

 *Background gradient*

Why Study the History of Mathematics?

- Mathematics was **invented by real people** solving real problems
- Every formula you have learned has a **human story** behind it
- Ideas emerged **independently** across continents
- Understanding *where* math came from helps us understand *what* it is



*Simplified world
outline (rectangle
placeholders for contine*

💡 Key Insight

Mathematics is not a fixed body of knowledge handed down from above — it was created, debated, lost, and rediscovered by people just like you.



 *Main timeline axis*

This timeline is our roadmap. We will mark “you are here” as we travel through each era.

Where It All Began

Pre-Classical Mathematics ~20,000 BCE – 500 BCE



 *Region highlights*



 *Diagram*

The Ishango Bone — The Oldest Mathematics?


Ishango Bone

Date: c. 20,000 BCE

Discovered: 1960, near Lake Edward, modern DR Congo

Now held at: Royal Belgian Institute of Natural Sciences, Brussels

- A bone tool with **notched markings**
- Possibly represents: arithmetic sequences, prime numbers, or a **lunar calendar**
- One of the **earliest known mathematical artefacts**
- Interpretation is *debated* (De Heinzelin, Marshack vs. sceptics)

 *Photograph of the Ishango bone showing three columns of tally marks (Royal Belgian Institute of Natural Sciences)*


 *Complex diagram*

Babylon — The First Mathematicians

- Civilization in Mesopotamia (modern Iraq), c. 2000–500 BCE
- Developed a **base-60** (sexagesimal) number system
- Why **60 minutes** in an hour, **360 degrees** in a circle
- Wrote mathematics on **clay tablets** in cuneiform script
- Thousands of mathematical tablets survive

Key Insight

The next time you check the clock, thank a Babylonian scribe from 4,000 years ago.

 *Photograph of a cuneiform clay tablet with mathematical content (Yale Babylonian Collection or British Museum)*

 *Wedge for 1*

Plimpton 322 — A 3,800-Year-Old Mystery

Anonymous Babylonian Scribe(s)

Date: c. 1800 BCE

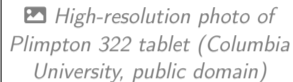
Origin: Mesopotamia (modern Iraq)

Now held at: Columbia University Rare Book & Manuscript Library

- Contains **Pythagorean triples**
- Written **~1,200 years BEFORE** Pythagoras
- Interpretation debated:
 - Neugebauer & Sachs (1945): table of triples
 - Robson (2001): teacher's aid for exercises

💡 Key Insight

The theorem we call "Pythagorean" was known to Babylonians over a millennium earlier. Math rarely has a single inventor.


 *High-resolution photo of Plimpton 322 tablet (Columbia University, public domain)*

a	b	c
119	120	169
3367	3456	4825
65	72	97

Selected rows from Plimpton 322

Egyptian Mathematics — Practical Genius

- Driven by **practical needs**:
 - Land surveying after Nile floods
 - Architecture (pyramids!)
 - Taxation and accounting
- Two main sources:
 - **Rhind Papyrus** (next slide) — larger, more complete
 - **Moscow Papyrus** — contains the frustum formula
- Used unit fractions: $\frac{2}{5} = \frac{1}{3} + \frac{1}{15}$

 *Section of the Rhind Papyrus (British Museum, EA 10057-8)*

 *height*


Ahmes — The Oldest Named Mathematician

Ahmes (Ahmose)

Dates: fl. c. 1550 BCE

Origin: Ancient Egypt

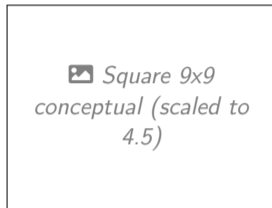
Contribution: Scribe who copied (and possibly compiled) the *Rhind Mathematical Papyrus* — our best source on Egyptian mathematics

 *Portion of the Rhind Papyrus showing a geometry problem (British Museum digital collection)*

- Contains problems in **arithmetic**, **algebra**, **geometry**
- Implies $\pi \approx 3.16$ (via circle area formula)
- Ahmes wrote: *“Accurate reckoning for inquiring into things, and the knowledge of all things, mysteries. . . all secrets.”*

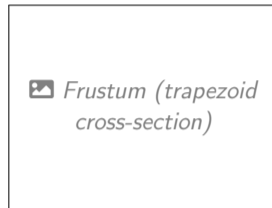
Egyptian Geometry in Action

Circle area (Rhind Papyrus):



Egyptian rule: $A \approx \left(\frac{8}{9}d\right)^2$
 $\Rightarrow \pi \approx \frac{256}{81} \approx 3.16$

Frustum volume (Moscow Papyrus):



$$V = \frac{h}{3}(a^2 + ab + b^2)$$

Exactly correct!

c. 1850 BCE — from the Moscow Papyrus

💡 Key Insight

They got π accurate to within 1% — without calculus, without computers, using reeds and papyrus.

Mesopotamian Algebra

Babylonians solved quadratic equations

(in verbal/geometric form, not symbolic notation)

Babylonian word problem:

"I have added the area and the side of my square: 0;45."

Modern equivalent:

$$x^2 + x = \frac{3}{4}$$

Babylonian solution (completing the square):


$$x = \sqrt{\frac{3}{4} + \frac{1}{4}} - \frac{1}{2} = \frac{1}{2}$$



 Adding the side:
rectangle $x \cdot 1$

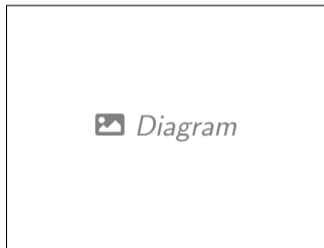
Key Insight

Your algebra homework has a 4,000-year pedigree.

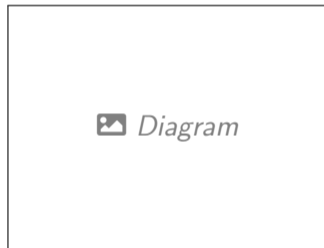
 **Think–Pair–Share:** “Why do you think the Babylonians never developed the concept of mathematical proof? Was their approach inferior, or just different?” (2–3 min)

What Was Missing?

Ancient mathematics was **computational**, not **axiomatic**.



VS.



This is **not a deficiency** — the procedural approach served its purpose brilliantly for millennia.
But the Greeks would add something new: the idea that you must *prove* your claims.

Mayan Mathematics — An Independent Tradition

Maya Civilization

Era: c. 4th century CE and earlier


Region: Mesoamerica (modern Mexico, Guatemala, Belize, Honduras)

- **Vigesimal** (base-20) number system
- Independently invented **the concept of zero**
- Long Count calendar required sophisticated positional arithmetic
- Zero used **centuries before Europe** knew the concept

💡 Key Insight

Zero was invented independently at least twice: in India and in Mesoamerica.

