

# Classes till Mid Sem.

Science in Ancient time  
and  
Middle Ages

# Pre Historic and Historic

- Humans have existed for at least 500,000 years and probably for close to 2 million years.
- Until 12,000 years ago or last Ice age, they all lived in tribal group subsisting on natural vegetation and meat of wild animals
- Between 98 to 95.5 percent of our existence, we have been hunter and gatherer
- Pre historic- Architectural analysis for example Mary Leaky, D Johansson

# Paleolithic- lasted until 12000 years ago

- Hand held tool made of Stone, wood and bone
- Cave art
- Discovery of fire
- Shelter, language and religion

# Paleolithic period

- Shape of bucket, sickle
- Flint blades for example obsidian
- Practice of burying the dead
- Continuity and sustenance of food collecting system

# Paleolithic to Neolithic

- Ice age- Spread of population to all parts
- Food collection to food production
- Agriculture- Season, permanent assets, concept of work, distribution
- Domestication- taming, breeding, genetic selection, introduction of new species etc.

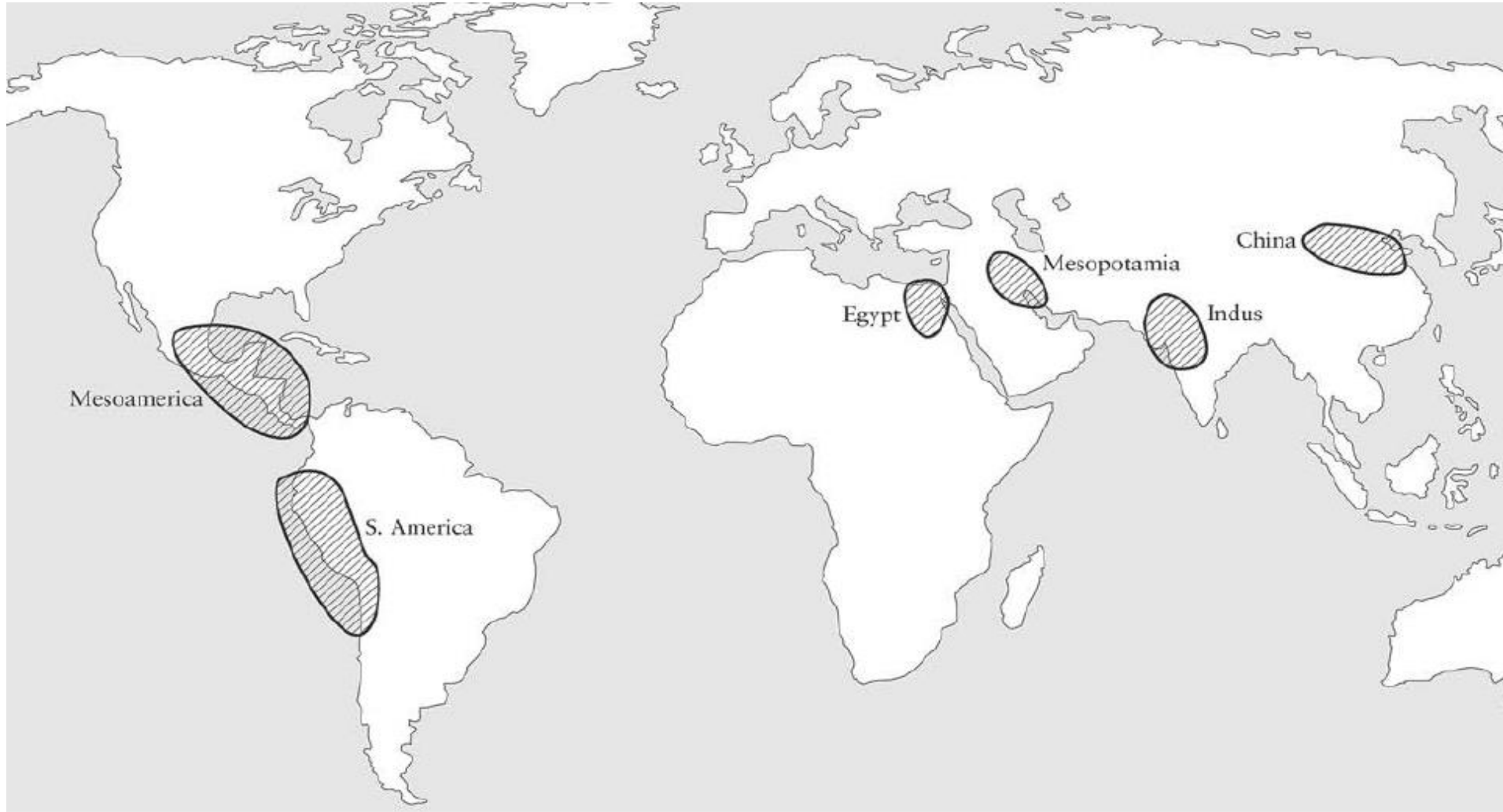
# Neolithic period (12000-5000)

