

Chapter 16: Science, Math, and Ideas

Summary

The digits you write every day, 0 through 9, have a long history that runs through South Asia. This chapter follows that history from Brahmi numerals carved on stone, to the place value system and the zero, to the scholars who carried "Indian reckoning" to Baghdad and on to Europe. It also meets mathematicians such as Aryabhata, Brahmagupta and the Kerala School, the grammarian Panini, healing traditions like Ayurveda and Unani, the board game chaturanga, wootz steel, and modern scientists from India, Pakistan and Bangladesh. Along the way, it shows how historians test big claims and sometimes change their minds.

Concepts Covered

1. Brahmi Numerals
2. Place Value System
3. Zero
4. Aryabhata
5. Brahmagupta
6. Hindu-Arabic Numerals
7. Al-Biruni
8. Kerala School
9. Panini's Grammar

10. Ayurveda
11. Sushruta Samhita
12. Unani Medicine
13. Yoga
14. Chaturanga
15. Wootz Steel
16. Srinivasa Ramanujan
17. C. V. Raman

Prerequisites

- **Chapter 2: Ancient Roots**, for the Gupta period and the early kingdoms.
- **Chapter 3: Empires and Encounters**, for trade routes and the arrival of new rulers and scholars.
- **Chapter 6: Languages and Scripts**, for Brahmi and the scripts that grew from it.

Numbers have a family tree too



Hi, it's Mora! Every time you type a phone number, check a game score or scroll a price tag, you're using an idea that people in South Asia helped build more than a thousand years ago. Knowing that story can make you proud without needing to exaggerate it, and it helps you answer when someone says the region "never invented anything." Every tradition has a story. Let's find it!

16.1 "Why Are They Called Hindu-Arabic?"

It's a Wednesday in October, and Ben Lindqvist walks out of geometry class at Prairie Ridge High School looking puzzled. He catches up with Zara Hossain at her locker.

"Okay, weird question," he says. "Mr. Dahl just said our numbers aren't 'Arabic numerals.' He called them 'Hindu-Arabic numerals.' He said they started in India. Is that true? Did your family know that?"

Zara thinks about it. Her Nanu does sums in her head faster than anyone Zara knows, and she counts in Bangla under her breath when she's measuring rice. But Zara has never once wondered where the digits themselves came from. "I honestly don't know," she admits. "I didn't even know numbers *had* a place they came from."

They decide to make it the first "ideas" topic for their club, and they write the question on the whiteboard: how did a way of writing numbers from South Asia end up in every math class on Earth, and what else did people in the region figure out along the way?

16.2 Start With an Odometer

Before any history, try a thought experiment.

Picture the mileage counter in an old car, the kind with rolling number wheels. When the ones wheel passes 9, it rolls back to 0 and nudges the tens wheel up by one. When the tens wheel passes 9, it nudges the hundreds. Every wheel uses the same ten symbols, but each wheel is worth ten times as much as the wheel to its right.

That is the whole trick behind the way you write numbers today. In 507, the 5 means five hundreds, the 0 means "no tens," and the 7 means seven ones.

Notice the 0. Without it, 507 and 57 would look alike. The zero is holding an empty seat so the other digits stay in the right places.

Now compare that with Roman numerals, which you've seen on clocks and in movie credits. In Roman numerals, 507 is DVII: D (500) plus V (5) plus I plus I. The letters keep their value wherever they sit, and there is no symbol for "nothing in this place." That makes Roman numerals fine for labels like "Super Bowl LX," but slow for multiplying or dividing large numbers on paper.

Idea	Roman numerals	Our digits today
Number of symbols	7 letters (I, V, X, L, C, D, M)	10 digits (0–9)
Does position change value?	Mostly no	Yes, each place is worth 10 times the next
Symbol for an empty place	None	0
2026 written out	MMXXVI	2026
Easy to do long multiplication?	Hard	Much easier

Keep the odometer in mind. The story of this chapter is how people in South Asia, building on ideas from many places, put those wheels together.