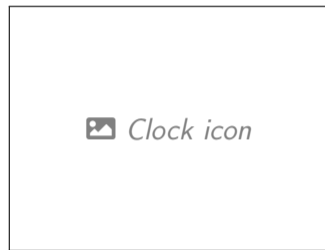
 *Mayan Numerals*

 *Mayan zero glyph
and section of a Long
Count calendar stone
(Wikimedia
Commons)*

Legacy of Ancient Mathematics

What survives from the ancient world:

- **Base-60 system** → clocks, angles
- **Basic algebra** → quadratic equations
- **Geometry** → surveying, architecture
- **Approximations of π**
- **Independent number systems** across continents
- **Zero** appearing in multiple civilizations



“But one civilization would transform math from a tool into a way of thinking. . .”

The Greek Revolution

Math Becomes Logic ~600 BCE – 300 CE

 *Mediterranean outline
hint*

 *Diagram*

Thales of Miletus

Thales of Miletus (Thalēs ho Milēsios)

Dates: c. 624 – c. 546 BCE

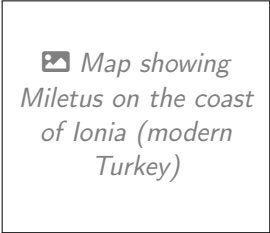
Origin: Miletus, Ionia (modern Turkey)


Contribution: Traditionally regarded as the first person to use *deductive reasoning* in mathematics

- **Thales' theorem:** any angle inscribed in a semicircle is a right angle
- Credited with predicting a solar eclipse
- Marks the shift from “*what*” to “*why*”



 *Semicircle*



 *Map showing
Miletus on the coast
of Ionia (modern
Turkey)*

Pythagoras and the Pythagoreans

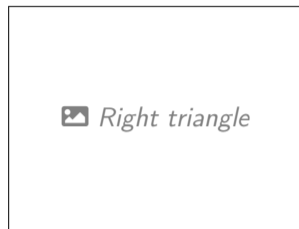
Pythagoras of Samos (Pythagoras ho Samios)

Dates: c. 570 – c. 495 BCE

Origin: Samos, Greece; active in Croton, Magna Graecia (southern Italy)

Contribution: Founded a school that saw numbers as the foundation of reality

- $a^2 + b^2 = c^2$ bears his name (but known earlier — recall Plimpton 322)
- Discovery that $\sqrt{2}$ is **irrational** — a crisis for their philosophy
- “All is number” — numbers govern the universe



$$16 + 9 = 25 \quad \checkmark$$


Euclid of Alexandria (Eukleides)

Dates: fl. c. 300 BCE (birth/death unknown)

Origin: Active in Alexandria, Ptolemaic Egypt

Contribution: Wrote *The Elements* — the most influential mathematics textbook in history

- Used for **over 2,000 years** as a textbook
- Organized geometry into a **deductive system from axioms**
- Proved the **infinitude of prime numbers**
- 13 books covering geometry, number theory, proportion

 *Page from a medieval manuscript of The Elements (Bodleian Library or Vatican Library)*

 *Diagram*

Archimedes — The Greatest?

Archimedes of Syracuse

Dates: c. 287 – 212 BCE

Origin: Syracuse, Sicily (Greek colony)

Contribution: Calculated π with high accuracy; discovered principles of buoyancy and the lever; method of exhaustion

- Bounded π : $3\frac{10}{71} < \pi < 3\frac{1}{7}$
- Used inscribed / circumscribed polygons
- **Method of exhaustion** → compared to early integral calculus
- Killed during the siege of Syracuse (212 BCE)

 *Circumscribed hexagon*

$$\underbrace{P_{\text{in}}}_{\text{lower}} < \underbrace{C}_{\pi} < \underbrace{P_{\text{out}}}_{\text{upper}}$$

Used 96-sided polygons!

 *The Archimedes Palimpsest (Walters Art Museum, public domain)*

Eratosthenes of Cyrene

Dates: c. 276 – c. 194 BCE

Origin: Cyrene (modern Libya); worked in Alexandria

Contribution: Calculated Earth's circumference; Sieve of Eratosthenes for primes

- Compared shadow angles at **Alexandria** and **Syene** (Aswan)
- At summer solstice: no shadow in Syene, $\sim 7.2^\circ$ shadow in Alexandria
- Result: $\sim 252,000$ stadia \approx remarkably close to the true value



 *Earth circle*

Apollonius — Conic Sections

Apollonius of Perga

Dates: c. 262 – c. 190 BCE

Origin: Perga, Pamphylia (modern Turkey); worked in Alexandria

Contribution: Wrote *Conics* — named the ellipse, parabola, and hyperbola

- The definitive ancient work on conic sections
- **These names are his:** ellipse, parabola, hyperbola
- Essential for Kepler's planetary orbits **1,800 years later**

Key Insight

Apollonius named the curves you study in precalculus. Kepler would later show that planets travel in the ellipses Apollonius described.



Slicing a cone at different angles produces all four curves.

Diophantus — Father of Algebra?


Diophantus of Alexandria

Dates: fl. c. 250 CE

Origin: Alexandria, Roman Egypt

Contribution: Wrote *Arithmetica* — algebraic problems seeking integer or rational solutions; introduced proto-algebraic notation

- **Diophantine equations** (integer solutions) named after him
- One of the earliest uses of **symbolic abbreviations** for unknowns
- Fermat's "Last Theorem" was *scribbled in the margin* of a copy of *Arithmetica*

 *Page from a manuscript of Arithmetica (Wikimedia Commons)*

 *Diagram*

Hypatia of Alexandria


Hypatia of Alexandria (Hypatia hē Alexandrinē)

Dates: c. 350–370 – 415 CE

Origin: Alexandria, Roman Egypt

Contribution: Mathematician, astronomer, philosopher. Commentaries on Diophantus and Apollonius. Head of the Neoplatonist school in Alexandria.

- Wrote commentaries on Diophantus's *Arithmetica* and Apollonius's *Conics*
- One of the **last great scholars** of ancient Alexandria
- **Murdered** by a Christian mob in 415 CE
- Her death is often seen as a symbol of the end of classical learning

 "Hypatia" by Charles William Mitchell, 1885 (Laing Art Gallery, Newcastle)

 Diagram

Greek Legacy and the Great Transition

What the Greeks gave us:

- **Axiomatic reasoning** and **proof**
- The idea that math is about *eternal truths*, not just practical calculation
- Geometry as a deductive system
- Foundations of number theory



But then...

- Much Greek knowledge **lost** in the West
- **Preserved** in Byzantine and Islamic libraries
- Two very different journeys ahead...

Greek texts survived thanks to Islamic and Byzantine scholars.

“Greek mathematical texts were about to take two very different journeys — east to India and the Islamic world, and into near-oblivion in medieval Europe.”

India

The Invention of Nothing (and Everything)

~500 BCE – 1200 CE

 *The number that changed everything*

 *Diagram*

Early Indian Mathematics — The Sulba Sutras

- **Sulba Sutras** (c. 800–200 BCE)
- Geometric rules for Vedic **altar construction**
- Include **Pythagorean triples** — independently of Babylon and Greece
- Approximation of $\sqrt{2}$:


$$\sqrt{2} \approx 1 + \frac{1}{3} + \frac{1}{3 \cdot 4} - \frac{1}{3 \cdot 4 \cdot 34} \approx 1.4142156 \dots$$

(true value: 1.4142135...)