- Agriculture- Wheat, Barley, Potato, Rice, Maize etc. And domestication- Cattle, horse, sheep, goat
- Advanced tools
- Textile, Pottery- weaving, spinning, removal of water from clay
- Division of labor, patriarchal, urbanization

# Ancient Cities and Civilization

- Mesopotamia- 3500 BC
- Egypt- 3400 BC
- Indus- 3400 BC
- China- 1800 BC, Meso-America- 500 BC

# Hydraulic civilizations





# Key Features of Ancient civilization

- Intensified agriculture and hydraulic engineering projects
- City- palaces, army, police, tax collectors, temples etc.
- Trade
- Class society- Mathematics, Astronomy preserve of upper class

# Mesopotamia

- City States, Akkadians first empire- Nobles, Commoners and Slaves
- Irrigation- Hundreds of channels, some 75ft wide and several miles
- Religions- Polytheistic, Ziggurat, each city with different God
- Trade system was a necessity due to soil and weather condition-  
conception of wheel

# Mathematics and Astronomy

- Mathematics- sexagesimal system, pre calculated table, compound interests, square root of two to six places etc.
- Mathematical advances for practical interests such as coefficient for carrying loads, mathematical astronomy for Ziggurat etc.
- In Astronomy, Lunar Calendar by 1000 BCE comprising 12 months totaling 354 days
- By fifth century BCE- calendar for many centuries in advance, lunar and solar eclipses, New moon problem

# Mesopotamia- Medicine

- Codified in the tablets recovered for example library of Asshurbanipal
- Diseases are blamed on Gods and Ghosts
- Two kind of healer: Ashipu (Sorcerer) and Ashu or Physician
- Surgical procedures, Laws for example penalty and compensation

# Egyptian civilization (3400-332BCE)

- Architecture and Engineering
- Metallurgy
- Writing and paper, bureaucracy
- Medicine

# Writing system: Babylonian and Egyptian



Earliest Pictograph  
Head & Bowl



Later Pictograph  
(Pre-2500 BCE)

Meaning: "To Eat"



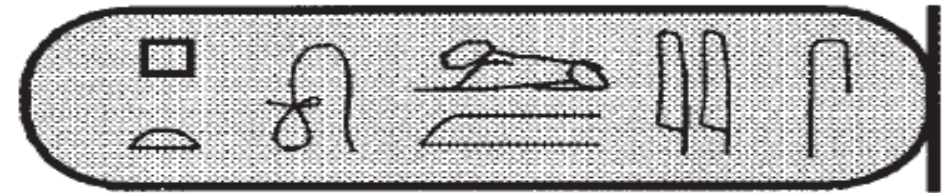
Developed Cuneiform  
(1800 BCE)

"Ku"

Phonetic Value

a. Development of Cuneiform Script

Cartouche: "Ptolemy"



Phonetic Equivalents

P	T	O	L	M	Y	S
↕	↕	↕	↕	↕	↕	↕
Stool	Loaf	Lasso	Lion	Gazelle (Side)	Reeds	Cloth Bolt

Pictographs

b. Egyptian Hieroglyphs

# Ancient Egypt: Social Organization

- Pharaohs
- Vizier and High priests
- Royal Overseer
- Governors
- Artisans
- Farmers and Laborers

# Egyptian soul: Ka, Ba and Akh

- Ba- type of personality, which leaves the body
- Ka- vital essence or soul which distinguishes animate and inanimate
- Akh- comes through synthesis of ka and ba
- Relationship- afterlife



# Giza pyramid

- 94 million cubic ft. of masonry over area of 13.5 acre
- 2.3 million blocks averaging 2.5tons
- 485 ft. high with chambers and passageways
- 100,000 people worked for 20 years

# Construction of Pyramid

- Ramp theory- Wooden ramp with water lubrication
- Wooden crane theory- Was there strong tree to be used for crane?
- Pulley and Fulcrum theory- Use of pulley for ships
- Peasant farmers as labor force