16.3 Brahmi Numerals: The Oldest Branch

Brahmi Numerals are the number signs written with the Brahmi script, the ancestor of most South Asian scripts that you met in Chapter 6. They appear on inscriptions from the 3rd century BCE. One of the earliest examples is the number 256 written in an edict of the emperor Ashoka at Sasaram, in today's Bihar, from about 250 BCE.

Brahmi numerals were not yet a place value system. They had separate signs for 1 through 9, and then extra signs for 10, 20, 30 and so on, and for 100 and 1,000. To write 256, a scribe would use the sign for 200, then the sign for 50, then the sign for 6. There was no zero, because no empty place ever needed filling.

Even so, these signs matter a lot. Historians of mathematics trace the shapes of our modern digits, through many small changes over many centuries, back to Brahmi. The first three signs seem to have started as simple strokes, one, two and three lines, which is easy to imagine if you've ever kept score with tally marks.

Some descendants of Brahmi numerals are still used today. Look at the same ten digits in four South Asian writing systems:

Value	Our digits	Devanagari (Hindi, Marathi, Nepali)	Bengali- Assamese (Bangla)	Tamil	Urdu (Eastern Arabic style)
zero	0	०	০	௦	۰
one	1	१	১	௧	۱
two	2	२	২	௨	۲

Value	Our digits	Devanagari (Hindi, Marathi, Nepali)	Bengali- Assamese (Bangla)	Tamil	Urdu (Eastern Arabic style)
five	5	५	৫	௫	۵
nine	9	९	৯	௯	۹

Zara's Nanu can read the Bangla digits at a glance, because they still appear in newspapers and on calendars in Bangladesh. Urdu newspapers and shop signs in Pakistan often use the Eastern Arabic style of digits, which, as you'll see in Section 16.6, came back to the region after a long journey through the Arab and Persian world. Tamil is a special case: traditional Tamil numbering had its own signs for ten (ௐ), one hundred (௮) and one thousand (௹), and in everyday life today most Tamil speakers simply use the digits 0 to 9.

16.4 Place Value and the Zero

The place value system

A **Place Value System** is a way of writing numbers in which a digit's value depends on its position, with each position worth a fixed multiple of the one beside it. Ours is base ten, so each place is worth ten times the place to its right:

$$507 = 5 \times 100 + 0 \times 10 + 7 \times 1$$

People in several parts of the world came up with place value. The Babylonians of ancient Iraq used a base-60 system (which is why an hour

has 60 minutes). The Maya of Central America used a base-20 system. The South Asian version was base ten, used just nine signs plus a zero, and turned out to be the one that spread around the world.

By around 600 CE, Indian scribes were writing dates and other numbers in place value form. The oldest dated Indian document that uses place value numbers is a donation charter from 594 CE, though some historians think its date was added later by a forger.

Zero as a placeholder and as a number

Zero is both a symbol that marks an empty place in a number and a number in its own right, the number you get when you subtract any number from itself. Those are two different ideas, and they didn't arrive at the same time.

The first idea, an empty-place marker, appeared in more than one civilization. Babylonian scribes started inserting a special mark for an empty place by about 400 BCE. Greek astronomers, including Ptolemy around 130 CE, used a small circle as a placeholder in their tables. The Maya had a zero sign by 665 CE, completely on their own. In South Asia, early manuscripts marked an empty place with a dot.

In Sanskrit and Hindi, the word for zero is शून्य (*SHOON-yuh*), which also means "empty" or "void." In Bangla it is শূন্য (*SHOON-no*). The idea of "emptiness" was also important in Buddhist philosophy, and some historians think that way of thinking made it natural to treat "nothing" as something you could name and work with. That's a reasonable suggestion, but it's hard to prove.

The second idea, zero as a number you can add, subtract and multiply, is where South Asian mathematicians made a clear first. You'll meet the person who wrote the rules down in Section 16.5.

The oldest securely dated zero in an Indian inscription that every historian accepts is carved in a small temple at Gwalior, in today's Madhya Pradesh, from 876 CE. It appears in ordinary numbers written into the inscription. By then, zero was already so normal that nobody bothered to explain it.

