XIV of Euclid's Elements.

190 BC - 120 BC Hipparchus, Astronomer, Cataloged 1000 stars. Invented Trigonometry

Perseus ~150BC
Spiric section of Perseus: intersection of a torus with a plane that is parallel to the rotational symmetry axis of the torus: 4-th order curves (conic sections are second order)

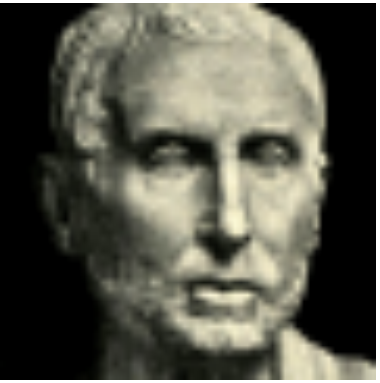


Theodosius 160-100BC Greek astronomer and mathematician, geometry of the sphere. sundial suitable for any place on Earth. Spherical geometry.



Zeno of Sidon 150-75BC

Epicurean philosopher from the Phoenician city of Sidon.
Criticized Euclid, seeking to show that deductions from the fundamental principles of geometry cannot, on their own, be proved.



Posidonius of Apameia, Seria (Rhodes), 135-51 BC lost work

Geminus of Rhodes 1st century BC

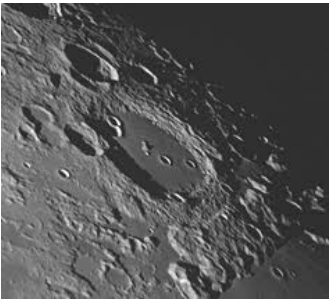
Book on astronomy, including the zodiac, the motion of the Sun; the constellations; the celestial sphere; days and nights; the risings and settings of the zodiacal signs; lunar-solar periods and their application to calendars; phases of the Moon; eclipses; star phases; terrestrial zones and geographical places; and the foolishness of making weather predictions by the stars.

Strabo 63BC - 24

Geographer - 17 books about history of people

Heron of Alexandria 10-70,

experimental nature and math. compositions: dioptra



Cleomedes 1st century BC

Astronomer who is known for his book On the Circular Motions of the Celestial Bodies.

Plutarch 45-120AD

Plutarch then named, on his becoming a Roman citizen, Lucius Mestrius Plutarchus, c. 46 – 120 AD, was a Greek historian, biographer, and essayist, known primarily for his Parallel Lives and Moralia. He is considered today to be a Middle Platonist.

Lucius Annaeus Seneca the younger 4 BC-65 AD

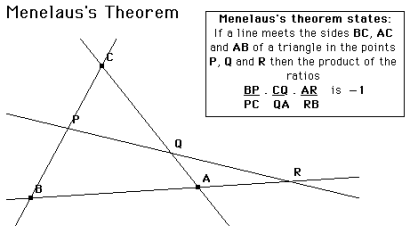
Roman Stoic philosopher, statesman, dramatist, and in one work humorist, of the Silver Age of Latin literature. He was tutor and later advisor to emperor Nero.

Nicomachus 60-120AD

Arithmetic and Manual of Harmonics

Nicomachus theorem: $1^3 + 2^3 + \ldots + n^3 = (1 + 2 + \ldots + n)^2$

$$\left(\sum_{n=1}^{k} n\right)^2 = \sum_{n=1}^{k} n^3$$



Menelaus 70-140AD

Greek mathematician and astronomer, the first to recognize geodesics on a curved surface as natural analogs of straight lines.

Zhang Heng 78 - 139

Chinese astronomer & math

Theon of Smyrna ~100AD

Books about Plato's mathematics. numbers and music harmony.

90-168 - Ptolemy,

Greek astronomer who taught that the stars were attached to a single crystal sphere surrounding the Earth. Theory held till Copernicus, 1543.

Pausanias 120-180 (Times of Marcus Aurelius)
Geographer. Description of ancient Greece from firsthand observations

Galen of Pergamun 129-217
Physician and medical researcher. Cannon till Vesalius, 1543

Dionysius 470-544
Christian calendar

Yavanesvara

Diophantus, born 200-214, died 284-298 at age of 84. Wrote "Arithmetica" - solution of algebraic equations. Father of ALGEBRA

Porphyry of Tyre 234-305AD
Neoplatonic philosopher, opponent of Christianity and defender of Paganism: *Philosophy from Oracles*

Sporus 240-300

squaring the circle and duplicating the cube. Approximations->integrals


PAPPI
ALEXANDRINI
MATHEMATICARVM
COLLECTIONVM
LIBER TERTIVS.
CVM COMMENTARIIS
FEDERICI COMMANDINI VRBINATIS.