# Hellenistic Period: Natural Philosophers

- Aristarchus from Samos- Astronomy (310-230 BCE)
- Archimedes- Machines, Buoyancy (287-212 BCE)
- Vitruvius- Meteorology (80-10 BCE)
- Hero from Alexandria- Machines (10-80 CE)

# Anaximander of Miletus

- Studied work of Thales and succeeded his school- nature is ruled by laws
- Apeiron or 'the absolute': Boundless and formless initial state out of which duality and the World grew. Initially there was air or gas which condensed to form liquids and species
- Earth is floating in the vacuum while Sun, Moon and Stars are located on concentric rotating cylinders- First cosmological model
- Luminous heavenly bodies or stars are holes in the wheels of fire

# Anaximenes

- Air 'pneuma' is the primeval element- Material monism
- Two conflicting forces: rarefaction and condensation
- Condensation: air-fire- wind- cloud-water- earth- Stone and  
Rarefaction- Stone-earth-water-cloud-wind-fire-air
- The Earth- a flat disc, Sun and Moon etc. float in the air

# Empedocles

- The world is made of four elements: Water, Air, Fire and Earth
- Variation is due to aggregation and segregation of these roots
- Love and Strife are the two forces which cause variation and never disappear altogether
- Comprehensive theory on light and vision, jumped into Mount Etina

# Pythagoreans

- Organized brotherhood sect in Italy on religion, political and philosophical beliefs
- Members pursued mathematics, medicine and music
- Alogon/unutterable number, Q.E.D./thus proven
- Cosmology: Earth and Sun rotating around a body of fire, with Concept of Counter Earth

# Philosophers of Change

- Heraclitus: No primeval element but fire is important symbol
- Law of change: Everything is constantly changing and opposite things are identical- Flux
- Parmenides: Reality is illusory, Single unchanging unified whole, Apriori logical deduction rather than senses
- It is impossible for there to be change without something coming from nothing



# Atomists: Leucippus and Democritus

- Atoms are solid, indestructible and invisible.
- Void is important for motion
- They are homogeneous but differ in size, shape and arrangement and have density proportionate to their volume
- Democritus- the laughing philosopher

# Hippocratic contribution

- Knidian and Koan School- Diagnosis and Prognosis
- Diseases caused naturally
- Humorism- Balance of Blood, Phlegm, Yellow and Black Bile
- Categories- Acute, Chronic, Endemic and Epidemic

# Socrates (470-399 BCE)

- Valued knowledge, Questioning or dialogues leading to inference but without him giving an answer
- He was against the idea of democracy as practiced in Athens- advocated intellectual democracy
- Socratic method- questioning and I know nothing
- Unexamined life is not worth living, Executed in 399 BCE- death is something we do not know

# Plato (428-347 BCE)

- Academy at Athens- Dialectic
- Forms are eternal or Form theory
- Matter theory- Five elements and five three dimensional solids
- Cosmology- Geocentric with heavenly bodies revolving in circles