The Bakhshali manuscript: a lesson in how history works

In 1881, a farmer digging in a field at the village of Bakhshali, near Peshawar in what is now Pakistan, found a bundle of birch-bark pages covered in mathematics. The Bakhshali manuscript is a set of 70 fragile leaves with rules and worked problems, and it uses a dot for zero many times. In 1902 it was given to the Bodleian Library at the University of Oxford, where it is still kept.

In 2017, the Bodleian announced that radiocarbon tests suggested some of its leaves dated from as early as the 3rd or 4th century CE. Newspapers around the world reported that the "oldest zero" had been found. But a group of historians of Indian mathematics, writing in the journal *History of Science in South Asia*, pushed back. They pointed out that the test results for different leaves were centuries apart, so the oldest leaf could not date the whole manuscript. The latest leaf, they argued, was a better guide to when the scribe actually wrote it. They also criticized announcing the result by press release before other experts could check it.

Then, in 2024, Oxford's radiocarbon lab published a new report on five leaves. It said the very early result for one leaf had been inaccurate, and all five leaves now dated to roughly the late 700s to the early 1000s CE. So the Bakhshali manuscript is still an important early mathematical text, but it is no longer counted as older than the Gwalior inscription.

Notice what happened. A big claim was made, experts questioned it, the lab tested again, and the answer changed. That is how good history and good science are supposed to work.

Two kinds of nothing



Here's a way to keep the two ideas straight. The 0 in 507 is a parking spot saved for "no tens," while the 0 in "5 minus 5 equals 0" is an actual answer you can do math with. Which one do you think is harder to invent, and why?

16.5 Aryabhata and Brahmagupta

Two names come up again and again when people talk about early South Asian mathematics.

Aryabhata

Aryabhata (476 to 550 CE) was a mathematician and astronomer who worked at Kusumapura, probably near Pataliputra (today's Patna, in Bihar), during the time of the Gupta kings. He wrote that he finished his book, the *Aryabhatiya*, in 499, when he was just 23 years old. It's a short book written in verse, so students could memorize it.

Some of what's in it:

- He gave a rule that works out to $\pi \approx \frac{62832}{20000} = 3.1416$, which is correct to four decimal places.
- He explained that the stars seem to wheel across the sky because the Earth itself rotates on its axis. Many later astronomers rejected that idea, but Aryabhata was right.
- He worked with place value, using the Sanskrit word *kha* ("space") for an empty position, and gave methods for square and cube roots.

India named its very first satellite *Aryabhata*, after the 5th-century astronomer. It was launched on 19 April 1975 on a Soviet rocket. You'll meet India's space agency in [Chapter 17](#).

Brahmagupta

Brahmagupta (born 598 CE) was an astronomer and mathematician who wrote the *Brahmasphutasiddhanta* in 628 CE at Bhillamala (today Bhinmal, in Rajasthan). He later led the astronomical observatory at Ujjain.

Brahmagupta's book is the first known text to treat zero as a number with its own rules. He defined zero as what you get when you subtract a number from itself. He also wrote rules for negative numbers, which he called "debts," and positive numbers, which he called "fortunes." A few of his rules, in modern words:

- A fortune plus zero is a fortune. A debt minus zero is a debt.
- Zero times any number is zero.
- A debt times a debt is a fortune. (In other words, a negative times a negative is positive.)

He didn't get everything right. He said that zero divided by zero is zero, which mathematicians today say is undefined. Later Indian mathematicians, such as Mahavira and Bhaskara, also struggled with dividing by zero. That's nothing to be embarrassed about, since dividing by zero still confuses people today, and Brahmagupta was the first person we know of who even tried to write down the rules.

	Aryabhata	Brahmagupta
Dates	476 to 550 CE	born 598 CE

	Aryabhata	Brahmagupta
Where he worked	Kusumapura, near Patna	Bhillamala (Bhinmal), later Ujjain
Main book	<i>Aryabhatiya</i> (499)	<i>Brahmasphutasiddhanta</i> (628)
Best-known idea	Earth's rotation; $\pi \approx 3.1416$	First rules for zero and negative numbers

16.6 How the Numbers Traveled: Hindu-Arabic Numerals

Hindu-Arabic Numerals are the ten digits 0 through 9 and the place value system that goes with them, which began in South Asia and reached Europe through scholars writing in Arabic. Historians use the double name to give credit to both parts of the journey. (Here "Hindu" is an old word meaning "Indian," the way people used it at the time, not a statement about religion.)