Papus 4th century AD

Books about Arithmetic, multiplications, geometry, astronomy and mechanics

Serenus of Antinoeia (Egypt) 300-360AD

Sections of cones and cylinders

Theon of Alexandria 335-405

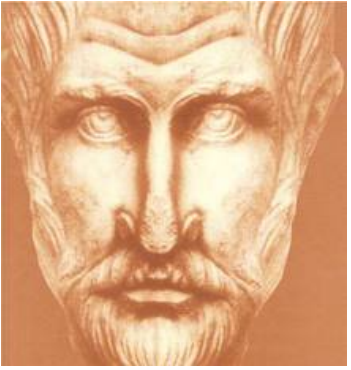
Astrolabe - used by the Arab**s**


HYPATIA

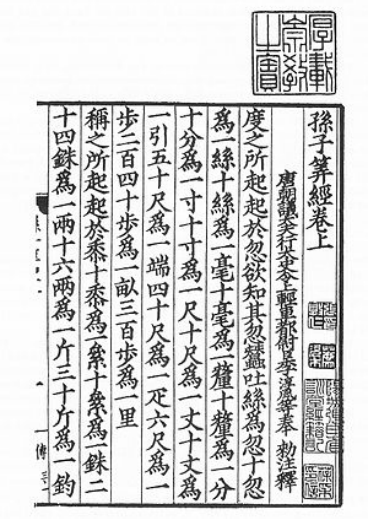
Hypatia of Alexandria 350-415

Greek Neoplatonist philosopher in Roman Egypt who was the first well-documented woman in mathematics. Daughter of Theon.

Was murdered by Christians after their slaughter by pagans and Jews (a fraud that the church was burning)



Proclus 412-485 AD
Athens and Constantinople. Greek Neoplatonist philosopher, one of the last major Classical philosophers.



Domnius

Sun Tsu ~3-5th century
astronomy, calendar, Diophantine equations, Chinese remainder theorem.

Marinus of Neapolis (Israel) ~500AD
Possibly a Jew from Samaria

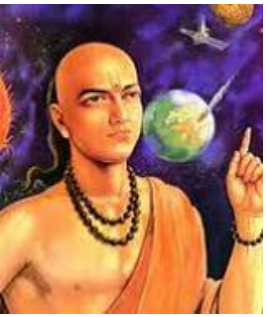
Anthemius 474-558 AD
professor of Geometry in Constantinople and architect, who collaborated with Isidore of Miletus to build the church of Hagia Sophia.
String construction of the ellipse, and light focusing properties.

Aryabhata_I, 476-550
Math & Astronomy. Inventor of digit ZERO

Boethius 480-524 AD
His books were very influential on middle ages science.

Eutocius 480-540 AD
wrote commentaries on Apollonius and on Archimedes.

Simplicius of Cilicia 490-560 AD
commentaries on Aristotle



Yativrasabha

Varahamihira 505-587 AD
Astronomer and astrologer (horoscopes)

Brahmagupta, 598-670
Math & Astronomy.

Bhaskara_I 600-680

first to write numbers in the Hindu-Arabic decimal system with a circle for the zero. approximation of the sine function

$$\sin x \approx \frac{16x(\pi - x)}{5\pi^2 - 4x(\pi - x)}, \qquad (0 \leq x \leq \frac{\pi}{2})$$

520 AC – translation of Aristo to Latin by the Roman philosopher Boatius.

Isidore of Seville 560-636 CE wrote "Etymologies" collection of ancient wisdom

Boethius 480-524 CE translated to Latin Aristo, Plato, Ptolemy

Thomas Aquinas (1225-1274)

John Scotus Eriugena (815-877) Irish theologist Neoplatonist & poet.

Procopius of Gaza (465-528) - describes earthquake that partly destroyed Hagia Sophia. Describes the water system to Jerusalem.

Timothy of Gaza (491-518) - Book of Animals: zoology

John Philoponus of Constantinople (490-570) Aristotelian scientist. Quoted by Galilee.

Hierocles (6th century) - Byzantine geographer, author of Synecdemus: list of administrative divisions and cities in the Byzantine empire

Hesychius (end of 5th century) - compilation of ancient writings

Anthemius of Tralles (474-558) & Isidore of Miletus (532-537) - Architecture: St. Sophia

Justinian (530-533)- digest of Roman law

Michael Psellus (1018-1096) -Byzantine historian

Claudius Aelian (3rd Century) *On the Nature of Animals*

Agathemerus (1st CE) - "Geography" earth is a sphere, Delphi is the center. Info from Alexander the Great's conquests, and Hecataeus & Herodotus work.

Marcellinus Ammianus (325-395 CE) historian under Constantinus II & III

Arrian (89-180 CE) Roman historian

Asclepiades of Bithynia (1st BC) - Greek physician, flourished in Rome. Against Hippocrates humors, diseases treated by diet, bathing, exercise, induce vomiting and bleeding, wine. First to open direct airway to breath by incision in the neck.

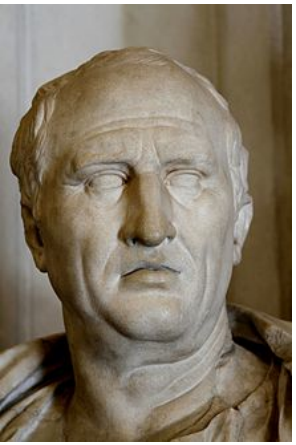
Athenaeus (3rd CE) Greek rhetorician and grammarian

Marcus Aurelius (121-180 CE) Roman Emperor (good) and stoic philosopher, wrote "Meditation" self control.