💡 Key Insight

Pythagorean triples appear in at least THREE independent traditions: Babylonian, Indian, and Greek.

 *Falcon-shaped altar
(simplified)*

 *Diagram from the
Sulba Sutras showing
altar construction
with geometric
proportions*


Aryabhata (Aryabhata I)

Dates: 476 – 550 CE

Origin: Kusumapura (likely modern Patna), Gupta Empire, India

Contribution: Wrote *Aryabhatiya* (499 CE) — trigonometric tables, place-value system, approximation of π , Earth's rotation

- $\pi \approx 3.1416$ — remarkably accurate
- Used a **place-value number system**
- Tabulated **sine values** (the first systematic trigonometric table)
- Proposed that the **Earth rotates on its axis**
- **Kuttaka method** for indeterminate equations

 *Statue of Aryabhata (IUCAA Pune) or page from a manuscript of Aryabhatiya (Wikimedia Commons)*

 *Data points*

Brahmagupta — The Rules for Zero

Brahmagupta

Dates: 598 – c. 668 CE

Origin: Bhinmal, Rajasthan, India

Contribution: *Brahmasphutasiddhanta* (628 CE) — first to formalize rules for zero and negative numbers; general quadratic formula; cyclic quadrilateral formula

- **First rules for arithmetic with zero:**
 $a + 0 = a$, $a \times 0 = 0$, $0 + 0 = 0$
- **Negative \times negative = positive**
- **General solution to the quadratic equation**
- Said $0 \div 0 = 0 \rightarrow$ mathematically wrong, but historically important

 *Rules in boxes*

 *Cyclic quadrilateral*

Bhaskara II (Bhaskaracharya)


Bhaskara II — “Bhaskara the Teacher”

Dates: 1114 – 1185 CE

Origin: Bijjada Bida (likely modern Karnataka), India

Contribution: Wrote *Lilavati* (mathematics) and *Bijaganita* (algebra); solved Pell’s equation before Pell; preliminary concepts related to infinitesimals

- *Lilavati* — a math textbook **addressed to his daughter**
- One of the earliest textbooks written for a specific student
- Solved $x^2 - ny^2 = 1$ (“Pell’s equation”) **before** Pell
- Preliminary ideas related to **derivatives** and infinitesimals

 *Opening verse of Lilavati in Devanagari with English translation*

 *Diagram*

The Kerala School — Calculus Before Calculus?

Madhava of Sangamagrama

Dates: c. 1340 – c. 1425 CE

Origin: Sangamagrama (modern Irinjalakuda), Kerala, India

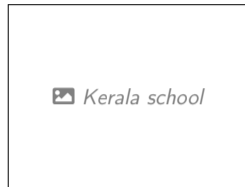
Contribution: Founder of the Kerala school; infinite series for π , sine, and cosine — BEFORE European discovery

Also: **Nilakantha Somayaji** (1444–1544 CE, Kerala) — wrote *Tantrasamgraha* (1501), extended Madhava's work.

- Infinite series for π (Madhava–Leibniz):

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \dots$$

- Power series for $\sin x$ and $\cos x$
- 200+ years before Newton and Leibniz



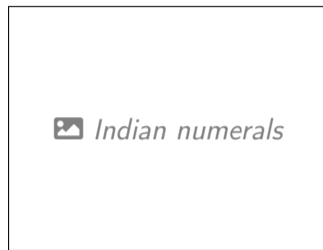
💡 Key Insight

Was this transmitted to Europe or independently rediscovered? An open question in the history of mathematics.

Indian Mathematics — A Legacy for the World

India gave the world:

- The **decimal place-value system**
- **Zero** as a number
- **Negative numbers** with formal rules
- Trigonometric functions (**sine**)
- **Infinite series**
- Solutions to Pell's equation
- The foundations of the number system we use today



The numeral system you use every day was invented in India, transmitted through the Islamic world, and adopted by Europe.

“Meanwhile, on the other side of Asia, a parallel mathematical tradition was flourishing. . .”

China

Parallel Discoveries

~200 BCE – 1300 CE

 *Horizontal rods for
1-5*

 *Diagram*

The Nine Chapters on the Mathematical Art

Jiuzhang Suanshu

Date: Compiled c. 2nd century BCE – 1st century CE

Origin: Han Dynasty, China

Content: 246 problems covering arithmetic, algebra, geometry, engineering

- China's most important ancient mathematical text
- Includes **Gaussian elimination** — ~2,000 years before Gauss!
- Methods for **square roots** and **cube roots**
- Practical problems: taxation, construction, surveying
- Nine chapters = nine topic areas

 *Page from the*

*Nine Chapters
showing
mathematical
problems (Wikimedia
Commons / Chinese
library digital
collections)*

 *Ground line*

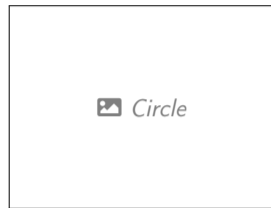
Liu Hui

Dates: fl. c. 263 CE

Origin: Cao Wei kingdom, China (Three Kingdoms period)

Contribution: Commentary on the *Nine Chapters* (263 CE); polygon method for π ; principles of cartographic surveying

- Used a **polygon method** (like Archimedes) to calculate π
- Achieved $\pi \approx 3.14159$ (5 decimal places)
- Developed independently of Archimedes
- Also pioneered **map-making techniques**



Who	When	π accuracy
Archimedes	c. 250 BCE	3.1408...
Liu Hui	263 CE	3.14159
Zu Chongzhi	c. 480 CE	3.1415926...

Zu Chongzhi — The World's Best π for a Millennium

Zu Chongzhi

Dates: 429 – 500 CE

Origin: Liu Song / Southern Qi dynasties, China

Contribution: Calculated π to 7 decimal places — the most accurate value in the world for nearly 1,000 years

- $3.1415926 < \pi < 3.1415927$
- The fraction $\frac{355}{113}$ is accurate to **6 decimal places**
- This approximation was not bettered for **$\sim 1,000$ years**
- Extended Liu Hui's polygon method

 *Diagram*

 *Entries*

Chinese Mathematics — Legacy

Independent discoveries:

- **Gaussian elimination** (~2,000 yrs before Gauss)
- **Horner's method** for polynomials
- **Yang Hui's triangle** (= Pascal's triangle)
- **Chinese Remainder Theorem** — still used in modern cryptography



 *Triangle rows*

Key figures:

Sunzi (fl. c. 3rd–5th c. CE) — Chinese Remainder Theorem

Yang Hui (c. 1238–1298) — described the triangle in 1261

Zhu Shijie (c. 1249–1314) — polynomial algebra with 4 unknowns

Yang Hui published this 392 years before Blaise Pascal.

“Now we arrive at one of the most transformative periods in mathematical history — one that is too often overlooked in Western textbooks...”