This simplified timeline shows that journey.

When	Where	What happened
662 CE	Syria (on the Euphrates)	A Christian bishop, Severus Sebokht, praised the Indians' way of calculating with nine signs.
776 CE	Baghdad	An Indian scholar brought an astronomy book to the court of the caliph, and it was

When	Where	What happened
		translated into Arabic. Some historians think it was Brahmagupta's.
800s	Baghdad	The scholar al-Khwarizmi wrote a book on Indian reckoning. Its Latin title was <i>Algoritmi de numero Indorum</i> , and his name gave English the word algorithm .
mid-900s	Arab world	Al-Uqlidisi wrote the oldest surviving book on "Hindu arithmetic" for pen and paper.
976	Spain	A monk copied the digits into a manuscript, the first surviving example in Europe.
1202	Pisa, Italy	Fibonacci published <i>Liber abaci</i> , teaching the nine figures and zero, which he had learned as a boy in North Africa.
1600s	Europe	Zero and the new digits finally came into wide everyday use.

In Arabic, the zero was called صفر (*SIFR*), meaning "empty." That word passed into Latin and then into English as "cipher."

The digits changed shape as they moved. Scribes in Baghdad and Persia developed one set of forms, the Eastern Arabic digits that many Urdu, Persian and Dari writers still use. Scribes in North Africa and Spain developed another, which became the digits in this book. So when Ben's teacher said "Hindu-Arabic," he was describing a real relay race across three continents.

A math word with a passport



Next time your computer science teacher says "algorithm," remember it comes from al-Khwarizmi, a scholar in Baghdad who wrote about Indian numbers. That one word has passed through three regions over more than a thousand years.

16.7 Al-Biruni: A Scholar Who Asked Questions

Al-Biruni (973 to 1048) was a Muslim scholar born in Khwarazm in Central Asia, who wrote one of the most careful early books about South Asian science and society. After 1017 he went to Ghazni (in today's Afghanistan) after Mahmud of Ghazni conquered his home region, probably as a prisoner at first, and he spent the rest of his life connected to that court. He traveled into the Punjab and northern India with Mahmud's expeditions and measured the positions of towns there.

What makes al-Biruni special is how he studied. He learned Sanskrit so he could read Indian texts in the original, and he translated several of them into Arabic. Around 1030 he finished a long book usually called *India*. It describes Indian religion, philosophy, social customs, writing, numbers, geography, astronomy and the calendar. He compared Indian ideas with Greek ones, pointed out where he thought each side was right or wrong, and tried to describe beliefs as their followers understood them.

He wrote it during a time of war, when Mahmud's armies were raiding Indian cities and temples. So al-Biruni is a complicated figure: a scholar who admired Indian learning, working for a ruler many Indians remember as a destroyer. Historians read his book both as a valuable record and as one outsider's view.

16.8 The Kerala School: Infinite Series

Jump forward to the 1300s and travel to the southwestern coast of India, to Kerala.

The **Kerala School** was a line of astronomers and mathematicians in Kerala, beginning in the 1300s, who discovered ways to write some important quantities as infinite series, sums that go on forever but get closer and closer to an exact value. Its founder was Madhava of Sangamagrama (about 1350 to 1425), who lived near Kochi (formerly Cochin). His own writings are lost, but students such as Nilakantha and Jyesthadeva recorded his methods. Jyesthadeva's book, the *Yuktibhasha* (about 1550), was written in Malayalam, the language of Kerala, rather than Sanskrit, and it explains the proofs.

One of Madhava's results is a series for π :

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \dots$$

Madhava also found series for sine, cosine and arctangent, the same ones you'll meet if you take calculus, and he used extra correction terms to calculate π to 11 decimal places.

European mathematicians found the same series independently more than two centuries later. The Scottish mathematician James Gregory rediscovered the arctangent series in the 1600s, and Isaac Newton found the sine and cosine series around 1676. (The π series above is often called the Madhava-Leibniz series, after Madhava and the German mathematician Gottfried Leibniz.)

