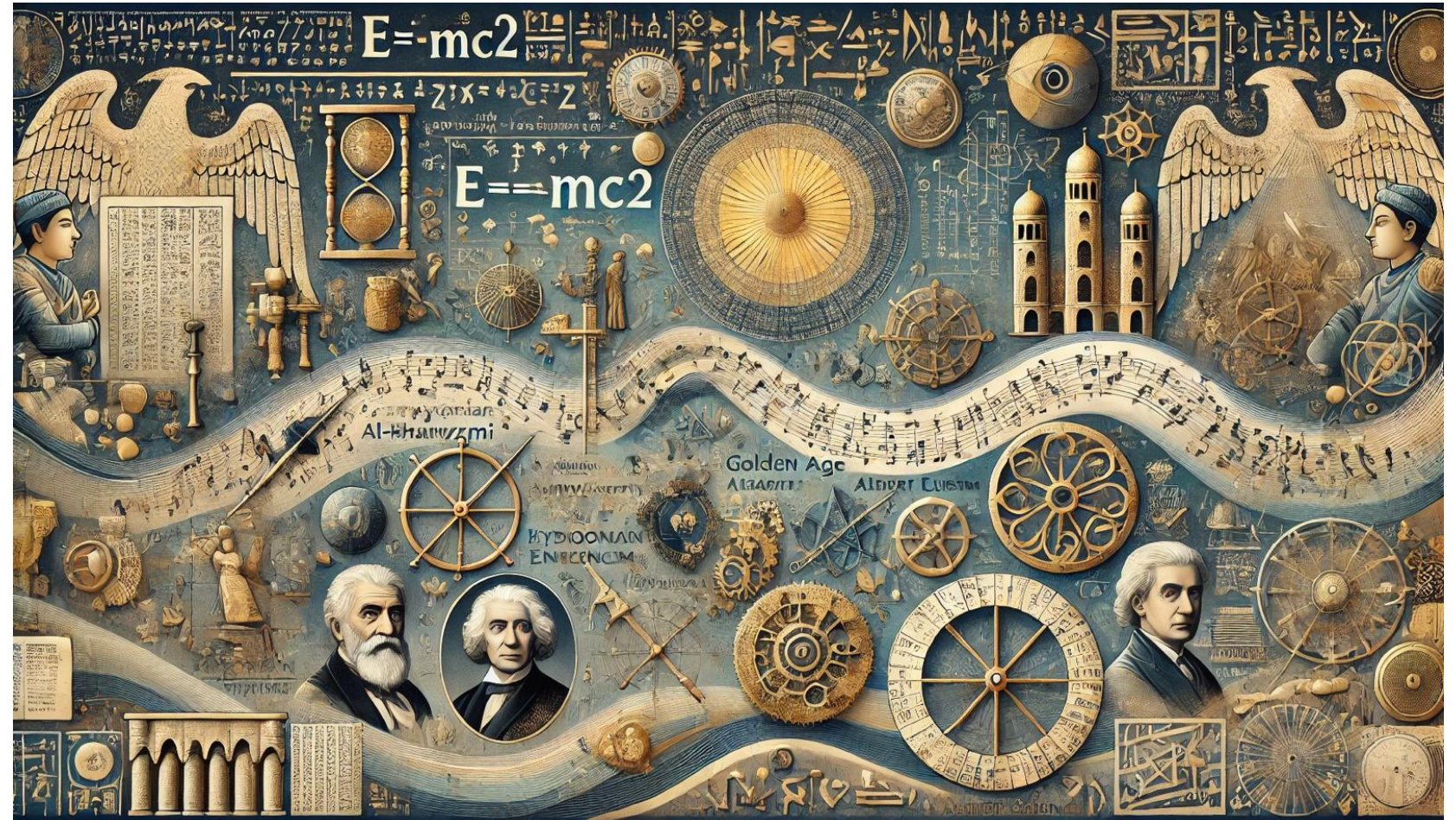


MAN, NATURE
MATH
SCIENCE

Dr. Samer Atasi



Man encounter with Mathematics & Science

Man started with a brain that can sense & give meanings to things in nature

.

Science enables understanding & prediction of things in nature

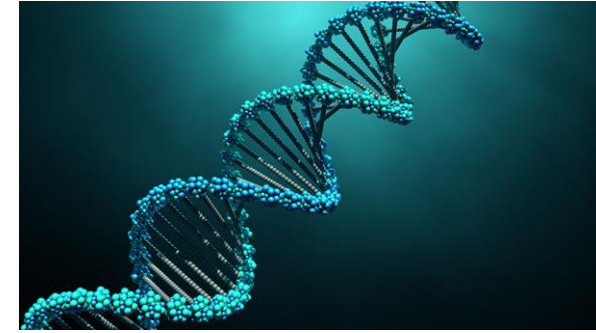
Mathematics is a language Science uses to search & express its findings

What happened then?

PALEOLITHIC MAN (until ~12.000 BC)

HAS OUR GENES

Can observe , give meaning , think creatively, LIKE US



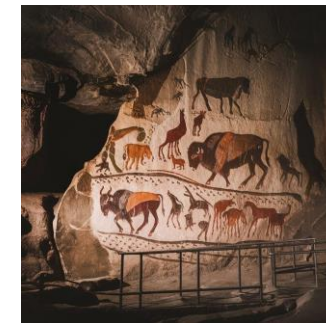
SOMEWHAT IMPROVED HIS LIFE

Protected himself, Bettered his life



DEVELOPED STRONG SPIRITUALITY

Imagined stronger forces ruling his life, Institutionalized death



LIVED IN SMALL GROUPS

Fed on nature

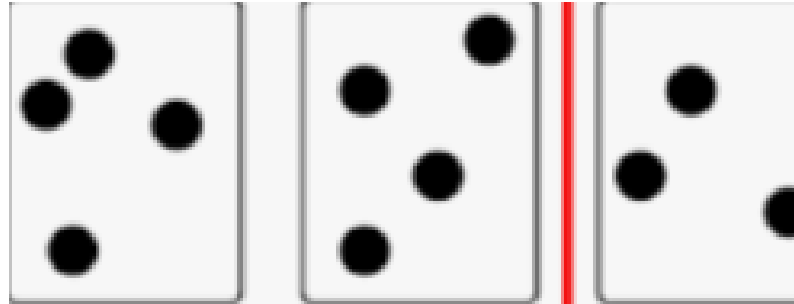


MAN'S HISTORY WITH MATHEMATICS

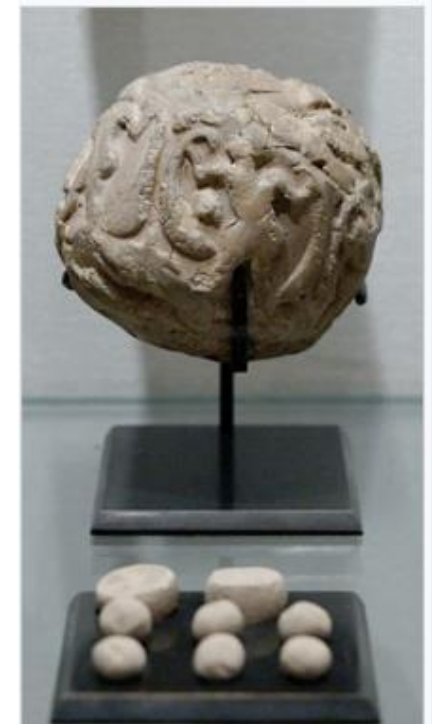
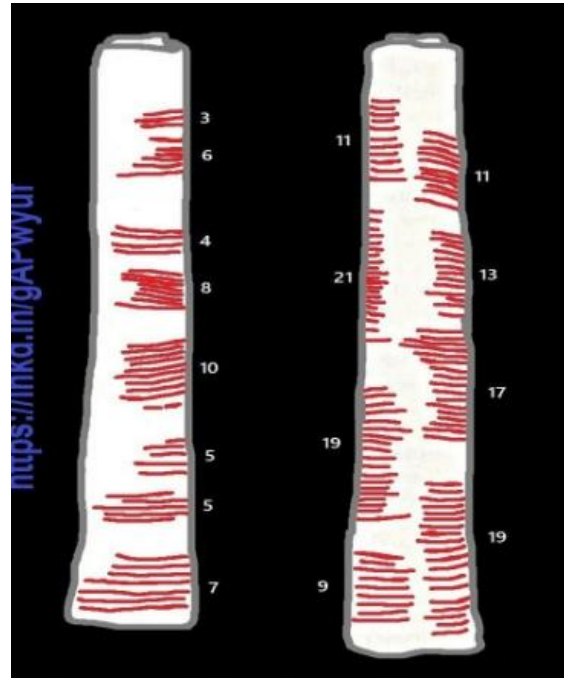
FOR TENS OF THOUSANDS OF YEARS,
DESPITE MAN'S 2X5 FINGERS THE CONCEPT
OF NUMBERS TOOK A LONG TIME TO
DEVELOP