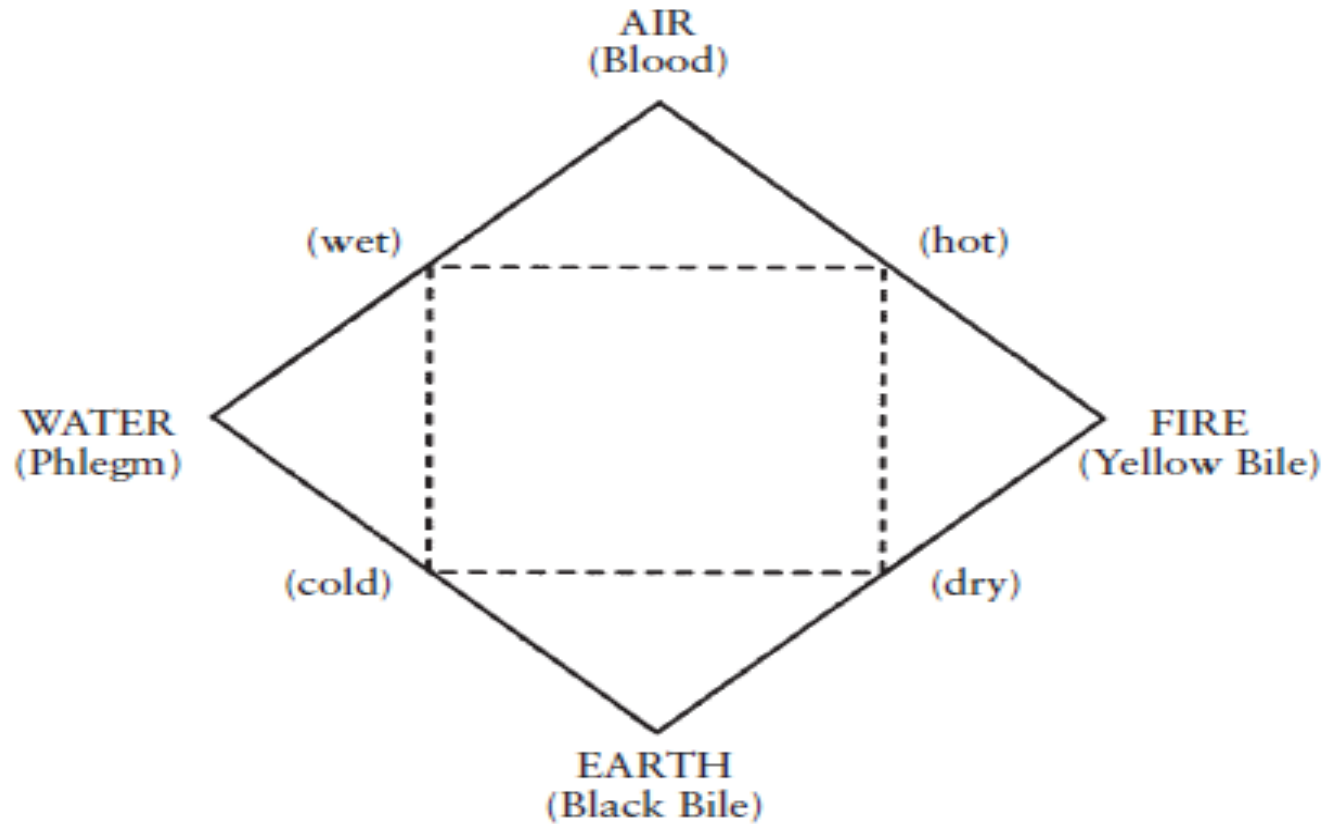
# Aristotle

- 200 treatises of which 31 survive- Metaphysics, Ethics, Logic, Mathematics, Biology, Medicine, Dance, Theatre
- Syllogism, Lyceum- Peripatetic
- Argued forms are intrinsic to objects except in art
- Cause- Material, Formal, Efficient and Final

# Aristotle's Biology

- Coming into being: actualization of that which is potential
- Three kind of souls; nutritive, sensitive and rational: vegetable, animal and human
- Reproduction: form and matter
- Galen, Theophrastus etc.

# Theory of Aristotle and Hippocrates



# Hellenistic Philosophers- Euclid (300BCE)

- Euclid started his own school within Alexandria- Elements
- 1-6 Plane Geometry, 7-9 Arithmetic and Number Theory, 10-13 Irrational number and Solid Geometry
- Postulate, Axiom and Proof
- Most number of copies sold after Bible, 1000 English edition since 1492
- <http://archimedespalimpsest.org/about/history/archimedes.php>



# Archimedes (287-212 BCE)

- Study of statics and hydrodynamics
- Military application for example catapult
- Spiral screw system <https://www.youtube.com/watch?v=A-xPRbj88V4>
- <http://archimedespalimpsest.org/about/history/archimedes.php>

# Pneumatics- Hero and Ctesibius of Alexandria

- Wind wheel operating an organ
- Holy water dispenser- Vending machine
- Theatre mechanism, Temple Door opener, Syringe
- Hero of Alexandria (10-70 CE)-Hero engine or Aeolipile

# Aristarchus of Samos (310-230 BCE)

- Heliocentric model
- Inconsistent with Aristotle's doctrine
- Absence of stellar parallax
- Eratosthenes (275-194 BCE)- Circumference of Earth 24700 miles

# Ptolemy (100-170 CE)

- Almagest or Mathematical Syntaxis or Treatises- constellations
- Astrological treatise- Tetrabiblos or Four Books
- Cosmographia or Geographia- Treatise on Geography
- Harmonics- Musical tones to mathematical equation

# Hellenistic era

- Alchemy as a practical science: metallurgical practice, mystical and spiritual elements
- Hermes Trismegistus: Heremtic tradition
- Mechanics: Archimedes as architecton
- Natural philosophy

# Greco Roman Accomplishment

- Latin language- many other languages developed from it for example Spanish, French, Italian, Portuguese etc.
- Republican form of Government- Senate, President etc.
- Law- Jury, Witness, Innocent until proven guilty
- Art and Architecture, Buildings, Roads, Bridges, Public Baths, Aqueducts etc.