Some writers claim the Kerala results traveled to Europe through missionaries and traders, but there is no solid evidence for that, so historians call the European results rediscoveries. It is fair to say that the Kerala School

found infinite series centuries before Europe. It is not accurate to say that Kerala "invented calculus," because calculus as a full system, with derivatives and integrals linked together, was built later.

16.9 Panini's Grammar

Not every big idea in this chapter is about numbers.

Panini's Grammar, the *Ashtadhyayi* ("eight chapters"), is a complete description of the Sanskrit language written as just under 4,000 short rules called *sutras*. Panini came from Shalatula, a town near Attock on the Indus River, in what is now Pakistan. Nobody knows exactly when he lived. Scholars have suggested dates from about the 7th to the 4th century BCE.

Why does a grammar book belong in a chapter about science? Because of how it works. Panini's rules are written like a computer program. Short rules apply in a set order, some rules override others, and special marker sounds act like labels that tell you which rule to use. Feed the rules a root word and some endings, and they produce correct Sanskrit sentences.

In 1959, the computer scientist John Backus created a notation for describing programming languages, now called Backus-Naur Form. Historians of mathematics have pointed out that Panini's notation is just as powerful, and it is more than 2,000 years older. That's why Panini is often called a forerunner of the formal language theory used in computer science, and why linguists around the world still study him.

Whose Story?

Ask "Who invented zero?" and you'll hear different answers depending on who is speaking. Many popular books and speeches in India tell it as a proud national achievement, sometimes with dates pushed earlier than the evidence supports. In the Arab world the digits are often called "Indian numbers," while for centuries Europeans called the same digits "Arabic," because that's who they learned them from. Historians of mathematics such as the team behind the MacTutor archive tell a longer relay story: Babylonian placeholders, Greek astronomers, Indian place value and zero, Arabic-language scholars, then Europe. And the Bakhshali debate shows that even experts in Britain, the United States, France, Japan, New Zealand and Canada can disagree about the evidence until new tests settle it.

16.10 Healing Traditions

Not medical advice



This section describes healing traditions as history and culture. They are traditions, not proven treatments, and nothing here is medical advice. If you or someone in your family has a health problem, talk to a doctor or pharmacist, and tell them about any traditional remedies you use.

Many South Asian families keep healing traditions alive at home: turmeric in warm milk for a cold, ginger tea for an upset stomach, oil massages for babies, morning stretches. These habits connect to long written traditions. Here are four of the best known.

Ayurveda

Ayurveda (आयुर्वेद, *AA-yur-vay-duh*, "knowledge of life" or "science of health") is a traditional medical system from South Asia, based on old Sanskrit texts, that uses diet, herbs, daily routines, exercise and sometimes minerals to try to keep the body in balance. It is still widely practiced in India, Nepal and Sri Lanka, often alongside modern medicine, and India has a government ministry for traditional systems called AYUSH.

What does science say? The US National Center for Complementary and Integrative Health (NCCIH), part of the National Institutes of Health, reports (in its fact sheet last updated in January 2019) that only a few well-designed studies have tested Ayurvedic treatments, and that scientific evidence for most uses is limited. It also warns about safety: some Ayurvedic products sold online or abroad have been found to contain toxic levels of lead, mercury or arsenic, and the US Food and Drug Administration has warned about them. Many families value Ayurveda as part of their heritage, and that heritage is worth understanding. But it is not a substitute for medical care.

The Sushruta Samhita

The **Sushruta Samhita** is an old Sanskrit medical text, traditionally linked to a physician named Sushruta, that is famous for its detailed descriptions of surgery. Its 186 chapters describe surgical instruments, how to practice cutting on gourds and other objects before operating on people, and many operations. The most famous is a way to rebuild a damaged nose using a flap of skin from the cheek, a forerunner of what surgeons later called the "Indian method" of nose reconstruction.