Session 1 Complete

“Greek knowledge is about to take two very different journeys. . .”

The House of Wisdom

When Baghdad Was the Center of the World

800–1400 CE



 *Diagram*

The Translation Movement

- Under the Abbasid Caliphate, a massive translation project preserved Greek, Indian, and Persian texts in Arabic
- The **House of Wisdom** (*Bayt al-Hikma*) in Baghdad was the epicenter
- Without this effort, much of Greek mathematics might have been permanently lost



Greek Texts (some lost originals)

💡 Key Insight

When Europeans later “rediscovered” Greek mathematics, they were often translating *Arabic* translations of Greek originals that no longer existed in Greek.

Muhammad ibn Musa al-Khwarizmi — The Father of Algebra

Al-Khwarizmi


Full name: Abu Abdallah Muhammad ibn Musa al-Khwarizmi
(Arabic name — see manuscript image)

Dates: c. 780 – c. 850 CE

Origin: Khwarezm (modern Khiva, Uzbekistan);
worked in Baghdad at the House of Wisdom

- Wrote *Kitab al-Jabr wa-l-Muqabala* (c. 820)
- The word “**algebra**” comes from *al-jabr* (“completion”)
- The word “**algorithm**” comes from the Latin form of his name
- Introduced the Hindu-Arabic decimal system to the Islamic world

 *Arabic script: al-jabr*
– requires Arabic font
image

 *Page from*
the al-Jabr
manuscript
(Bodleian
Library MS.
Huntington
214)


Al-Khwarizmi's Algebra: Completing the Square

His words (paraphrased):

"A square and ten roots equal thirty-nine dirhams"

Modern form: $x^2 + 10x = 39$

Geometric method:

 *Completing the square – geometric diagram*

Step-by-step:

1. Start with $x^2 + 10x = 39$
2. Draw the x^2 square
3. Distribute $10x$ as two rectangles of $\frac{5}{2} \times x$
4. **Complete** the square: add $(\frac{5}{2})^2 = \frac{25}{4}$
5. Now: $(x + \frac{5}{2})^2 = 39 + \frac{25}{4} = \frac{181}{4}$
6. $x + \frac{5}{2} = \frac{\sqrt{181}}{2}$, so $x = \frac{\sqrt{181}-5}{2} = 3$

Key Insight

He solved the same equations you solve — but geometrically, in words, with no symbols.

Thabit ibn Qurra — Translator and Innovator

Thabit ibn Qurra

(Thabit ibn Qurra)

Dates: 826 – 901 CE

Origin: Harran (modern Turkey); worked in Baghdad

- Prolific translator: Euclid, Archimedes, Apollonius
- Extended Euclid's number theory
- Proved a generalization of the Pythagorean theorem to arbitrary triangles
- Discovered a rule for finding **amicable numbers**


💡 Key Insight

Amicable numbers: 220 and 284. Each equals the sum of the other's proper divisors.

$$220 \rightarrow 1+2+4+5+10+11+20+22+44+55+110 = 284$$

$$284 \rightarrow 1+2+4+71+142 = 220$$

 *Arbitrary triangle*

 *Manuscript page from Thabit's translation of Euclid*


Abu Kamil Shuja ibn Aslam

(Abu Kamil Shuja ibn Aslam)

Dates: c. 850 – c. 930 CE

Origin: Egypt

- Extended al-Khwarizmi's algebra *significantly*
- Worked with **irrational numbers** as both solutions *and* coefficients
 - Al-Khwarizmi had restricted to rationals
- Solved systems of equations
- Influenced al-Karaji and, through Latin translation, **Fibonacci**

 A problem from Abu Kamil's Algebra with its geometric solution

 Al-Khwarizmi

Abu Bakr al-Karaji

(sometimes written al-Karkhi)

Dates: c. 953 – c. 1029 CE

Origin: Karaj (or Karkh, Baghdad); worked in Baghdad

- Freed algebra from geometry — treated algebraic operations **purely arithmetically**
- Proved the **binomial theorem**
- Proved the sum-of-cubes formula using a method akin to **mathematical induction**
- Extended algebra to powers beyond cubes



*Visual representation:
stacked squares*



Key Insight

He arguably used the first form of **mathematical induction** — a proof technique you may encounter at university.

Omar Khayyam

Ghiyath al-Din Abu l-Fath Umar ibn Ibrahim al-Khayyam

Dates: 1048 – 1131 CE

Origin: Nishapur, Khorasan (modern Iran)

- Classified and solved **all cubic equations** geometrically (intersecting conic sections)
- Contributed to the **Jalali calendar** reform
- Famous for the *Rubaiyat* poetry



 *Parabola diagram*

Ibn al-Haytham — The First Scientist?

Ibn al-Haytham (Alhazen)

Abu Ali al-Hasan ibn al-Hasan ibn al-Haytham
known in Latin as Alhazen

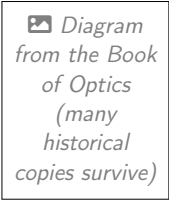
Dates: c. 965 – c. 1040 CE


Origin: Basra (modern Iraq); worked in Cairo

- *Kitab al-Manazir* (Book of Optics) — revolutionized the understanding of vision and light
- Solved **Alhazen's problem**: finding the reflection point on a spherical mirror (4th-degree equation)
- Used an early form of **integral calculus** to compute the volume of a paraboloid
- Pioneered the **scientific method**



 *Spherical mirror*



 *Diagram
from the Book
of Optics
(many
historical
copies survive)*

Abu Rayhan al-Biruni

(Abu Rayhan al-Biruni)

Dates: 973 – c. 1048 CE

Origin: Kath, Khwarezm (modern Uzbekistan)

- Calculated the Earth's radius to within $\sim 1\%$ of the modern value
- Used trigonometry and a mountain
- Wrote *Tarikh al-Hind* on Indian mathematics and astronomy
- Pioneered comparative anthropology and geodesy



 *Earth (partial arc)*

Al-Samawal

(al-Samawal ibn Yahya al-Maghribi)

Dates: c. 1130 – c. 1180 CE

Origin: Baghdad

- Advanced algebraic notation
- First statement of **polynomial long division**

 *Diagram*


Sharaf al-Din al-Tusi

(Sharaf al-Din al-Tusi)

Dates: c. 1135 – 1213 CE

Origin: Tus (modern Iran)

- Analyzed cubic equations by finding their **maxima and minima**
- Anticipating differential calculus!
- *Not* the same person as Nasir al-Din al-Tusi

 *Cubic equation
analysis diagram*

Nasir al-Din al-Tusi — Trigonometry Becomes Its Own Field

Nasir al-Din al-Tusi

Muhammad ibn Muhammad ibn al-Hasan al-Tusi
known as Nasir al-Din al-Tusi

Dates: 1201 – 1274 CE

Origin: Tus, Khorasan (modern Iran)

- Wrote *Treatise on the Quadrilateral* — the **first work** to treat trigonometry as an independent discipline
- Stated and proved the **law of sines** for plane and spherical triangles
- Built the **Maragheh observatory**, one of the most advanced of its era