TOWARDS THE ABSTRACT CONCEPT OF NUMBER



- **SUBSITIZING** (early humans)
- **NUMBERS in first Oral Languages** (70000 to 50000 BC)
The Number concept, Its origin and development, Levi Leonard Conant (1896)
- **TALLYING** (40000 to 20000 BC)
- **Group Clay tokens** (10000BC)
- **NUMERICAL SYSTEMS**

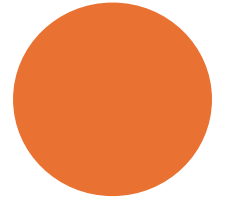


MAN AT DAWN OF HISTORY

- * AFTER THE LAST GLACIATION MAN STARTS TO GATHER IN LARGER GROUPS
- * GROUPS INTERACT AND SOMETIMES UNITE INCREASING ORGANIZATIONAL NEEDS
- * AGRICULTURE, ANIMAL FARMING, TRADE, ADMINISTRATION DEVELOP, CREATING NEW NEEDS
 - COUNTING (GOODS, INVENTORY, EXCHANGE, LABOR)
 - RECORDING (EVENTS, TRANSACTIONS)
 - SPACE MEASUREMENT (LENGTHS, AREAS, ANGLES)
 - TIME MEASUREMENT (NATURAL CYCLES, RITUAL SCHEDULES)
- * RECORDED HISTORY APPEARS (TEXT & NUMBERS IN WRITING)

Early Neolithic period

- Göbeklitepe Temple



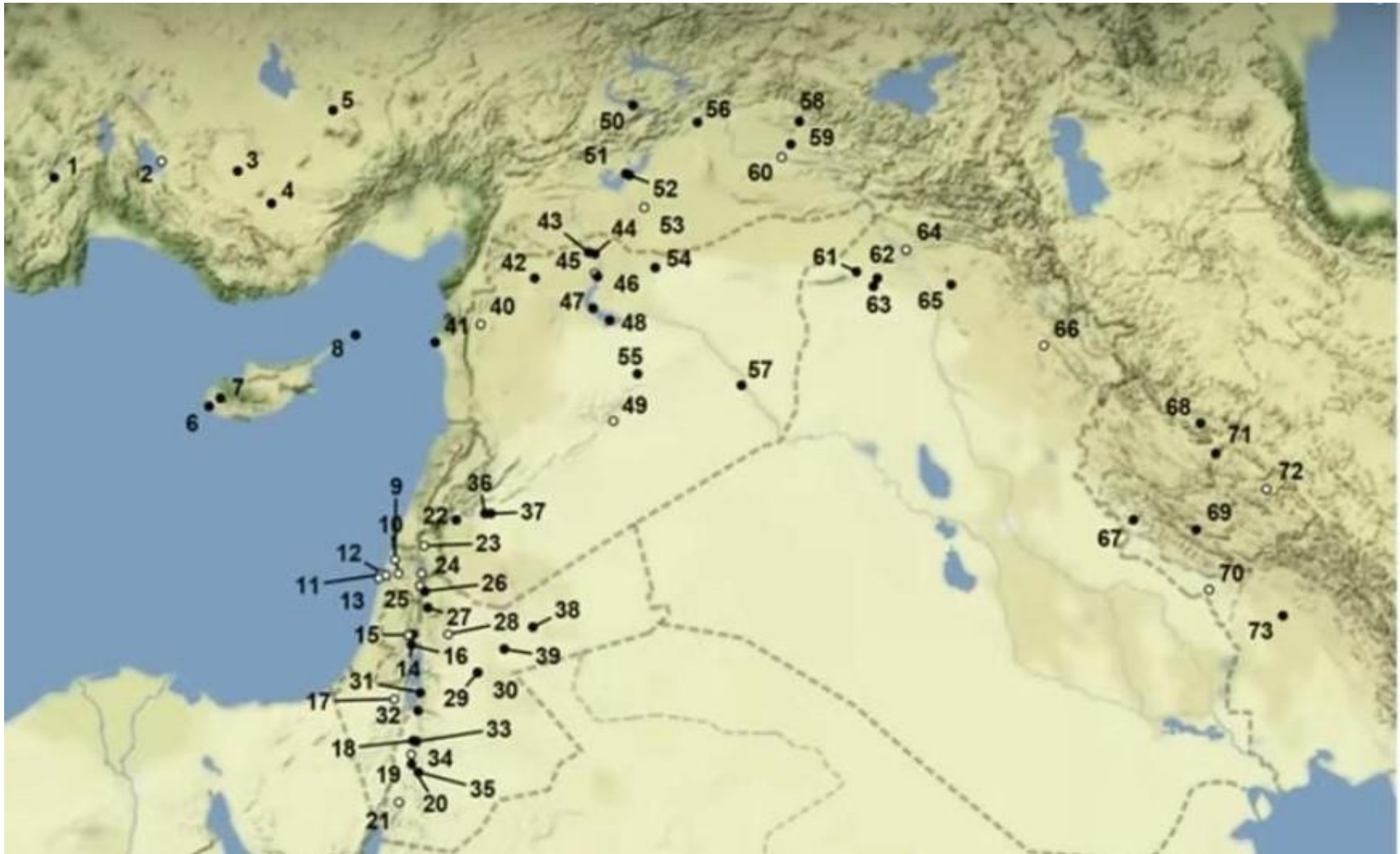
- Karahantepe Statues



12000 to 10000 years ago in South East Anatolya




12000 to 10000 years ago: the Fertile Crescent





NUMERAL SYSTEMS ARITHMETICS

- BABYLONIAN NUMERAL SYSTEM
 - EGYPTIAN NUMERAL SYSTEM
 - GREEK NUMERAL SYSTEM
 - ROMAN NUMERAL SYSTEM
 - GOLDEN AGE ISLAMIC NUMERAL SYSTEM
- 

PROPERTIES OF NUMERAL SYSTEMS

Base b: 10, 60

Positional or non Positional :
231
or
hundred hundred, ten ten ten one

Fractional numbers integrated or
separate notation:
231,5 or 231 & 1/2

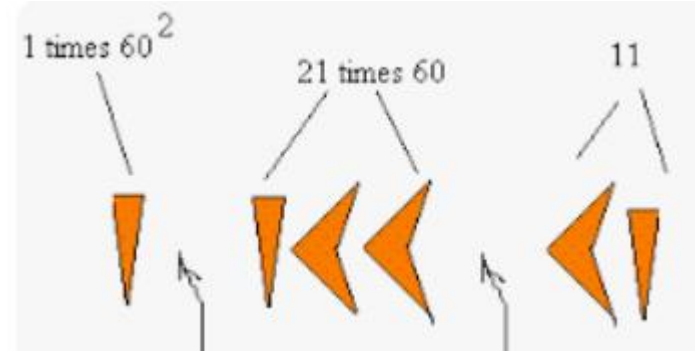
Ease of manipulating fractions
(divisibility of base by
2,3,4,5,6,12)

Zero needed for
Placeholder, Equations,
Negative, Algorithms, Coordinate
Systems, Set Theory, Calculus...

multiplication division
algorithms

Babylonian Numerals and Arithmetics (2000BC)