When was it written? Traditional accounts place Sushruta very early, but the text we have was built up in layers over a long time. Many scholars think its composition began in the last centuries BCE and that the version we read today took shape by around the 3rd or 4th century CE. The oldest surviving manuscript is a palm-leaf copy kept at the Kaiser Library in Kathmandu,

Nepal, dated 878 CE. The book was later translated into Arabic in Baghdad, another example of ideas moving west.

Unani medicine

Unani Medicine (یونانی, *yoo-NAA-nee*, "Greek") is a healing tradition that began with the ancient Greek physicians Hippocrates and Galen, was developed by doctors writing in Arabic and Persian such as Ibn Sina (Avicenna), and came to South Asia by the 1100s. It grew under the Delhi Sultanate and the Mughal emperors, and its practitioners are often called *hakims*. Unani is based on the old Greek idea that health depends on balancing four "humors" in the body, an idea that came long before scientists discovered germs.

Today Unani is officially recognized in India, where it is part of the AYUSH system, and in Pakistan, where practitioners register with the National Council for Tibb (*tibb* is the Arabic and Urdu word for medicine). Like Ayurveda, it is a tradition with a long history, not a proven way to cure disease.

Yoga

Yoga (योग, *YOH-guh*, "joining" or "union") is a set of practices rooted in South Asian philosophy that combines body postures, breathing and meditation, and that began as a spiritual discipline aimed at training the mind. It is important in Hindu, Buddhist and Jain traditions. The poses many Americans learn at a gym are only one part of a much bigger tradition.

On 11 December 2014, the United Nations proclaimed 21 June the International Day of Yoga. The NCCIH says research suggests yoga may help with stress, sleep, balance and some kinds of pain, but it does not claim yoga cures any disease, and it notes that beginners should avoid extreme poses and practice with a qualified teacher.

Tradition	Where it comes from	Key idea	Status today
Ayurveda	Sanskrit texts of South Asia	Balance through diet, herbs, routine	Practiced widely; limited scientific evidence; some products unsafe
Sushruta Samhita	Sanskrit medical text	Surgery, instruments, nose repair	Studied as medical history
Unani	Greek medicine, developed in Arabic and Persian	Balance of four humors	Recognized in India and Pakistan; traditional, not proven
Yoga	South Asian philosophy	Posture, breath, meditation	Practiced worldwide; may help stress and some pain

16.11 Games and Metals: Chaturanga and Wootz Steel

Chaturanga

Chaturanga is an old board game from India, first clearly mentioned in the 6th or 7th century CE, that is the earliest known ancestor of chess. The name is Sanskrit for "four limbs," meaning the four parts of an old Indian army: elephants, chariots, cavalry (horses) and infantry (foot soldiers). It was played on an 8-by-8 board called the *ashtapada*. One of the earliest texts to

name it is the *Harshacharita*, a biography of King Harsha written around 625 CE.

From India the game traveled to Persia, where it became *chatrang* and then *shatranj*. Arabic-speaking players spread shatranj across the Middle East and North Africa, and it reached Europe in the Middle Ages. Over the centuries the pieces changed. The elephant became the bishop, the chariot (*rukḥ* in Persian) became the rook, and the counselor, a weak piece that moved one square, was renamed the queen in Europe and later became the strongest piece on the board. So chess as you play it today is a group project, with an Indian beginning.

Wootz steel

Wootz Steel is a high-carbon steel made in South India and Sri Lanka by melting iron with carbon-rich material inside sealed clay pots called crucibles, and it was famous for centuries for its strength and its wavy surface pattern. The English word "wootz" is a garbled form of *ukku*, the word for steel in Kannada and Telugu. Archaeological finds in Tamil Nadu suggest crucible steel was being made there before the Common Era.

Traders carried wootz ingots west, and smiths in the Middle East forged them into the famous "Damascus" swords, which had very high carbon content, about 1.5 to 2.0 percent. In the early 1800s, European scientists, including Michael Faraday, studied wootz to learn how it was made.

Sri Lanka has its own steel story. At Samanalawewa, in Sri Lanka's hill country, archaeologist Gill Juleff found many ancient furnaces built along the western edges of hills and ridges. Her experiments, published in the journal *Nature* in 1996, showed that these furnaces used the strong monsoon winds to blow air through the fire and could make high-carbon steel. They supported a major industry there during the first millennium CE.