 *Triangle*




*Reconstruction
of the
Maragheh
observatory*

Jamshid al-Kashi


Ghiyath al-Din Jamshid Mas'ud al-Kashi

Dates: c. 1380 – 1429 CE

Origin: Kashan (modern Iran);
worked at the Samarkand observatory under Ulugh Beg

- Calculated π to **16 decimal places** — a world record that stood for ~ 180 years
- Invented an iterative algorithm for computing n th roots
- Wrote *The Key to Arithmetic* (1427), a comprehensive mathematical encyclopedia
- Systematic use of **decimal fractions**

 *Diagram*

 *The Ulugh Beg
observatory
in Samarkand
(modern
photo)*

Islamic Mathematics: Legacy and Transmission

Islamic mathematicians did not merely “preserve” Greek knowledge — they **transformed** and **extended** it:

- ✓ **Invented** algebra as a discipline
- ✓ **Advanced** trigonometry to independence
- ✓ **Developed** computational methods
- ✓ **Pushed** toward symbolic thinking
- ✓ **Extended** number theory, optics, geodesy



 *Simplified map outline (just positioning)*

💡 Key Insight

The Islamic mathematical tradition was essential to the development of Renaissance mathematics, Enlightenment science, and the modern world.

“Let us now see what happened when these ideas reached medieval Europe. . .”

Session 2 Complete

“These ideas are about to reach Europe and ignite a revolution. . .”

Europe Awakens

Arabic Mathematics Crosses the Mediterranean

1200–1500 CE

 *Diagram*

Fibonacci — Bringing Arabic Mathematics to Europe

Leonardo of Pisa (Fibonacci)

Full name: Leonardo Bonacci (“Fibonacci”)

Dates: c. 1170 – c. 1240–50 CE

Origin: Pisa, Italy; traveled extensively in North Africa

- Wrote *Liber Abaci* (1202) — introduced the **Hindu-Arabic numeral system** to Europe
- The “Fibonacci sequence” appeared as a **rabbit population problem**
- Convinced European merchants to abandon Roman numerals

💡 Key Insight

He did *not* invent the Fibonacci sequence or Hindu-Arabic numerals — he was the **messenger** who brought them to Europe.

 *Sequence display*

 *Page from
Liber Abaci
showing
Hindu-Arabic
numerals*

Nicole Oresme — Graphs Before Descartes

Nicole Oresme

Dates: c. 1320 – 1382 CE

Origin: Normandy, France; worked in Paris

- Pioneered **graphical representations** of changing quantities (“latitude of forms”)
- A precursor to **Cartesian coordinates** — 250 years before Descartes
- Proved the **harmonic series diverges**:

$$1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \cdots = \infty$$

- Discussed **fractional exponents**

 *Oresme's version*

 *Diagram*

Blaise Pascal — Probability and the Triangle

Blaise Pascal

Dates: 1623 – 1662 CE

Origin: Clermont-Ferrand, France

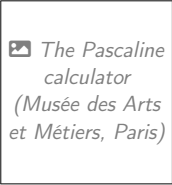
- Co-founded **probability theory** (correspondence with Fermat, 1654)
- “Pascal’s triangle” — known centuries earlier in China, India, and the Islamic world
- Built one of the first **mechanical calculators** (the Pascaline, 1642)
- Major philosopher and writer (*Pensées*)


💡 Key Insight

“Pascal’s triangle” was known in China 400 years before Pascal was born. But Pascal discovered deep new properties — including its connection to probability.



 *Triangle rows*



 *The Pascaline calculator*
(Musée des Arts et Métiers, Paris)

The Stage is Set

By 1500, the ingredients for a mathematical revolution were in place:

1. Indian and Islamic mathematics absorbed via Arabic translations
2. The **printing press** spreading knowledge (Gutenberg, c. 1440)
3. Universities growing across Europe
4. A new confidence in human reason (the Renaissance spirit)

“And then came the Renaissance, when mathematics exploded...”



 *Vertical timeline*

The Modern Age Begins

Revolution in Symbol, Method, and Thought

1500–1700 CE



 *Diagram*

Cardano and the Cubic Equation — A Mathematical Drama

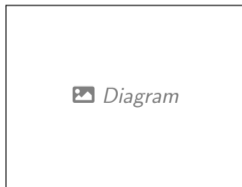
Gerolamo Cardano

(Latin: Hieronymus Cardanus)

Dates: 1501 – 1576 CE

Origin: Pavia, Italy

- Published the general solution to **cubic equations** in *Ars Magna* (1545)
- But who really discovered it?
- The solution forced the invention of **complex numbers** ($\sqrt{-1}$)



François Viète

(Latin: Franciscus Vieta)

Dates: 1540 – 1603 CE

Origin: Fontenay-le-Comte, France

- Introduced systematic use of **letters** for *both* unknowns and known quantities
- Vowels for unknowns, consonants for knowns
- A major step toward **modern algebraic notation**
- Also worked on trigonometric identities and cryptanalysis



 *Medieval style*

John Napier — Logarithms Change Everything

John Napier


Dates: 1550 – 1617 CE

Origin: Edinburgh, Scotland

- Invented **logarithms** (published 1614)
- Transformed computation: turned **multiplication into addition**
- Laplace: logarithms “doubled the life of astronomers” by halving their computational labor

 *Diagram*

 *Page from
Napier's
logarithm tables
(1614)
Mirifici
Logarithmorum
Canonis Descriptio*

 *“Napier's
bones” —
his mechanical
multiplication
device*

René Descartes

(Latin: Renatus Cartesius)

Dates: 1596 – 1650 CE

Origin: La Haye en Touraine, France;
lived in the Dutch Republic

- Created **analytic geometry** — the merger of algebra and geometry
- Published in *La Géométrie* (1637)
- **Cartesian coordinates:** describe curves as equations, solve geometric problems algebraically



 *Grid lines*

Pierre de Fermat — The Prince of Amateurs

Pierre de Fermat


Dates: 1601 – 1665 CE

Origin: Beaumont-de-Lomagne, France

- Co-founded **probability theory** (with Pascal, 1654)
- Developed early **differential calculus** methods (tangents, maxima/minima)
- Stated **Fermat's Last Theorem** in a marginal note (c. 1637)

 *Diagram*

 *Timeline*

 *The
Fermat–Pascal
correspondence
on probability
(1654)*

Isaac Newton — The Method of Fluxions

Sir Isaac Newton

Dates: 1642 – 1726/27 CE

Origin: Woolsthorpe-by-Colsterworth, England

- Co-invented **calculus** (“the method of fluxions”), developed independently during 1665–1666
- Published *Principia Mathematica* (1687) — used calculus to describe gravity and planetary motion
- Also: optics, reflecting telescope

 Page from the
Principia
(Cambridge
University Library)

Newton's notation:

\dot{x} (fluxion of x)

\ddot{x} (second fluxion)

Still used in physics today for time derivatives

Gottfried Wilhelm Leibniz — The Notation that Won

G. W. Leibniz

Dates: 1646 – 1716 CE

Origin: Leipzig, Germany;
worked in Hanover and Paris

- Co-invented calculus **independently** of Newton (published 1684–86)
- His **notation** is what we use today
- Invented a mechanical calculator (Stepped Reckoner)
- Pioneered **binary arithmetic**

💡 Key Insight

Every time you write $\frac{dy}{dx}$ or the integral sign \int , you are using **Leibniz's** language, not Newton's.