Augustine Aurelius (354-430 CE) early Christian theologian

Julius Caesar (100-44 BC) Emperor, Latin prose writer. Calendar.

Marcus Porcius Cato (Elder) (234-149 BC) History of Italy, Speeches.



Celsus (25 CE) Greek philosopher, encyclopedist, medical compilations, and opponent of Early Christianity

Cicero (106-43 BCE) Roman lawyer speaker and political theorist.

Lucius Junius Moderatus Columella (5BCE-60CE) writer on agriculture of the Roman empire

Diogenes of Apollonia (late 5th BC) Philosopher, known through Diogenes Laërtius and Simplicius: air source of all.

Epictetus (55-135 CE) Slave who became philosopher in Nero Caesar's court

Erasistratus (304–250 BC) Greek anatomist and royal physician under Seleucus I Nicator of Syria.

Erasistratus of Ceos (275-194 BC) physician

Eunapius (5th CE) Greek sophist and historian

Sextus Julius Frontinus (late 1st CE) Roman statesman: senator & consul

Hecataeus of Miletus (500BC) early Greek historian & geographer: world map

Hellanicus of Lesbos (5th BC) ancient Greek logographer and historian

Heraclides of Pontus (390–310 BC) Greek astronomer: star move because of earth rotation. irregular planet motion explained if earth move and sun is still.

Hero: the first steam engine

Hero (62-152 CE) Alexandria inventor, physicist and mathematician. Fascinated by air and water. Vacuum and kinetic energy. Boiling water steam whistler, turns a ball, holds a ball in stream, etc.

Herophilus of Chalcedon (3rd BC) Dictionary of Medicine, pioneering neuroscientist.

Hesiod (late 8th BC) Ancient Greek poet, probably a bit after Homer.

Hippo of Croton (late 5th BC) one of the most eminent natural philosophers and medical theorists of antiquity.

Homer (8th BC) The greatest Greek poet. Wrote Iliad & Odyssey.

Iamblichus (250-325 CE) Syrian Neoplatonist philosopher, wrote about Pythagorean philosophy

Julian (331-363 CE). reasons for Earthquakes ("pneuma" gas, winds, fog, rain, dry land)

Lucretius (1st BC) Roman poet and epic philosopher

Maximus of Ephesus (4th CE) Neoplatonist philosopher and a magician in Rome. Influenced emperor Julian, but executed to death after he died.

Nearchus of Crete (360-312 BC) Officer in the army of Alexander the Great. Wrote about his trips in the Indus valley.

Oribasius (4th CE) Greek medical writer and the personal physician of the Roman emperor Julian the Apostate

Palladius (mid-4th BC) a Roman writer on agriculture: activity for each month in farms and caring of animals.

Philolaus (5th BC: 470–385 BC) Greek Pythagorean and Presocratic philosopher: limiting and limitless. Earth is not the center of the universe, but some body made of fire.

Philostratus (170-250 CE) Greek sophist of the Roman imperial period

Pliny the Elder (23-79 CE) Roman author of encyclopedia, naturalist and geographer.

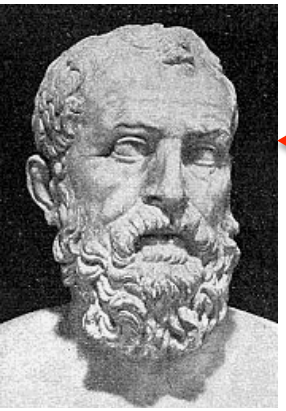
Pliny the Younger (61-113 CE) Lawyer, author, and magistrate in Rome.

Plotinus (205-270 CE) philosopher of the ancient world who is widely considered the founder of Neoplatonism

Polybius (208-126 BCE) Greek historian of the Hellenistic period and rise of the Roman republic. Separation of powers.

Porphyry (234-305 CE) Neoplatonic philosopher wrote introduction to logics and philosophy.

Posidonius of Rhodes (135-50 BC) Greek Stoic philosopher, politician, astronomer, geographer, historian



Pytheas of Massilia (late 4th BC) Greek geographer and explorer

Solon (640-560 BC) Athenian statesman, lawmaker, and poet. Set the constitution in Athens.

Tacitus (56-117 CE) senator and a historian of the Rome (Tiberius, Claudius Nero)

Themistius (317-388 CE) Statesman, rhetorician & philosopher

Thucydides (460-400 BC) Greek historian and Athenian general described the Peloponnesian war between Sparta and Athens

Varro (116-27 BC) Ancient Roman scholar and writer

Vitruvius (25 BC) Roman author, architect, and engineer. First book on architecture

Xenophon (430-355 BC) Greek historian, soldier, mercenary, philosopher. Life in Athens (supported Socrates) and Persia. Was exiled from Athens.