16.12 Modern Scientists of the Region

The story doesn't stop in the distant past. Here are four modern scientists, from three of today's countries.

Srinivasa Ramanujan

Srinivasa Ramanujan (1887 to 1920) was a mathematician from Tamil Nadu, mostly self-taught, whose discoveries about numbers, infinite series and fractions still keep mathematicians busy today. He was born in Erode and grew up in Kumbakonam. In 1912 he took a job as a clerk at the Madras Port Trust in Madras (now Chennai), and he kept filling notebooks with formulas. In January 1913 he wrote to the Cambridge mathematician G. H. Hardy, who was amazed and invited him to England. Ramanujan arrived in 1914.

In 1918 he was elected a Fellow of the Royal Society, one of the highest honors in science, and a Fellow of Trinity College, Cambridge. But he was often ill in England. He was a strict vegetarian, and during World War I the foods he needed became hard to find. He returned to India and died in Kumbakonam in 1920, at just 32.

C. V. Raman

C. V. Raman (Chandrasekhara Venkata Raman, 1888 to 1970) was a physicist born in Tiruchirappalli, Tamil Nadu, who discovered that when light bounces off molecules, a tiny part of it comes back with a slightly different color. This is now called the Raman effect. He won the Nobel Prize in Physics in 1930 "for his work on the scattering of light and for the discovery of the effect named after him," while working at Calcutta University (now the University of Calcutta). Today, scientists around the world use Raman's discovery, in a method called Raman spectroscopy, to identify what materials are made of.

Satyendra Nath Bose and Abdus Salam

Two more names show how science in the region crosses today's borders.

- **Satyendra Nath Bose** (1894 to 1974) was a physicist born in Calcutta who taught at the University of Dhaka, in today's Bangladesh, from 1921. In 1924 he sent a short paper to Albert Einstein, who was so impressed that he translated it into German and had it published. Particles that follow Bose's rules are called **bosons** in his honor, including the famous Higgs boson.
- **Abdus Salam** (1926 to 1996) was born in Jhang, in the Punjab of British India, now in Pakistan. He shared the 1979 Nobel Prize in Physics for helping show that two of nature's basic forces, electromagnetism and the weak force, are two sides of one force.

Back at Prairie Ridge, Zara and Ben add a slide to their club presentation called "Not just ancient history." Ben wants to put Ramanujan first. Zara wants Bose, because Dhaka is her parents' capital city. They compromise and put them side by side.

Diagram: Zero and Place Value

Zero and Place Value

Tap the arrows to build a number. Then tick "Hide the zeros".

Thousands	Hundreds	Tens	Ones
			
0	5	0	7
			
			

Our digits (Hindu-Arabic)

507

Devanagari digits

५०७

Roman numerals (no zero)

DVII

The glowing 0 holds an empty place. Roman numerals just skip it.

Devanagari (Hindi, Marathi, Nepali) ▼

☐ Hide the zeros

Random

Clear

[Back to Zero and Place Value Lesson Plan](#)

Interactive simulation: <https://aaryavvatts-lab.github.io/south-asian-culture-textbook/sims/ch16-zero-place-value/main.html>

Open the Zero and Place Value MicroSim fullscreen

MicroSim specification: Zero and Place Value

sim-id: ch16-zero-place-value

Library: p5.js

Status: Implemented

Bloom Level: Understand

Bloom Verb: explain

Learning Objective: The learner will explain why a symbol for zero makes a place value system work, by comparing the same number in Roman numerals, in a place value table and in a South Asian digit set.

Canvas: responsive width; 560 px drawing area plus 80 px control area.

Controls: up and down arrows in each column (thousands, hundreds, tens, ones), tapped or clicked on the canvas; a digit-set menu (Devanagari, Bengali, Tamil, Urdu); a "Hide the zeros" checkbox; Random and Clear buttons.

Behavior: The learner builds a number from 0 to 9,999. The sim shows it as a place value table with counters in each column, as Roman numerals (with a note that Roman numerals have no zero), and in the chosen South Asian digit set using real Unicode digits. Empty columns are highlighted with a glowing zero. Ticking "Hide the zeros" removes the zero symbols, so the digits slide together and the learner sees the number become a different, wrong number.