 Winner arrow

The Bernoulli Family — A Mathematical Dynasty

The Bernoulli family of Basel, Switzerland:
at least **eight** notable mathematicians across
three generations.

Jacob Bernoulli (1655–1705)

Basel, Switzerland

Bernoulli numbers • *Ars Conjectandi* (1713)

The **law of large numbers**

Johann Bernoulli (1667–1748)

Basel, Switzerland

Taught Euler • Brachistochrone problem

Fierce rivalry with brother Jacob



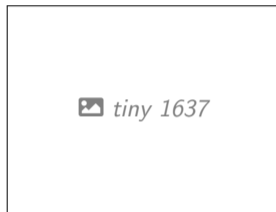
 *Generation 1*



 *start*

Calculus Invented — The Floodgates Open

With calculus, analytic geometry, and modern notation in place, mathematics had the tools for **explosive growth**.



What was now possible:

- ✓ Describe motion and change precisely
- ✓ Compute areas, volumes, arc lengths
- ✓ Model planetary orbits
- ✓ Predict physical phenomena mathematically

What came next:

- Euler: the most prolific mathematician ever
- Lagrange & Laplace: mechanics and celestial theory
- Gauss: the “Prince of Mathematicians”

“With calculus invented, mathematics entered a new era of explosive growth. . .”

The Age of Giants

When Mathematics Conquered the Physical World

1700–1800 CE



 *Diagram*

Leonhard Euler — The Most Prolific Mathematician in History

Leonhard Euler

Dates: 1707 – 1783 CE

Origin: Basel, Switzerland;
worked in St. Petersburg and Berlin

- Published ~ 866 papers and books — more than any other individual mathematician
- Standardized notation: $e, i, \pi, f(x), \Sigma$
- Founded **graph theory** (Königsberg bridges)
- Foundational contributions to number theory, topology, mechanics, optics, astronomy
- Continued producing mathematics *after going blind*



 *Five constants labeled*



 *Four land masses*

Joseph-Louis Lagrange

(born Giuseppe Lodovico Lagrangia)

Dates: 1736 – 1813 CE

Origin: Turin, Sardinia (modern Italy);
worked in Berlin and Paris

- *Mécanique Analytique* (1788) — reformulated Newtonian mechanics using **pure analysis**
- Boasted: “no diagrams in this book”
- **Lagrange multipliers** — optimization with constraints
- **Lagrangian mechanics** — foundation of modern theoretical physics
- Major contributions to number theory

 *Diagram*

 *Portrait of
Lagrange*

Pierre-Simon Laplace

(marquis de Laplace)

Dates: 1749 – 1827 CE

Origin: Beaumont-en-Auge, Normandy, France

- *Mécanique Céleste* — applied calculus to celestial mechanics, completing Newton's program
- **Laplace transform** — essential tool in engineering and physics
- Major contributions to **probability theory** (Bayesian reasoning, central limit theorem precursors)

When Napoleon asked where God was in his system:
“Sire, I had no need of that hypothesis.”



 *Diagram*



 *Portrait of Laplace*

Carl Friedrich Gauss — *Princeps Mathematicorum*

Carl Friedrich Gauss

Dates: 1777 – 1855 CE

Origin: Braunschweig (Brunswick), Germany;
worked in Göttingen

- *Disquisitiones Arithmeticae* (1801) — foundational work in number theory
- Proved the **fundamental theorem of algebra**
- Discovered **non-Euclidean geometry** (unpublished!)
- The **Gaussian distribution** (bell curve)
- First major result at age 19: constructibility of the regular **17-gon**



 *Bell curve (filled)*



 *Regular 17-gon*

"Gauss bridges two centuries. The 19th century would bring a crisis — and a transformation — in what mathematics IS..."

The Century of Rigor and Revolution

1800–1900 CE

Galois · Riemann · Cantor · Noether · Ramanujan · Kovalevskaya

Evariste Galois — Genius Cut Short

Evariste Galois (1811–1832)

Origin: Bourg-la-Reine, France

Key work: Founded **group theory**. Proved there is no general algebraic formula for polynomials of degree 5 or higher, building on Niels Henrik Abel (1802–1829, Norway) who first proved the impossibility of solving the general quintic by radicals (Abel–Ruffini theorem, 1824). Galois went further: he characterised *exactly which* equations can be solved by radicals, using the group structure of their roots.

💡 Key Insight

He died in a duel at age 20. The night before, he wrote down his mathematical ideas, scribbling: *“I have not time.”*



 Symmetry group of a triangle

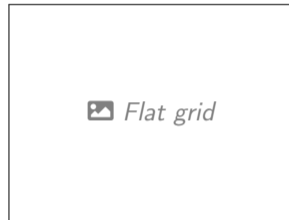
Bernhard Riemann — Curved Spaces and a Million-Dollar Question

Georg Friedrich Bernhard Riemann (1826–1866)

Origin: Breselenz, Kingdom of Hanover, Germany; worked in Göttingen

Key work:

- **Riemannian geometry** — curved spaces of arbitrary dimension, essential for Einstein's general relativity
- The Riemann integral
- The **Riemann hypothesis** (1859) — still unproven as of 2026, one of the Millennium Prize Problems worth **\$1 million**



Georg Cantor — Infinity Has Sizes


Georg Ferdinand Ludwig Philipp Cantor (1845–1918)

Origin: St. Petersburg, Russia (German–Danish parentage); worked in Halle, Germany

Key work: Founded **set theory**. Proved that there are different sizes of infinity — the real numbers are “more infinite” than the natural numbers. This was so controversial that leading mathematicians tried to block his career.

💡 Key Insight

He proved that infinity comes in sizes. Some infinities are bigger than others. This drove him to a breakdown — and his critics nearly destroyed his career.

 *Suppose we list all reals between 0 and 1*

Emmy Noether — The Mother of Modern Algebra

Amalie Emmy Noether (1882–1935)

Origin: Erlangen, Germany; fled to the US in 1933

Key work:

- **Noether's theorem** (1918): symmetries in physics \longleftrightarrow conservation laws
- Transformed abstract algebra — ring theory, ideal theory
- Denied a proper faculty position for years because she was a woman

 **Key Insight**

Einstein called her “the most significant creative mathematical genius since higher education opened to women.”

 *Noether's Theorem*

 *Portrait of Emmy Noether (Wikimedia Commons)*

Srinivasa Ramanujan — The Self-Taught Genius

Srinivasa Ramanujan Aiyangar (1887–1920)

Origin: Erode, Tamil Nadu, India; worked at Cambridge


Key work: Self-taught mathematical genius. Produced thousands of results in number theory, infinite series, and continued fractions, many without formal proof. His notebooks continue to yield new mathematics a century later. Collaborated with G. H. Hardy at Cambridge.