7	1	𐎗	11	𐎗𐎗	21	𐎗𐎗𐎗	31	𐎗𐎗𐎗𐎗	41	𐎗𐎗𐎗𐎗𐎗	51
𐎗	2	𐎗𐎗	12	𐎗𐎗𐎗	22	𐎗𐎗𐎗𐎗	32	𐎗𐎗𐎗𐎗𐎗	42	𐎗𐎗𐎗𐎗𐎗𐎗	52
𐎗𐎗	3	𐎗𐎗𐎗	13	𐎗𐎗𐎗𐎗	23	𐎗𐎗𐎗𐎗𐎗	33	𐎗𐎗𐎗𐎗𐎗𐎗	43	𐎗𐎗𐎗𐎗𐎗𐎗𐎗	53
𐎗𐎗𐎗	4	𐎗𐎗𐎗𐎗	14	𐎗𐎗𐎗𐎗𐎗	24	𐎗𐎗𐎗𐎗𐎗𐎗	34	𐎗𐎗𐎗𐎗𐎗𐎗𐎗	44	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	54
𐎗𐎗𐎗𐎗	5	𐎗𐎗𐎗𐎗𐎗	15	𐎗𐎗𐎗𐎗𐎗𐎗	25	𐎗𐎗𐎗𐎗𐎗𐎗𐎗	35	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	45	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	55
𐎗𐎗𐎗𐎗𐎗	6	𐎗𐎗𐎗𐎗𐎗𐎗	16	𐎗𐎗𐎗𐎗𐎗𐎗𐎗	26	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	36	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	46	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	56
𐎗𐎗𐎗𐎗𐎗𐎗	7	𐎗𐎗𐎗𐎗𐎗𐎗𐎗	17	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	27	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	37	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	47	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	57
𐎗𐎗𐎗𐎗𐎗𐎗𐎗	8	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	18	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	28	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	38	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	48	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	58
𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	9	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	19	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	29	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	39	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	49	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	59
𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	10	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	20	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	30	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	40	𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗𐎗	50		



- Base 60

- Positional system

- Same writing for fractional numbers

- Fractions easier to use than in base 10 (60 divisible by 2,3,4,5,6,10,12,15,20,30)
(e.g $1/3 + 1/5 = 20/60 + 12/60 = 32/60$)

- Multiplication using

$$ab = \frac{(a+b)^2 - (a-b)^2}{4}$$

and

$$a(b+c+d) = ab + ac + ad$$

with precomputed tables of squares and smaller number products

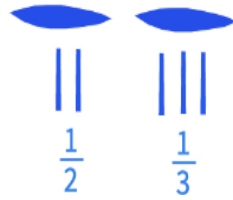
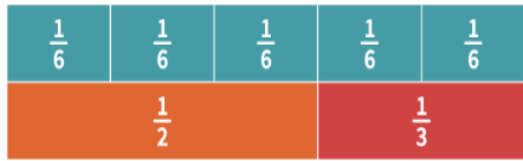
- Division $a/b = a \times 1/b$

with precomputed tables of inverses

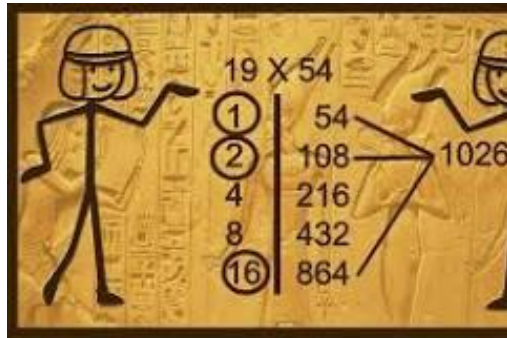
- Still our basis today for time and angles measurement

Egyptian Numerals & Arithmetics (2000 BC)

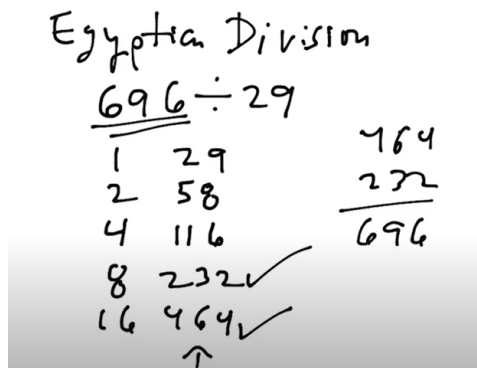
- Base 10
- Non positional system
- Elaborate system for fractions (unitary fractions)



Multiplication algorithm used until Islamic system



Division algorithm used until Islamic system



Digits and numbers [\[edit \]](#)

The following hieroglyphs were used to denote [powers](#) of ten:

Value	1	10	100	1,000	10,000	100,000	1 million, or many
Hieroglyph		∩	☉	☐	☐	☐	☐
Gardiner's sign list ID	Z1	V20	V1	M12	D50	I8	C11
Description	Single stroke	Cattle hobble	Coil of rope	Water lily (also called lotus)	Bent finger	Tadpole	Heh ^[3]

Multiples of these values were expressed by repeating the symbol as many times as needed. For instance, a number 4,622 as:



Greek Numerals & Arithmetics (400 BC)

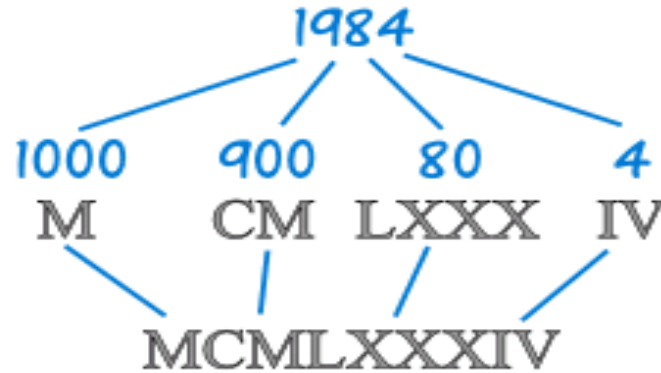
- Base 10
- Letters used to denote numerals
- Non Positional system
- Counting boards/Abacus
- Egyptian multiplication/division algorithm
- Egyptian unitary fractions
- Babylonian sexadecimal fractions

Formalized concepts on:
 prime numbers series
 prime number decomposition
 Greatest common denominator
 Smallest common multiple
 Approximated PI

unités	1	2	3	4	5	6	7	8	9
	α	β	γ	δ	ε	Ϝ	ζ	η	θ
	alpha	bêta	gamma	delta	epsilon	digamma	dzêta	êta	thêta
dizaines	10	20	30	40	50	60	70	80	90
	ι	κ	λ	μ	ν	ξ	ο	π	Ϛ
	iota	kappa	lambda	mu	nu	ksi	omicron	pi	koppa
centaines	100	200	300	400	500	600	700	800	900
	ρ	σ	τ	υ	φ	χ	ψ	ω	ϣ
	rô	sigma	tau	upsilon	phi	khi	psi	oméga	san
milliers	1000	2000	3000	4000	5000	6000	7000	8000	9000
	Ϡ	ϡ	ϣ	ϣ	ϥ	Ϧ	ϧ	Ϩ	ϩ
	alpha	bêta	gamma	delta	epsilon	digamma	dzêta	êta	thêta

Roman Numerals & Arithmetics (till 15th Century in Europe)

- In the Roman numeral system, the symbols I, V, X, L, C, D, and M stand respectively for 1, 5, 10, 50, 100, 500, and 1,000 in the Hindu-Arabic numeral system. A symbol placed after another of equal or greater value adds its value. A symbol placed before one of greater value subtracts its value



- Counting boards based on the Roman design were used throughout Europe until the Middle Ages. Even with these counting boards, multiplication and division of large numbers remained a difficult task.

Golden Age Islamic Numerals & arithmetics (10 AD).

- Far East influence
- Base 10
- Positional
- Zero
- Illimited Range of numbers with only 10 digits
- Same representation for Integers & Fractional numbers
- Algorithms mechanize many operations
- Adopted 13th century in Italy, 15th in all of Europe
- Negative numbers are used in equations
- Base 2 system used in digital computers is based on the same principles

x	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	2	4	6	8	10	12	14	16	18	20
3	3	6	9	12	15	18	21	24	27	30
4	4	8	12	16	20	24	28	32	36	40
5	5	10	15	20	25	30	35	40	45	50
6	6	12	18	24	30	36	42	48	54	60
7	7	14	21	28	35	42	49	56	63	70
8	8	16	24	32	40	48	56	64	72	80
9	9	18	27	36	45	54	63	72	81	90
10	10	20	30	40	50	60	70	80	90	100

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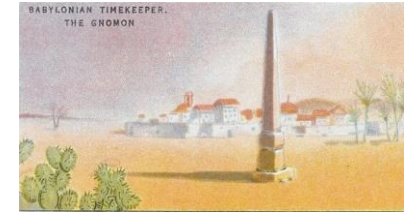
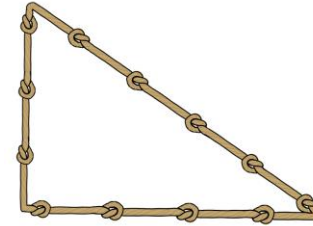
CONCLUSION ON NUMERAL SYSTEMS: Today we use Islamic system for arithmetics, Babybonian system for angles and time

Geometry: Properties & Relations of Points, Lines, Surfaces, Volumes

Required for construction, Land distribution, , Astronomy (time, religion)

Babylonians and Egyptians (2000 BC) developed most practical tools

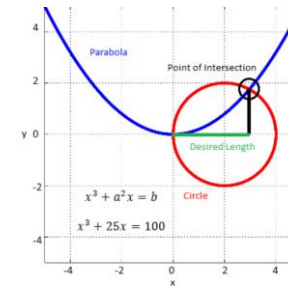
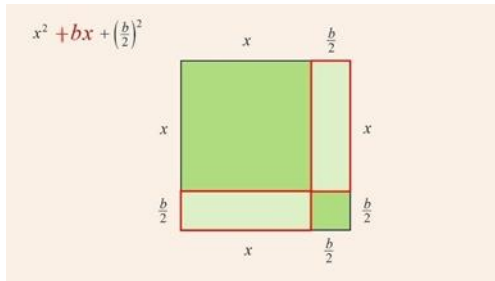
- Right triangle properties, 'Pythagorean' tables, 'Thales' proportions
- Calculation of areas and volumes
- Sky based Day/Night Time measurements



Greeks (400 BC) formalized previous knowledge, introducing the concept of axioms and proofs (Thales, Pythagore, Euclide) and improved the knowledge of the circle (angles, chords).