# Architecture

- Cement or Roman 'Opus Caementicium' made from lime, water and volcanic ash called Pozzolana- It was seismic resistant
- Arc, Vault, Doric, Dome etc.
- Amphitheatre- Colosseum with a capacity of 50000
- Mosaic

# Roman Road Network

- Approx. 400,000 km of which 80,000 km stone paved
- In Britain, there were 4000 km.
- It included main or highways, private or country roads and village or cross roads
- Laws of twelve tables stipulated that road should be 8 ft. where straight and twice that where curved



# Natural philosophy-Roman Period

- Seneca (65 CE) – Natural Question on Meteors, Halos, Thunder, Earthquakes, Wind, Comets etc.
- Pliny the Elder (23-79 CE)- Naturalis Historia or Natural History comprising 37 books
- Lucretius: On the Nature of things
- Galen (129-200 CE) Greek who excelled in Rome - Anatomy, Physiology, Pathology, Neurology, Philosophy and Logic, Out of 500, 83 works survive

# Galenic idea- Humorism and temperament

- Blood- Sanguine- Extroverted and Social
- Phlegm- Phlegmatic- Dependability, Kindness and affection
- Black Bile- Melancholic- Creative, Kind, Considerate
- Yellow Bile- Choleric- Energy, Passion, charisma

# Epicurus (341-271 BCE)

- Pleasure desire satisfaction and pain desire deprivation- natural necessary, natural non necessary and vain or empty desires
- Pleasure- Moving and static and there is no intermediate step between pleasure and pain
- Physical pleasure and pain concerns present while mental corresponds also to past and future
- Greatest threat to happiness is anxiety- fear of God and Death

# Stoicism- Zeno 300 BCE

- Three topoi of stoicism- Logic or study of reason, Physics or study of nature and cosmos and Ethics or study of human nature
- Virtues- Wisdom, Courage, Justice and Temperance
- Path to happiness is by accepting what we have
- Unhappiness is due human ignorance of reason of nature

# Epicurus and Stoics

- Purpose of life- Pleasure vs Wisdom
- Constitution- Atoms vs Cosmic Fire
- God- In the gaps between atoms vs permeating but no causal power
- Death- Annihilation or good soul returning to God
- [https://www.youtube.com/watch?v=o0MzQZ\\_eFEY](https://www.youtube.com/watch?v=o0MzQZ_eFEY)

# Factors of decline

- Burning of Books and Killing of 'Hypatia' in 415 CE, Closing of Academy in Athens
- Absence of social role for those engaging with natural philosophy, Separation of utility from knowledge
- Feudal production
- Shift towards religious life, Rise of Christianity

# Rise of Faith

- Mithiras (1<sup>st</sup> to 4<sup>th</sup> Century CE) God of Light
- Demeter
- Christianity- Constantine 391 CE
- Buddhism
- Zoroastrianism