The Taxicab Number

Hardy visited Ramanujan and mentioned his taxi was number 1729 — “a rather dull number.” Ramanujan instantly replied:

“No, it is a very interesting number; it is the smallest number expressible as the sum of two cubes in two different ways.”

$$1729 = 1^3 + 12^3 = 9^3 + 10^3$$

 Page from
Ramanujan's notebooks
(Cambridge University
Library)

 Diagram

Sofia Kovalevskaya — First Woman Doctorate in Mathematics

Sofia Vasilyevna Kovalevskaya (1850–1891)

Origin: Moscow, Russia; worked in Stockholm, Sweden

Key work:

- First woman to obtain a doctorate in mathematics in modern Europe (Göttingen, 1874)
- Major contributions to analysis, partial differential equations, and mechanics
- The **Kovalevskaya top** — a new integrable case of rigid body rotation
- First woman appointed to a full professorship in northern Europe (Stockholm, 1889)

💡 Key Insight

To get an education, she entered a marriage of convenience just to be allowed to travel abroad and study.

 *Portrait of Sofia Kovalevskaya (Wikimedia Commons)*

 *Three known integrable cases*

The 19th Century — An Overview



 *Five pillars*

Transition: *“The 20th century would bring a crisis at the very foundations of mathematics. . .”*

Crisis, War, and Computers

1900–1950 CE

Hilbert · Gödel · Turing · von Neumann · Nash

David Hilbert (1862–1943)


Origin: Königsberg, Prussia (modern Kaliningrad, Russia); worked in Göttingen

Key work: In 1900, posed **23 unsolved problems** that shaped 20th-century mathematics. Hilbert's program aimed to put *all* of mathematics on a provably consistent, complete foundation.

Kurt Gödel (1906–1978)

Origin: Brno, Austria-Hungary (now Czechia); worked at Princeton, USA

Incompleteness Theorems (1931): Any sufficiently powerful mathematical system contains true statements that **cannot be proved** within the system.

 *G "odel's theorem in plain English*

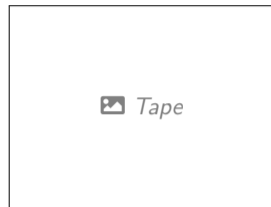
Alan Turing — The Birth of Computer Science

Alan Mathison Turing (1912–1954)

Origin: London, England; worked at Cambridge, Bletchley Park, Manchester

Key work:

- The **Turing machine** (1936) — theoretical foundation of all computers
- Proved the **halting problem** is unsolvable
- Broke wartime Enigma at Bletchley Park, building on **Marian Rejewski** (1905–1980, Poland) and Polish cryptanalysts who cracked earlier Enigma versions in the 1930s
- Pioneered the “Turing test” for AI



John von Neumann — The Last Great Polymath

John von Neumann (1903–1957)

Born: Neumann János Lajos

Origin: Budapest, Hungary; worked in Germany and the USA (Princeton)

Key work: Contributions to quantum mechanics, game theory, computer architecture, cellular automata, nuclear weapons design, and set theory axiomatisation. Possibly the last great polymath.

💡 Key Insight

The computer you use, the phone in your pocket — they all follow the architecture he designed in the 1940s.



 CPU block

John Nash — Game Theory and the Nash Equilibrium

John Forbes Nash Jr. (1928–2015)

Origin: Bluefield, West Virginia, USA; worked at MIT and Princeton

Key work:

- **Nash equilibrium** (1950) — no player can improve their outcome by unilaterally changing strategy
- Applications: economics, evolutionary biology, AI
- Nobel Prize in Economics (1994)
- Struggled with schizophrenia for decades; eventually recovered



 *Matrix frame*

Portrayed in “A Beautiful Mind” (2001)

Mathematics Goes Digital

1950–2000 CE

Shannon · Lorenz · Mandelbrot · Wiles
Cryptography · Computer-Assisted Proof

Claude Shannon — The Bit and Information Theory

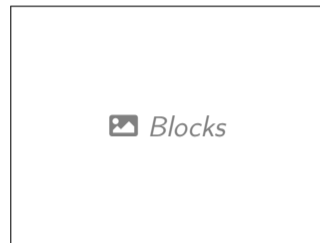
Claude Elwood Shannon (1916–2001)

Origin: Petoskey, Michigan, USA; worked at Bell Labs and MIT

Key work: Founded **information theory** (“A Mathematical Theory of Communication,” 1948). Defined the **bit** as the fundamental unit of information. Showed that all communication can be reduced to binary digits.

💡 Key Insight

Every text message, every video stream, every bit of data on the internet exists because of Shannon’s mathematics.



Edward Lorenz — The Butterfly Effect


Edward Norton Lorenz (1917–2008)

Origin: West Hartford, Connecticut, USA; worked at MIT

Key work: Discovered **deterministic chaos** (1963) while running a weather simulation. Tiny rounding differences in initial conditions produced wildly different outcomes — the **butterfly effect**. Even perfectly deterministic systems can be practically unpredictable.

💡 Key Insight

“Does the flap of a butterfly’s wings in Brazil set off a tornado in Texas?” Not magic — mathematics.

 *Approximate the butterfly shape with parametric curves*

The Four-Color Theorem (1976) — Computers Enter Mathematics

Kenneth Appel (1932–2013) & Wolfgang Haken (1928–2022)

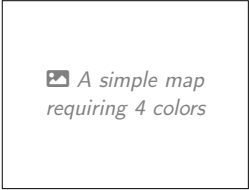
Proved at: University of Illinois, 1976

Any map can be coloured with at most **four colours** such that no two adjacent regions share a colour. Appel and Haken used a computer to check reducible configurations — the **first major theorem proved with essential computer assistance**.

💡 Key Insight

Is a proof that no human can fully verify still a “real” proof? The debate continues today.

The UIUC math department used a postmark reading “Four Colors Suffice” to celebrate.



🖼️ *A simple map requiring 4 colors*

Benoit Mandelbrot — Fractals and Hidden Patterns


Benoit B. Mandelbrot (1924–2010)

Origin: Warsaw, Poland (Lithuanian-Jewish origin); worked in France and at IBM/Yale in the USA

Key work: Founded **fractal geometry**. The Mandelbrot set (1980) revealed infinite complexity from simple equations. Natural phenomena — coastlines, mountains, blood vessels, financial markets — have fractal structure.

💡 Key Insight

The messiest, most irregular things in nature follow hidden mathematical patterns.

 *We use a simplified visual representation since true Mandelb*

Cryptography — The Mathematics of Secrecy

Public-key cryptography, invented in the 1970s, made secure internet communication possible. Based on number theory — specifically the difficulty of **factoring large numbers**.

Diffie–Hellman Key Exchange (1976)

Whitfield Diffie (b. 1944, USA)

Martin Hellman (b. 1945, USA)

Co-invented public-key cryptography.