They also gave the first «complete the square solution» solution to some Quadratic equations.

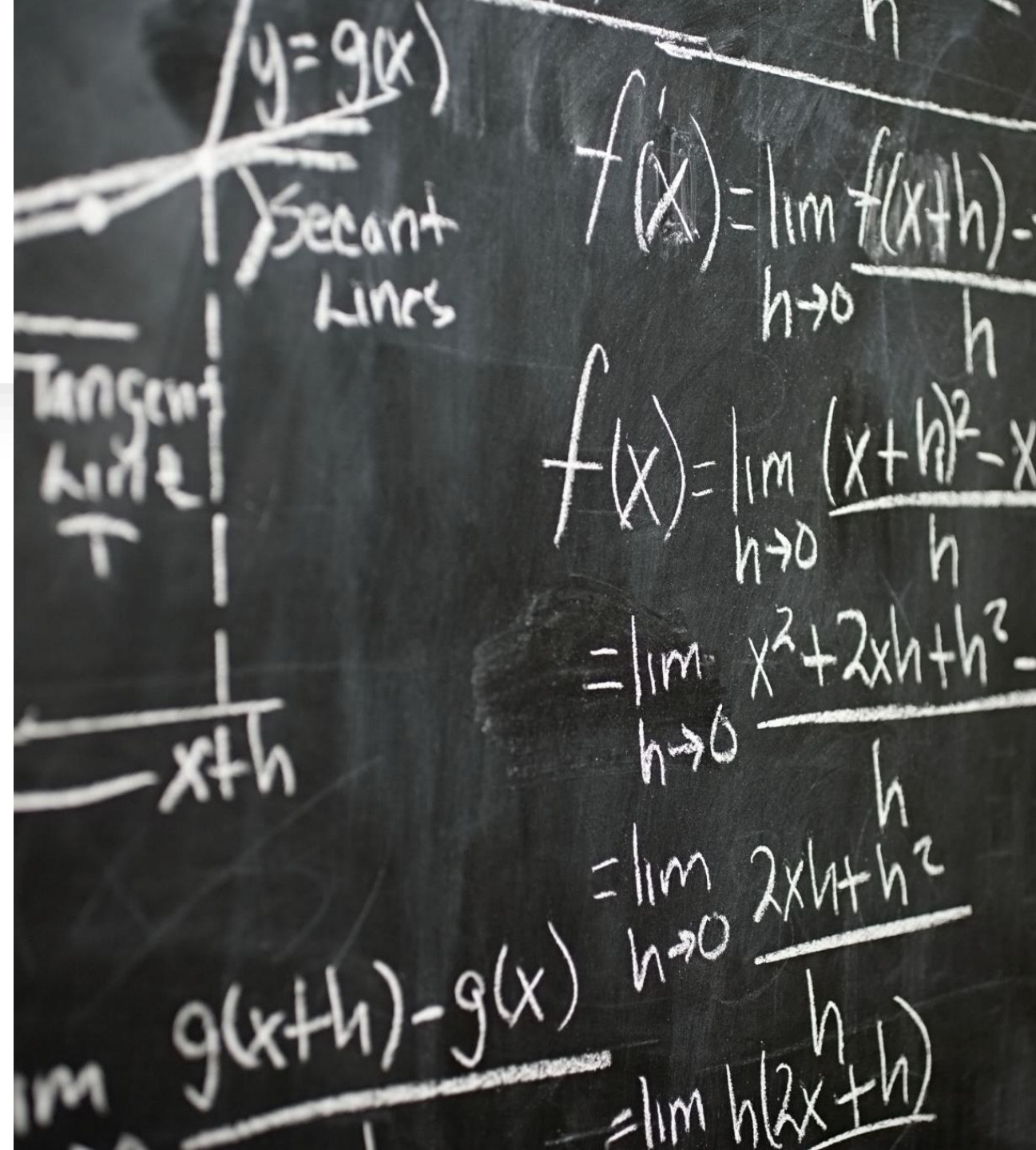
Islamic Golden age (10 AD) provided geometrical solutions to algebraic equations, based on intersection of conic sections (Al Khuarizmi, Omar Khayyam, Ibn Haytham), opening the way to Analytical Geometry



Later contributors: Leonardo Da vinci, Kepler, Descartes, Newton, Euler

Algebra: Solving Mathematical Problems using Formulas, Equations & Algorithms

- Babylonians and Egyptians used formulas to calculate areas & volumes
- Greeks were the first to use symbols to represent unknown quantities and to use the concept of equations with unknowns.
- Islamic scholars formulated general solutions to linear & quadratic equations and developed algorithms for solving cubic equations.
- Early renaissance Scholars were inspired by Golden Age Islamic Algebra (Fibonacci, Viète, Descartes)
- Calculus developed in 18th and 19th century to describe physical laws in Mechanics, Thermodynamics and Electrical Engineering
- 20th century MODERN algebra is crucial in Modern Physics (Relativity, Quantum) and in IT Technologies (computer science theories, cryptography etc..)

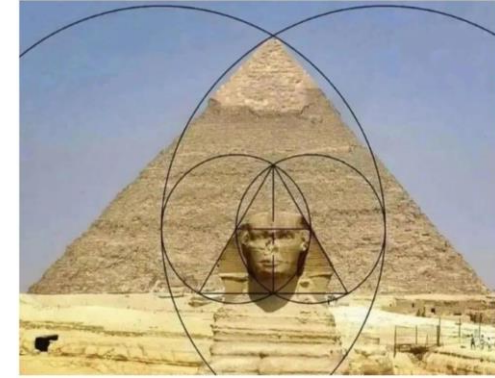


Trigonometry: Relations of sides & angles in triangles & circles

Rooted in Astronomy, Surveying, Navigation

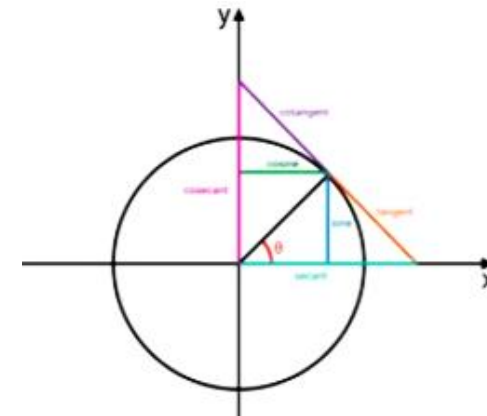
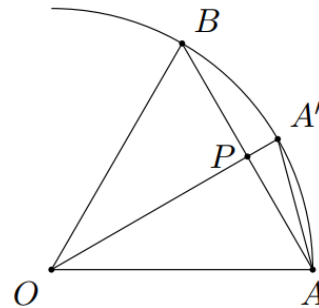
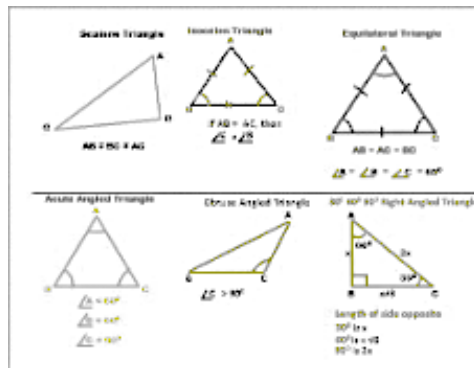
Babylonians used ratios of sides and angles to follow navigation of celestial bodies. The Babylonian division of the circle to 360 deg became the base for trigonometry

Egyptians used trigonometric properties also in surveying and construction (pyramids) .