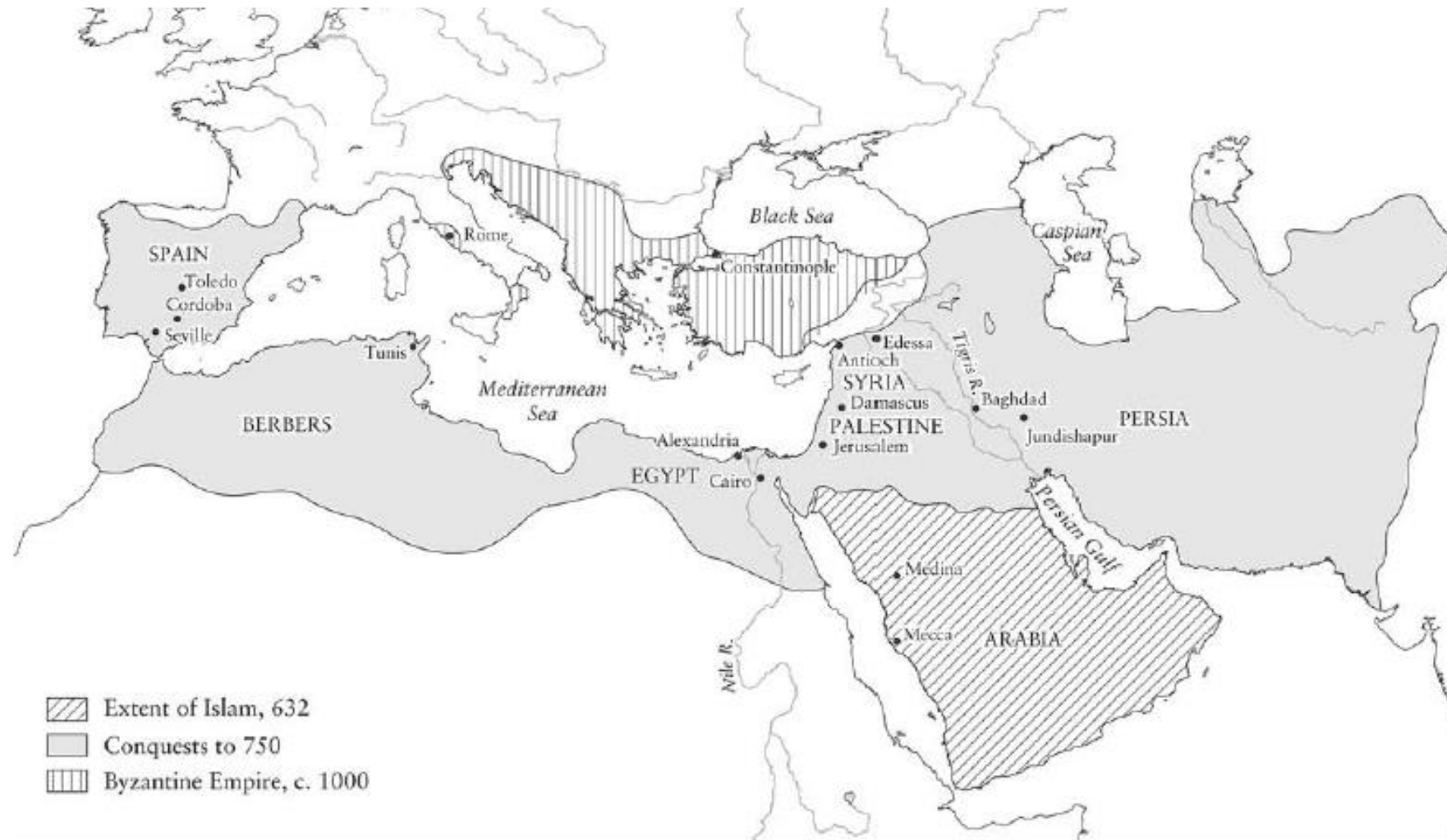
# Byzantine Empire

- The capital was shifted from Rome to Constantinople in 330 CE
- Rome collapsed by 476 CE and during 200-600 CE its population fell by nearly 50%- Byzantine survived up to 1453
- Work on Medicine and Veterinary Science, Astronomy and Astrology
- John Philoponus (Mid 6<sup>th</sup> Century CE)- Theory of impetus



# Names with Arabic origin

- Alcohol, Alkali
- Algorithm, Algebra, Average or damaged
- Azimuth
- Tariff, Saffron etc.



# Horticulture

- Earth and water source of life and God's gift
- Dates, orange, lemon, Peach apricot, different color grapes in a single vine, storage of fruits- sugar cultivation from India, Cotton from Egypt
- Ibn al-Awam wrote Al-Filahat describing more than 500 plants, method of grafting, soil conditioning, curing diseased trees
- Perfume, powder, henna or hair dyes, eye shadows etc.

# Medieval Islamic Science

- Influence of other culture- 760 CE Indian scholars
- Bayt al-Hikma or House of Wisdom (832) Baghdad by Al- Ma'mun and it continued during 9<sup>th</sup> to 13<sup>th</sup> century- Translation to Arabic, Commentary, Observatory
- Ishaq ibn Hunayn- Translated 150 works of Galen and Hippocrates
- Cultural Hellenization for example, Marginalist and Assimilationist

# Libraries

- Hundreds in Cairo, Baghdad, Damascus, Cordoba etc.- alongside Madrasas
- Cordoba alone had 70, one of which contained 500,000 volumes-  
Damascus had 150 in 1500, One collector boasted it will take 400 camels to transport
- Library In Cairo associated with House of Wisdom had 2 million- similarly one attached to Maraghah observatory had 400,000
- Support of Caliph-Paper making learned from Chinese in 8<sup>th</sup> century

# Avicenna (10<sup>th</sup> century CE)

I found there many rooms filled with books which were arranged in cases, row upon row. One room was allotted to works on Arabic philology and poetry, another to jurisprudence and so forth, the books on each particular science having a room to themselves. I inspected the catalogue of ancient Greek authors and looked for the books which I required; I saw in this collection books of which few people have heard even the names, and which I myself have never seen either before or since.