RSA Algorithm (1977)

Ron Rivest (b. 1947, USA)

Adi Shamir (b. 1952, Israel)

Leonard Adleman (b. 1945, USA)

Multiply two large primes — easy.

Factor the product — nearly impossible.



 *Alice and Bob*

Raise your hand if you have
used encryption today.

Raise your hand if you have
used encryption today.

Answer: everyone.

 *Diagram*

Andrew Wiles — Fermat's Last Theorem Proved

Sir Andrew John Wiles (b. 1953)

Origin: Cambridge, England; worked at Princeton

Key work: Proved **Fermat's Last Theorem** in 1995 (after finding and fixing a gap in his 1993 proof). Used deep connections between elliptic curves and modular forms (the Taniyama–Shimura–Weil conjecture, now the modularity theorem). Closed a **358-year-old problem**.

💡 Key Insight

He worked in secret for seven years. When he announced the proof, he famously choked up with emotion.

 *The simple statement*

The 20th Century — An Overview



Bottom summary

Mathematics in the Age of Machines

2000–2026 CE

Perelman · Tao · Mirzakhani · Uhlenbeck
Machine Learning · Large Language Models

Grigori Perelman — Solving the Unsolvable, Refusing the Prize

Grigori Yakovlevich Perelman (b. 1966)

Origin: Leningrad (now St. Petersburg), Russia

Key work: Proved the **Poincaré conjecture** (2002–2003, published on arXiv), one of the seven Millennium Prize Problems.

Then **refused** the \$1 million prize AND the Fields Medal — the only person to have declined a Fields Medal (as of 2026).

He essentially disappeared from public life.

💡 Key Insight

He solved one of the hardest problems in mathematics, turned down a million dollars and the highest honour in math, and vanished.




 *Sphere – rubber band contracts*


Terence Chi-Shen Tao (b. 1975)

Origin: Adelaide, Australia (Chinese–Hong Kong descent); works at UCLA

Key work:

- Fields Medal (2006)
- Work spans: harmonic analysis, PDE, analytic number theory, random matrix theory, combinatorics
- **Green–Tao theorem** (arXiv 2004, published in *Annals of Mathematics* 2008): there are arbitrarily long arithmetic progressions in the primes
- Pioneer of collaborative, open mathematics (blog, Polymath)



 *Number line with primes highlighted*

Maryam Mirzakhani — Breaking Barriers

Maryam Mirzakhani (1977–2017)

Origin: Tehran, Iran; worked at Stanford University

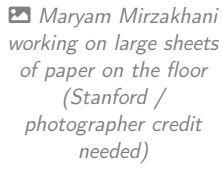
Key work:

- **First woman to win the Fields Medal** (2014)
- Dynamics and geometry of Riemann surfaces and their moduli spaces
- Connected hyperbolic geometry, complex analysis, and dynamical systems

💡 Key Insight

She died of cancer at 40. Iran honoured her with a postage stamp — showing her without a headscarf.

Her daughter called her work “painting” — she would draw huge diagrams on the floor, filling sheets of paper with ideas.

 *Maryam Mirzakhani working on large sheets of paper on the floor (Stanford / photographer credit needed)*

 *Genus-0 (sphere)*


Karen Keskulla Uhlenbeck (b. 1942)

Origin: Cleveland, Ohio, USA; worked at University of Texas at Austin and Princeton

Key work:

- **First woman to win the Abel Prize (2019)**
- “Pioneering achievements in geometric partial differential equations, gauge theory, and integrable systems”
- Work underpins modern mathematical physics, including the mathematics behind Yang–Mills gauge theories
- Co-founded the Women and Mathematics program at the Institute for Advanced Study

 *Portrait of Karen Uhlenbeck (Wikimedia Commons)*

 *A surface with connections (arrows showing parallel transport)*

Machine Learning — The New Mathematics

The mathematics of machine learning:

Math Inside Every AI

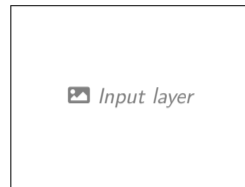
- **Linear algebra** — neural networks are matrix operations
- **Calculus** — gradient descent = optimisation via derivatives
- **Probability** — Bayesian inference, statistical learning
- **Information theory** — Shannon's legacy

Key figures:

Geoffrey Hinton (b. 1947, UK/Canada) — deep learning, backpropagation. Nobel Prize in Physics 2024 (shared with John Hopfield).

Yoshua Bengio (b. 1964, France/Canada) — deep learning. Turing Award 2018 (shared).

Yann LeCun (b. 1960, France/USA) — convolutional neural networks. Turing Award 2018 (shared).



The Story Continues

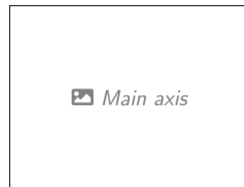
Mathematics is not finished.

Open Problems

- **Riemann hypothesis** (1859) — \$1M prize
- **P vs NP** — can every problem whose answer is quickly verifiable also be quickly solved?
- **Navier–Stokes** — do smooth solutions always exist?
- **Birch–Swinnerton-Dyer** conjecture

AI Discovers Mathematics

- DeepMind's **AlphaGeometry** — solves olympiad geometry
- **Automated theorem proving** (Lean, Coq)
- AI-assisted conjecture generation



Key Themes — What Have We Learned?

- 🌐 **Math has no single homeland** — built by people in Central Africa, Babylon, Egypt, Mesoamerica, Greece, India, China, the Islamic world, Europe, and every corner of the globe
- ↔ **Mathematical ideas travel** — the same concept was often discovered independently in multiple civilisations
- 👤 **People matter** — behind every theorem is a human story
- ✊ **Barriers have been broken** — from Hypatia to Noether to Kovalevskaya to Mirzakhani to Uhlenbeck, women have fought for and won their place in mathematics



*Mathematics was never the achievement of one culture.
It is humanity's collective masterpiece.*

Thank You — Questions?

 *Main axis*



Ishango bone
c. 20,000 BCE

Tally marks on bone



AI-assisted proof
2026 CE

Neural networks do mathematics

5,000 years. One story. Not over.






What questions do you have?

Which mathematician's story surprised you the most?

 *Diagram*


Further Reading

Recommended books for curious minds:

-  **Journey Through Genius**
William Dunham
Great theorems told as human stories
-  **The Crest of the Peacock**
George Gheverghese Joseph
Non-European roots of mathematics
-  **Mathematics in India**
Kim Plofker
500 BCE to 1800 CE — the full Indian story
-  **A History of Mathematics**
Victor Katz
The standard comprehensive textbook
-  **The Code Book**
Simon Singh
From Caesar ciphers to quantum cryptography

 *Book covers*

*montage:
Journey Through Genius,
The Crest of the
Peacock,
Mathematics in India,
A History of
Mathematics,
The Code Book*

 *QR code
linking to a
curated
online reading
list*

Thank you!

Prof. J. Osterrieder · 2026