Greeks (Asia Minor, Alexandria) established relations between lengths of sides and angles in a triangle. They also developed tables of chord lengths in circles .

Islamic Scholars (9th century) invented the trigonometric functions and produced more precise calculations that were essential for precise astronomical measurements



This helped Renaissance astronomers (Ticho Brahe, Copernic) in Europe improve their observation and opened the way for models of planets motion (Kepler)

Later Newton, Euler, Taylor, Fourier extended the use of trigonometry to every field of science

Man's History with Science

- Science is the systematic study of the natural world to understand, explain, predict & control phenomena
- To do so , Science must rely on
 - Empirical evidence
 - Critical thinking
 - Creative thinking
- Methods of Science
 - observation, experimentation, analysis
 - Discovering patterns, establishing facts
 - Formulating laws, Theories
 - Continue testing laws and theories

First human Scientific achievements

Creating and keeping Fire

Developing sophisticated tools

Understanding & Instituting Death

Recognizing Diurnal , Lunar ,
Seasonal cycles



NEOLITHIC SCIENCE

Experimenting with materials, motion and heat

- Identification of colorants and painting techniques (20000BC)
- Production of Pottery (10000 BC)
- Discovery & Melting of metals: Copper (9000 BC) Gold (6000BC), Silver (5000 BC), Bronze (3500 BC)

Development of techniques leveraging human strength in construction

These early achievements, created new possibilities for creating wealth, warfare power and trade





BABYLONIAN SCIENCE



Babylonians made precise measurements on heavenly bodies (Moon, Venus, other planets) & created the Zodiac.

They measured time (Gnomon, Klepsydra). Their sexadecimal system is the basis of day division used today (Hours, Minutes, Seconds)

They developed lunar and solar calendars as well as models predicting heavenly events (eclipses, planet rises etc..)

They developed medicine (partially holistic until the enlightenment time) and Pharmacology (plants)

They developed Metallurgy and Glass industry

Great wealth of Scientific information recorded on clay tablets (Ashurbanipal Library)

Influenced later Greek scholars and renaissance astronomers

ANCIENT EGYPTIAN SCIENCE

Egyptian Science is comparable to Babylonian Science with differences due to the physical environment

- * Wrote on Papyrus instead of Clay tablets.

- * Geometry practically oriented to serve construction

- * Astronomy practically oriented to serve agriculture and religion

- * Mastership in Irrigation and in construction Engineering

- * Treatment of Trauma and Surgery, body knowledge gained from mummification

- * Boat building (Thor Heyerdahl, RA expeditions 1969-1970)

The land of Egypt remained a pole of knowledge and Science and contributed significantly to the Greek Science (Alexandria Library and Museum)

Greek Science: A new approach

- * Greeks **Formalized** previous results & brought **concept of proof**
 - Geometry Theorems (Thales, Pythagore etc..)
 - Circle properties
 - Number Theory (prime numbers, perfect numbers etc..)
 - Formal Logic (syllogisms)
- * Hypocrates 'Father of Medicine': **diseases have natural causes**, nature heals.
- * Greeks emphasized the theoretical notion of Natural world governed by laws that can be discovered by **observation and logic**. Practical results often came from the East
 - Archimedes trained in Alexandria discovered the law of buoyancy in Syracuse
 - Aristotenes (Alexandria) measured the earth diameter
- * Greeks were **great theoreticians** but were often **driven by their esthetism**: heavenly bodies must turn in perfect circles, a force is required to keep a body in motion, eye sends rays that reflect on objects

Greeks contributed greatly in **Politics, Philosophy, and Arts.**

Golden Age Islamic Science (8-11 AD)

- Islamic Scholars made significant corrections and additions to previous Science
 - Provided the decimal **numerical system** (0-9) used today (Al Kuarizmi)
 - Invented and developed **algebra** (Al Khuarizmi, Omar Khayyam)
 - Produced more precise **astronomical tables** (Al Battani)
 - Advanced knowledge of **human physiology** e.g Cardio pulmonar system, & human vision (Ibn Sina, Al Razi, Ibn Al Nafis)
 - Developed Experimental **Chemistry** (Jabir Ibn Hayyan)
 - Developed scientific approach to **Light & Optics** (Al Kindi, Ibn Al Haytham)
 - Concept of **Inertia and the effect of forces** on movement (Ibn Al Haytham)
 - Mechanical systems such as **Automata** in watering systems (Al Jazari)
 - **Aristotolean Philosophy** (Al Farabi, Ibn Rushd) etc...
- * **Toledo School** of Translators

Science in Medieval Europe (12-15 AD)

- Western Europe 11th Century: Practically no scientific background, **Fanatic Catholicism, Crusades** (Holy land, Cathare)
- Holy Land Crusades (followed by Mogol destruction) **destroyed the Levant but helped develop the Occident**
- European Scholars started building upon Golden Age Islamic knowledge

Examples of **Books translated from Arabic to Latin**

- Al Khwarizmi translation «Algoritmi de numero Indorum» (12AD) introduced **Algebra** to Europe
- Al Battani translation «De Motu stellarum» (12AD) **astronomy tables** were used by Copernicus
- Al Hazen translation «De Aspectibus» on **vision & optics** influenced Kepler and Galileo
- Ibn Sina «Canon Medicinæ» «Sufficiencia» etc.. **Medicine books** were taught in European universities for centuries
- Fibonacci «Liber Abaci» brought the **decimal system** to Italy (13AD) then to Europe (15AD)
- Ibn Rushd **interpretations of Aristotle** «Liber de Anima» «Metaphysica» «Destrucio destrusionis» etc.. influenced the development of **European scholasticism**

These helped bridge the gap between Islamic World and Western Europe and spark the start of European Renaissance

Renaissance Science (1450-1650)

- **Rediscovery of previous Scientific work** (Greek, Islamic) fuelled interest in Astronomy, Mathematics, Medicine , Mechanics and empirical observation of nature
- **The Reform** came as a reaction to the Corruption of the Catholic Church and a new widespread Witch hunt by inquisition. Under the Reform **scholars moved away from Ecclesiastism.**

Key Scientific Achievements:

- Johannes Gutenberg invented the **Printing Press** (1440) giving an enormous boost to communication of knowledge
- Andraes Vesalius (1550) published results on **Human Anatomy** based on dissection and observation
- Nicolaus Copernicus (1543) proposed **Heliocentric model** that fits better with previous astronomical tables (Islamic astronomy tables & Tycho Brahe)
Johannes Kepler (1600) formulated 3 precise **laws of planetary motion** based on astronomical tables
Galileo (1600) experimented on motion and **free fall of objects** providing important data for Newton.
Telescope was improved (Galileo 1610)
- Francis Bacon (d.1625) developed **Empiricism** (experimentation & critical thinking).
Rene Descartes (d. 1650) developed **Rationalism** (trust reason & logical thinking).

Enlightenment Age Science (1650-1750)

Scientists, inspired by Francis Bacon and Rene Descartes developed further empirical methods & started the Mathematical framework of Modern Science

* Newton (1687) «Philosophiae Naturalis Principia Mathematica» formulated the laws of Motion and Universal gravitation. Newton theory explained «everything» in a mechanical world subject to **gravitational force (1st force of nature)**

- Body Movements on earth
- Movements of heavenly bodies
- Precise return Haley's Comet
- Tides on Earth
-

* Robert Hooke (1665) & Van Leeuwenhoek improved the microscope discovering **cellular biology**

* Robert Boyle (1680) established 1st quantitative properties Gases leading to **Thermodynamics**. Thomas Newcomen (1712 **steam pump**), Abraham Darby (1700 **coke smelting**) improved coal mining and production, first step to the industrial revolution

* Carl Linnaeus (1735) performed a classification of living things creating **modern Taxonomy**

* James Hutton (1750) proposed the Evolutionary theory of earth leading to **modern Geology**

Mathematics: Newton, Leibniz (17 AD developed Calculus which Newton immediately used for his theory of Gravitation)

First Industrial Revolution Science (1750- 1850)

This period saw scientific developments in new areas with many life changing industrial applications and early insights beyond the mechanical world model