# Arabic Astronomy

- Theoretical and computational, time keeping, instrumentation, folk astronomy- 10000 manuscripts around the world
- Maraghah school- 'Tusi couple' to replace epicycle and it was used by Ibn al- Shatir
- Calendar reform- error of one day in 5000 years, Astrology or study of impact of celestial bodies on human affairs

# Mathematical Science

- Algebra, Geometry, Mathematical Geography, Astronomy, and Optics- Practical purposes
- Algebra or al-jabr derived from 9<sup>th</sup> century polymath Al- Khwarizmi's "Al-jabr wa'l muqabalah"- Number Zero and decimal system
- Ibrahim ibn Sinan (946)- Geometry and translator of Archimedes, Al-Haytham on synthesis between algebra and geometry
- al- Biruni- 146 treatises 13000 pages, Earths rotation on its own axis



# Language and Music

- Arabic calligraphy was an art form
- A thousand and one night, Omar Khayyam's Rubaiyat
- A system of historiography- 'isnad' for example Ibn Khaldun
- Zither, drum, tambourine, flute etc. –Bagpiper

# Navigation and Geography

- Navigation and trade
- al-idrisi 12<sup>th</sup> century geographer based in Sicily- Roger's Book (Kitabal-Rujari) comprising seventy maps
- Ibn Battuta travelled 75,000 miles reaching region such as central Asia, Turkey, Bulgaria, Russia, Persia, China, West and North Africa
- Vasco da Gama while exploring east coast of Africa had an Arab help

# Arabic Medicine

- Religion stipulates that care need be taken for health. Followed theory of Hippocrates, Galen and others
- Rhazes or al-Razi (860-925)- 184 works, Challenged Galen's theory, wrote 23 volume encyclopedia, Kitab al Mansuri (Canon of Medicine) used in Europe until 16<sup>th</sup> century
- Identified Measles and Small pox to be associated with human contamination, and recognized fever as body's defense mechanism
- Some of the prominent doctors are, al Razi, Ibn Sina or Avicenna, al Majusi etc.- Avicenna known as Galen of Islam wrote 99 books

# Arabic Medicine

- Hospital, Medical centers - Separate section for male and female, for diseases for example surgery, orthopedics etc., lecture halls or majlis
- Ophthalmology- Ibn al-Haytham (965-1040) wrote 'Optics'
- Zakat tax used to support such medical centers-Medicine involved minerals, herbal, animal substance
- Dissection however was not allowed

# Contribution to Chemistry- Alchemy

- Classification- Seven classical metals which are Gold, Silver, Tin, Lead, Mercury, Iron, Copper
- Four spirits- Mercury, Sal ammoniac, Arsenic and Sulphur; Seven fusible metals such as gold, silver etc.; Thirteen stones for example gypsum, glass etc. Thirteen Salts for example lead acetate, Magnesium sulphate etc.
- Jabir ibn Hayan or Geber - Purification by crystallization, filtration, distillation etc. Distillation for acids such as Acetic from vinegar, Citric, Nitric, Hydrochloric etc. Petrol and Kerosene from Crude Oil, Tar use for roads
- Al- Razi's 'Secret of Secrets'- kind of laboratory manual

# Crafts

- Glasswork- new glazing techniques developed, color blue
- Textile- Silk weaving
- Moroccan leather for book binding, gold tooling- method of tanning, use of agriculture dyes
- Intricately designed chandelier, paintings etc.

# Decline of Arabic Science

- Religious Orthodoxy- Reason or Revelation, God's Power or Justice
- Cultural diversity became homogeneous under religion influence
- Mutazilite- God is rational and reason can tell us what is possible and not. By 12<sup>th</sup>-13th century Mu'tazilism or Mu'tazilites were replaced by Ash 'arite philosophy or Occasionalism, Abu Hamid al-Ghazali- The Incoherence of Philosophers
- Wars on west and east front, Economic decline

# Accomplishment of Chinese Civilization

- Oracle bone script, ideographic type (1600-1046 BCE), 5000 character by 9<sup>th</sup> century BCE- Pictographic and phonetic
- Paper making idea 105 AD, First Newspaper and paper money, Census 2 CE
- Civil services- Han period (206-210 CE)
- Inoculation against small pox- 960-1279 CE



# China Population

- World's largest except the Roman period
- 50 million in 800 CE to 115 million in 1200: Rice production
- Early ripening, Winter ripening varieties of rice
- 20 percent in urban centers, Five cities with more than a million during Song Dynasty