- Sadi Carnot, James Watt (1760) improved **steam engine**.
Gay Lussac (1800) developed **thermodynamics** (effect of temperature, Gas combinations)
Advancements in metallurgy, mechanics and Engineering led to **revolution in locomotion** (Georges Stephenson 1825) and construction
- Antoine Lavoisier(1770) stated conservation of mass in chemical reactions , discovered Oxygen) starting **modern chemistry**.
Friedrich Wöhler (1828) synthesised the first organic compound, starting **Organic Chemistry**
- Edward Jenner (1796) found the **Smallpox vaccine**
- Alessandro Volta (1800) produced first **Voltaic cell** confirming connection between Chemistry & Electricity
- Michael Faraday (1830+) discovered Magnetism, built first Electric motor, related Electromagnetism and light, mastered Electrolysis). **Greatest experimentalist ever**, opened the way to Maxwell's formulation of the whole Electromagnetic effect .
- Great developments in Mathematics that provided essential tools for next period Science: Leonhard Euler (1707-83), Jean D'alembert (1717-83), Jean Louis Lagrange (1736-1813), Pierre Laplace (1749-1827), Carl Friedrich Gauss (1777-1855), Auguste Cauchy (1789-1857), Niels Abel (1802,1829), Evariste Gallois (1811-1832)G

Second Industrial revolution Science (1850-1914)

Scientific progress accelerated and affected many new areas

- Charles Darwin (1859) created **evolutionary Biology** with «the origin of Species»
- Gregor Mendel (1860) established the rules of Heredity, foundation of **modern genetics**
- Louis Pasteur & Robert Koch (starting in the 1860's) developed the **theory of germs**, leading to generalized vaccines etc

- Willian Thomson (Lord Kelvin 1860) completed the basics of thermodynamics with the concepts of **Entropy and Absolute Zero temperature**.
- Dimitri Mendeleev (1866) developed the **Periodic Table of elements**

- Following the work of Michael Faraday, James Clerk Maxwell (1866) unified Electricity, Magnetism, Electromagnetism and light as manifestation of the **Electromagnetic Force (2nd force in nature)**. All summed up in 3 related equations (Maxwell equations).
- In the 1880's Thomas Edison & Nicholas Tesla developed first **electro technology applications**, Karl Benz developed the first car, then Henry Ford pioneered **industrial automation** (1913)

Abstract Mathematics brought advances in Algebra, Topology, Set Theory. names in this period include Georg Cantor (1845-1918) & Henri Poincarre (1854-1912)

MENDELEEV PERIODIC TABLE OF ELEMENTS

ORIGINAL TABLE 1861

Based on Chemical properties of elements
19th century rules of Chemistry

H 1.01	II	III	IV	V	VI	VII	VIII				
Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0					
Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5					
K 39.1	Ca 40.1		Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7		
Cu 63.5	Zn 65.4			As 74.9	Se 79.0	Br 79.9					
Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9		Ru 101	Rh 103	Pd 106		
Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127					
Ce 133	Ba 137	La 139		Ta 181	W 184		Os 194	Ir 192	Pt 195		
Au 197	Hg 201	Tl 204	Pb 207	Bi 209							
		Th 232			U 238						

CURRENT TABLE

Based on atomic number and Electronic layers

The modern periodic table is organized by atomic number and electronic configuration. It includes a legend for element categories and states of matter.

Legend:

- State of matter (color of name):** Gas (blue), Liquid (orange), Solid (green), Unknown (grey).
- Subcategory in the metal-metalloid-nonmetal trend (colour of square):**
 - Alkali metals (red)
 - Alkaline earth metals (orange)
 - Transition metals (green)
 - Lanthanides (light green)
 - Actinides (dark green)
 - Metalloids (yellow)
 - Actinoids (purple)
 - First transition metals (light blue)
 - Reactive non metals (pink)
 - Noble gases (grey)
 - Unknown properties (dark grey)

Element Example (Hydrogen):

- Atomic Number: 1
- Symbol: H
- Name: Hydrogen
- Atomic Weight: 1.008
- State of Matter: Gas



20th Century Science



Revolution in Physical Sciences



Revolution in Chemistry & Biology



Revolution in IT technology



Socio Technological Revolutions
(not our subject)

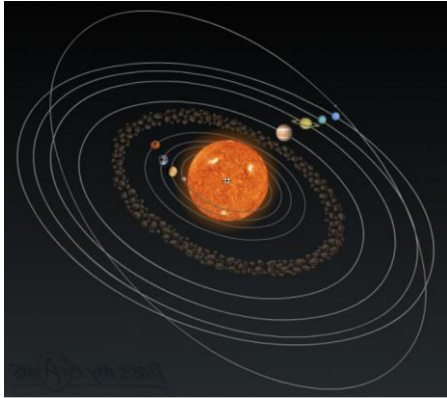
20th Century Revolution in Physics

- Michelson and Morley (1888) find that velocity of light is the same for any moving object, confirming Maxwell equations on Electromagnetism but contradicting Newton mechanics
- Albert Einstein develops 4D **Special Relativity** resolving Newton mechanics contradiction (1905) and established the equivalence of Mass and Energy ($E= mc^2$)
- In 1915 Einstein developed **General relativity** theory for gravitation as a force that relates Space/Time/Energy/mass in 1 set of equations, leading to Universe Expansion and Big Bang
- Pierre & Marie Curie discovered radioactivity (1898+) and radioactive elements, Enrico Fermi (1930) formulated the **weak nuclear force (3rd force in nature)** responsible for radioactivity
- Ernest Rutherford discovered atomic Nucleus (1911), Hideki Yukawa (1935) formulated the **Strong Nuclear force (4th force of nature)** binding together Nucleons (Protons & Neutrons)
- Max Planck (1900) explained enigma of black body radiation through **quantum energy** and Einstein (1905) explained the photo electric effect as a **quantum** phenomenon
- Werner Heisenberg , Erwin Schrödinger, Paul Dirac (1930) developed the foundations of **Quantum Mechanics** describing behavior of particles at atomic and subatomic level
- M. Gell-Mann proposed **Quarks** as components of Nucleons (1964), Quarks found in 1968.
- Fritz Zwicky first hypothesized «**Dark Matter**» (1933) evidenced by sky observations
- **Dark energy** evidenced by accelerated expansion of Universe (1998)

CURRENT VIEW OF THE UNIVERSE - FORCES

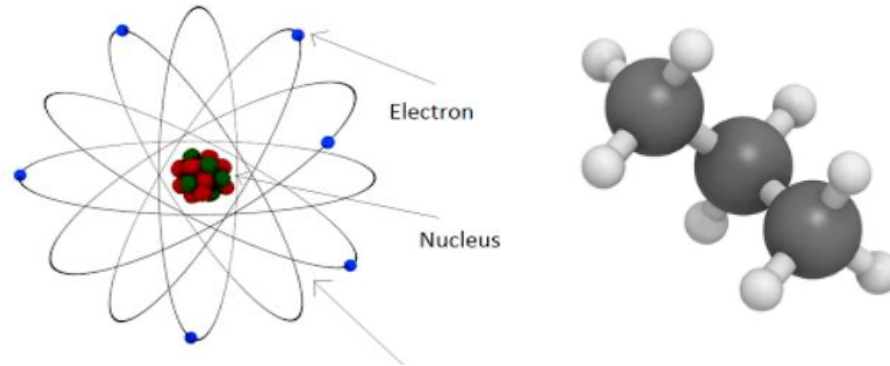
Gravitational force

Strength 1, Range infinite



Electromagnetic force

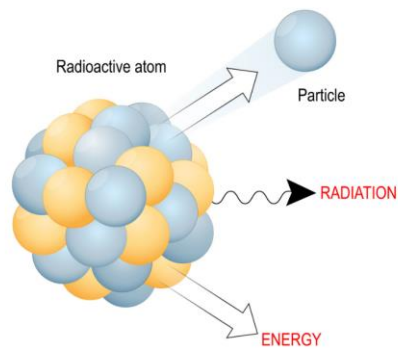
Strength 7×10^{35} , Range infinite



Weak Nuclear Force

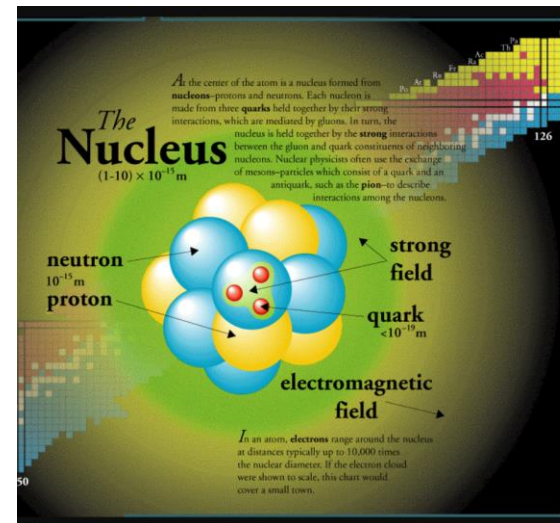
Strength 10^{32} , Range 0.1 millionth of a nm

Radioactivity



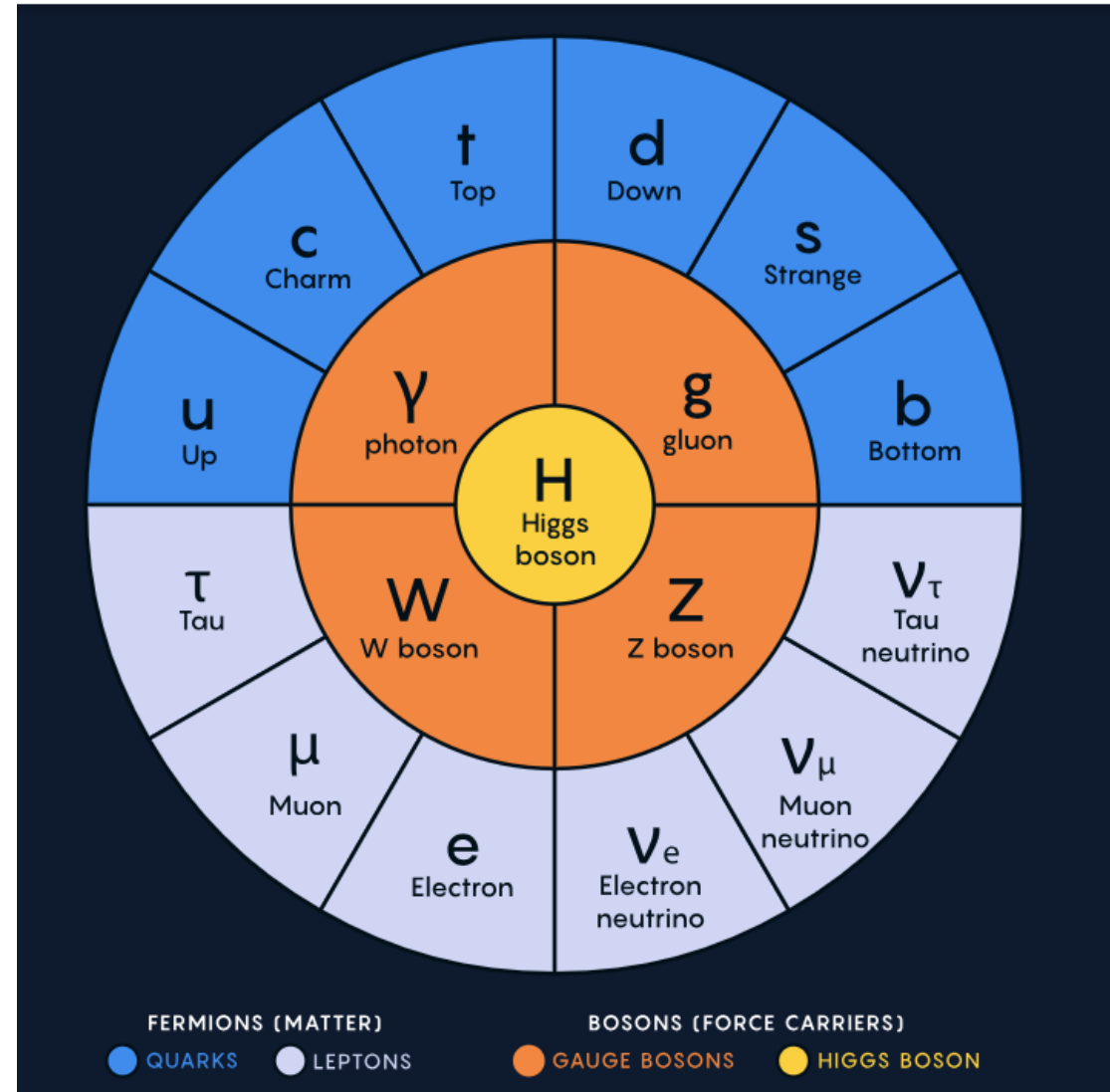
Strong Nuclear Force

Strength 10^{38} , Range 3xmillionth of a nm



CURRENT VIEW OF THE UNIVERSE – ELEMENTARY PARTICLES

- Fermions (in nucleons) and Leptons (electrons and Neutrinos) exchange of Bosons creates the forces of nature (gravitation not included yet)
- All particles have antiparticles which in our part of the universe can be generated for only tiny fractions of a second
- Elementary particles responsible for Electromagnetic, Weak, and strong nuclear force are 'quantum entities' with dual «particle wave» behavior
- Gravitation force creates space curvature and spatial waves but the existence of its elementary particle the graviton is not yet proven.
- At the particle scale Space, Time, Energy are quantized.



PHYSICAL EQUATIONS OF UNIVERSE

Classical mechanics

Our scale, Our time, Normal speeds

NEWTON, MAXWELL EQUATIONS

I General Relativity Mechanics

Close to speed of light & close to strong gravitational fields

Einstein's Field Equations

(The General Theory of Relativity)

fb/page/CosmologicalAstrophysics

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

tells matter-energy
how to curve
space-time

tells matter-energy
how to move through
curved space-time

The equations completely changed
how we understood the nature and
evolution of the Universe.

Quantum Mechanics

Atomic and subatomic scale, normal speeds
(electromagnetic, weak nuclear, Strong nuclear)

**Time-dependent Schrödinger
equation (general)**

$$i\hbar \frac{d}{dt} |\Psi(t)\rangle = \hat{H} |\Psi(t)\rangle$$

Quantum Field Theory (QFT)

Extreme conditions: Temperature, gravity
(Big Bang, CERN)