# Confucianism

- Kong Fuzi or Confucius (551-479 BCE)- Moral philosophy, Philosophy of art, Social and Political Philosophy
- Five constant relationship-Patriarchal society, Worship ancestors
- Meritocracy- civil servants were trained in Confucianism, humanities and administration
- Merchant activity and accumulation of private wealth anti social vices

# Taoism or Daoism

- Founded by Laozi or Lao tzu during the Warring States Period-Tao is the ultimate source and principle of Order.
- Five phases- Air, Water, Fire, Metal and Wood
- Tao flows and balance through two forces, Yin and Yang, which are in harmony and neither is superior
- Humans have to live in accordance with nature or Tao

# Waterways

- By 12<sup>th</sup> century, China had 50,000 km navigable waterways
- Grand canal 1776 km was completed in 1327 CE connecting Hwang Cho to Beijing
- In 14<sup>th</sup> Century, Ming period, 11,700 ships operated involving 120,000 sailors and support staff
- Dredging and maintainances

# Ship Building

- Multi-decked, largest 300ft, 1500 tons to carry thousand of sailors
- In 1281 attempted to invade Japan with 440 ships
- Ming dynasty carried out sea exploration
- Closed the program abruptly in 1433

# Chinese Civilization and Science

- Different Science- Mathematics, Astrology, Meteorology, Cartography, Medicine, Alchemy, Seismography etc.
- Buddhist Monk came to India during 600-700 CE
- Mongol conquest of China in 13<sup>th</sup> century- Islam scholars
- Mateo Ricci's arrival in Macau, 1582- Beijing in 1601

# Astronomy and Astrology

- Calculated length of solar year as  $365 \frac{1}{4}$  days in 4<sup>th</sup> century BCE-  
Calendarical knowledge was state secret
- Observed exploding star Crab Nebula in 1054
- Astrologers in Royal courts- 5000 during Mongol dynasty 13<sup>th</sup> century
- Barely any explanatory models

# Chinese technology

- Compass (100-1086 CE) Porcelain was a major source of income, Textile used mechanical features, Umbrella, Wheelbarrow
- Printing during 7-8<sup>th</sup> century CE- First wood carved printed book in 868
- Gunpowder in 9-11<sup>th</sup> century- went to West through Mongoloids
- Iron industry a consequence of limited supply of copper and tin, Cast Iron from Zhou dynasty- 48 foundries by 117 BCE and 150,000 tons in eleventh century



# Constraints in growth

- Nature of language for example ideographs and its scope to allow abstract theoretical thinking
- On account of labor availability less importance to labor saving technology- stress on conformity and tradition
- Confucianism's disdain of experiment as artificial, Mohist and Legalist
- Peripheral role of artisans and merchant class

# Mayan social system

- Polytheism
- Politically not united, City states and Hereditary Monarchy
- Divorce permitted, Prisoners as Slaves
- Tattoo- sign of courage

# Mathematics

- Shell symbol for Zero
- Dot for One and Line for Five
- Vigesimal system
- Did not use fraction

# Astronomy

- Earth is flat with four corners
- Each corner represented a cardinal direction and had color for example East red, North White etc.
- Pyramids were often used as observatory- Special emphasis to Venus
- First to observe Milky way

# Astronomy- Calendar

- Tzolkin (count of days) calendar- twenty days of thirteen months
- Habb or Vague calendar- twenty days of eighteen months, 365 days
- Round calendar- alternate cycle of tzolkin and habb, Fortune telling system
- Long count a Lunar calendar predicted End of World 23rd Dec. 2012

# Mayan Medicine system

- Religion, ritual and herbal medicine
- Sickness as captivity by supernatural forces. Practitioners known as Shamans- medium between physical and spiritual world
- Teas of plants were provided as remedy
- Sweat inducing saunas

# Decline of Mayan

- Endemic warfare
- Limited productivity of fragile eco system
- Drought of 800-1000
- Deforestation to make lime for plaster known as stucco

# Tutlec city of Tula 950-1168 CE

- Founded by priest Quetzalcoatl
- 35000-60000 population
- One of the largest pyramid- on 45 acres 133 million cft.
- Spanish conqueror Hernan Cortes arrives in 1519



# Aztec civilization 1250-1522

- Population- Five million
- Emperor, Council of Nobles and Priests
- Militaristic society
- Land sharing, Polytheism

# Aztec City of Tenochtitlan

- Population of 2-3 lakh on the bank of Texoco lake- 1325 -1521 CE
- Irrigation system, 30,000 acres of chinampas
- Rituals
- Domestication of red cochineal insect