PRINCIPLE OF LEAST ACTION

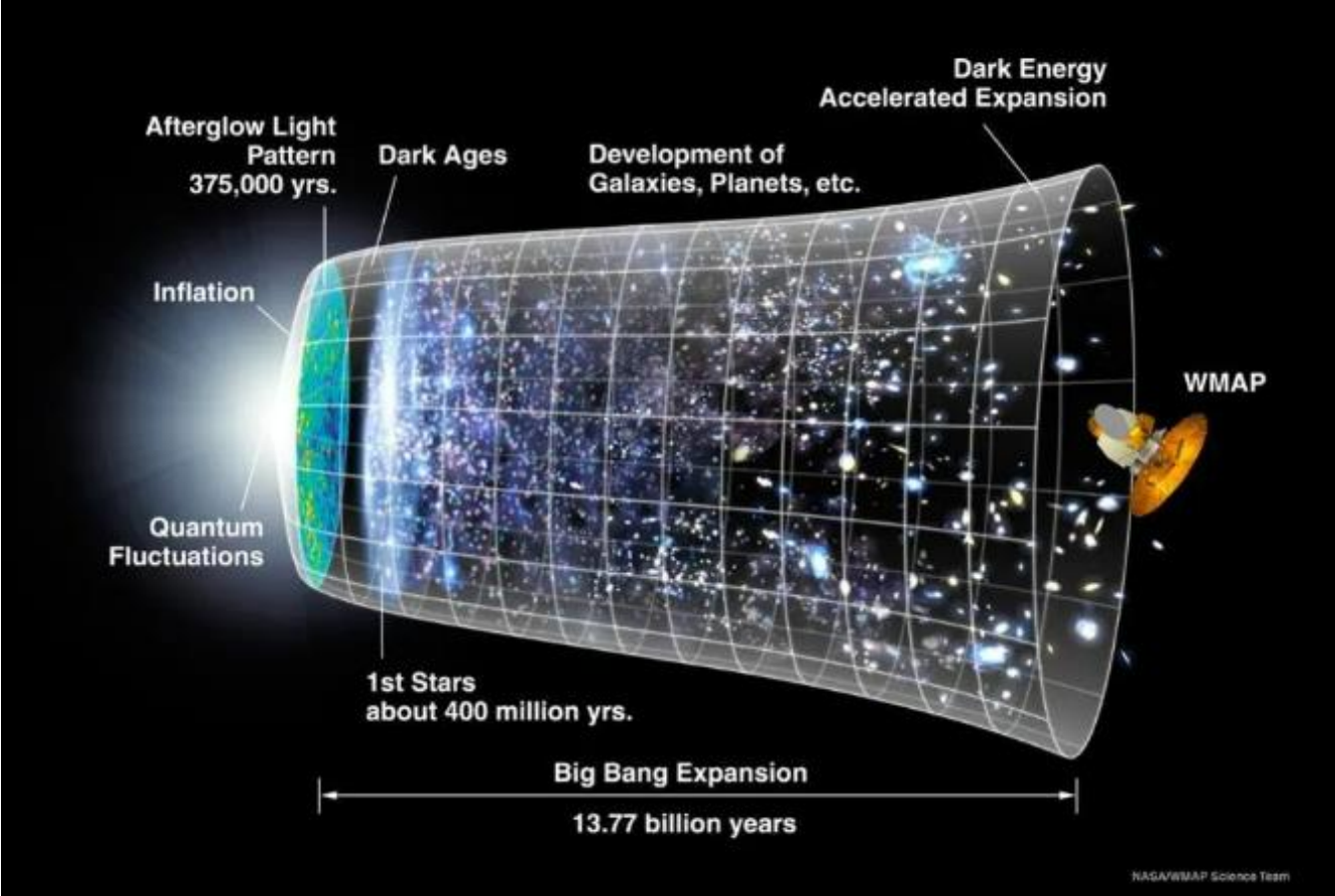
CURRENT VIEW OF THE UNIVERSE HISTORY

- At time 0 **bing bang**, near infinite T, energy. All forces unified
- Time 10^{-36} to 10^{-32} sec, $T = 10^{27}$, **Cosmic Inflation** period of extreme expansion and tiny fluctuations
- Time up to 10^{-6} sec, $T = 10^{13}$, **Quark Gluon Plasma**, start of **proton/neutron formation**
- Time up to 1 sec, $T < 10^{12}$, Hadron (Proton Neutron epoch), **Matter anti matter annihilate** with 10^{-9} excess matter
- Time up to 10 sec, $T = 10^{10}$, **Lepton (electrons, Neutrinos)**, Lepton anti lepton annihilate and huge amount of **primary neutrinos released**
- Time 3 to 20 minutes, $T = 10^9$, **Big bang Nucleosynthesis** : primary Deuterium, Helium, Lithium
- Time up to 380000 years, $T = 10^9$ to 3000, **Plasma state**, universe filled with high energy photons preventing electrons from binding to Nuclei
- Time 380000 years, electrons can combine with nucleia to form light atoms, releasing **Photons (Cosmic microwave background (CMB) radiation)**
- 380K to 150M years: **Dark ages** (no stars, only CMB), density irregularities create seeds of future stars
- 150M to 500M years: **First stars**, very massive, intense burning, short lived
- 500M to 1000M years: **Reionization**, UV Radiation from stars ionizes the atoms making the universe transparent to visible light
- 1B to 5B years: **Stars, Galaxies and Clusters** form
- 5B years to present: Acceleration of universe expansion due to **Dark Energy**. Formation of **Large Scale Filament Structure around Dark Matter Framework**

CURRENT VIEW OF THE UNIVERSE - HISTORY

Universe is 13.7 B, Milky way is 9 B , Our Sun is 5 B years old. Today universe temperature 2.7K (-270.3 C)
(Explosive expansion, Microwave radiation, 'Flat' universe, Dark matter framework, Accelerated Expansion)

TIME EVOLUTION SINCE BIG BANG



LARGE SCALE FILAMENT STRUCTURE OF UNIVERSE




REMAINING QUESTIONS IN THEORETICAL PHYSICS

- **Include Gravitation in Quantum Field Theory (QFT)**

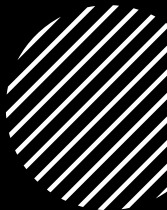

- In QFT there are only 'energy fields' in the universe. Particles are perturbations in those fields.
- Math difficulties to include gravitation in QFT theory
- Direct experiments would require 10^{15} times CERN energy

- **SOME QUESTIONS POSED BY QUANTUM PHYSICS**

- Full meaning of entanglement and superposition
- Error correction in Quantum Computing
- Negative time experiments?



20th Century revolution in Chemistry & Biology



Periodic table of elements was completed . New elements were predicted and found based on atomic theory



Polymer chemistry lead to plastics products which invaded our life!



Alexander Fleming (1928) discovered Penicillin leading to antibiotics treatment of infections



James Watson & Francis Crick (1953) discovered DNA base of all living organisms on earth, confirming evolutionnary theories



Development of Human Genome Project by end of 20th Century.

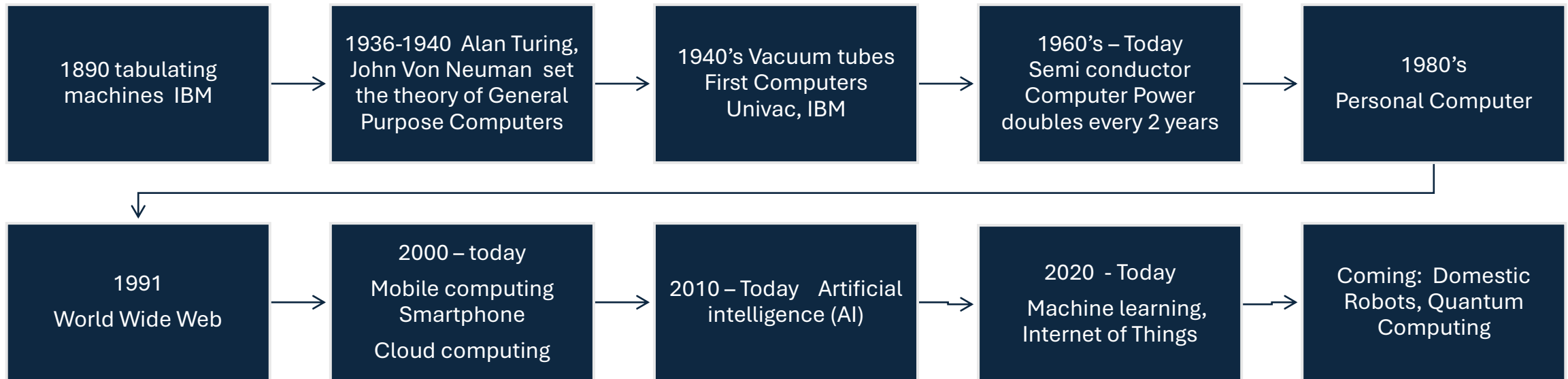


Bio/AI became new tool for investigating living functions (e.g. predicting 3D protein structures)

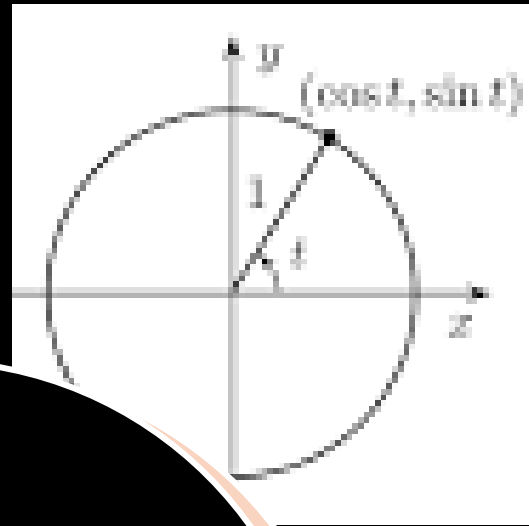


Bio/AI is expected to change the future of mankind (Gene editing etc)

20th Century revolution in Information Technology



MATH IS IN
NATURE NOT
JUST A HUMAN
MODEL



- MAN's DNA evolved in 2 billion years since the first Eucaryote cell. It is a CODE to build 3D proteins whose 3D geometry is determined by Maxwell equations & QM
- NATURE has inherent properties such as
 - If an object moves on a circle its x,y coordinates are sines and cosines
 - Sine waves are the basis of electromagnetic radiation and of all energy fields in QFT
 - Movements around an equilibrium point (Springs, Pendulums, Molecules) produce periodic movements made of sine waves
 - Gravity produces quadratic trajectories (ellipses, parabolas, hyperbolas)
 - Gravity & Electromagnetism forces are 'conservative' and must, in 3D space, decrease with square of distance
 - Nuclear forces are generated by the exchange of confined particles. These forces decrease exponentially with distance and with mass of exchange particle
 - Primary equations of Nature expressed so «naturally»

Reference on
primitive
counting
(PDF)

THE NUMBER CONCEPT

ITS ORIGIN AND DEVELOPMENT

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