Start by building 507 with the arrows. Look at all three rows: the place value table, the Roman numeral DVII and the Devanagari 507. Then tick **Hide the zeros**. The digits squeeze together into "57," and the sim warns you the number now reads as a completely different value. That's exactly the problem a zero solves. Try it with 2,026, 1,000 and 9,009 too.

Then switch the digit set to Bengali, Tamil and Urdu and watch the same number change costume. Notice that the Roman numeral never needs a

zero, but it gets long and clumsy (try 3,888). Ask yourself: which of the three ways would you want to use for long multiplication?

Ask Your Elders

Your interview for this chapter

Talk with a parent, grandparent, aunt, uncle, family friend or community elder about how they learned math, the home remedies their family used, and a scientist or thinker from the region they admire. If you don't have a South Asian elder to ask, interview a club advisor, a local temple, mosque, gurdwara or cultural center volunteer, or a classmate's family (with permission). Ten minutes is enough.

Before you start: Bring a pencil and paper and ask them to show you how they would add or multiply two numbers in their head. Ask if it's okay to take notes.

Questions to ask

1. How did you learn math in school? Did you memorize times tables, and in which language did you say them?
2. Do you know any mental math tricks, or ways of counting on your fingers, that you learned growing up?
3. When you were young, what did your family do for a cold, a cough or a stomachache? Who in the family knew the most about home remedies? (Remember, this is about family history, not medical advice.)
4. Did anyone in your family or town play chess, carrom or another board game? Who taught you?

5. How has the way children learn math or take care of their health changed since you were young, or since you moved?
6. Is there a scientist, mathematician or thinker from South Asia you're proud of? What do you hope I remember about them?

Listen for: whether they write or count in Devanagari, Bangla, Urdu or other digit sets (connect this to Brahmi Numerals and Hindu-Arabic Numerals), remedies that come from Ayurveda or Unani Medicine, and names like Srinivasa Ramanujan, C. V. Raman or Abdus Salam.

Save it: Write down one quote or story in their words, with their permission. If they agree, you can share it with the [Roots & Rivers Story Archive](#).

? Your turn: compare two answers

Compare the way your elder does mental math with the way you learned in school. Do they use place value in the same way, for example by breaking 47×6 into 40×6 and 7×6 ? If a friend interviewed someone from a different country, compare the remedies each family used and notice which ones overlap.

"Every family does it a little differently, and there is no wrong answer here."

Common Misconceptions

Myth: Indians invented all of mathematics.

Reality: South Asian mathematicians made major contributions, especially place value with zero, rules for zero and negative numbers, and early infinite series. But mathematics was built by many peoples, including Babylonians, Egyptians, Greeks, Chinese, Maya and scholars writing in Arabic and Persian. Overclaiming actually hides the real achievements.

Myth: Zero was invented by one person on one day.

Reality: Zero grew over centuries. Placeholder marks appeared in Babylon, Greece, the Maya world and South Asia. Brahmagupta, in 628 CE, was the first known writer to give rules for zero as a number, but he was building on earlier Indian place value and the dot used for an empty place.

Myth: Ayurveda is proven medicine that can cure diseases.

Reality: Ayurveda is a long-standing tradition that many families value. The US National Center for Complementary and Integrative Health says there are few well-designed studies of it, and some products have contained dangerous levels of lead, mercury or arsenic. It is not a substitute for medical care. This is not medical advice.

Myth: Chess was invented in India in its modern form.

Reality: Chaturanga, the ancestor of chess, comes from India. But the game changed a lot as it moved through Persia, the Arab world and Europe. The powerful queen, for example, is a much later European change.

Myth: "Arabic numerals" were invented by Arabs.

Reality: The digits and place value system began in South Asia. Scholars writing in Arabic, such as al-Khwarizmi and al-Uqlidisi, developed and spread them, and Europeans learned them from Arabic books, which is why historians say "Hindu-Arabic."

Check Yourself

 **1. What job does the zero do in the number 305?** 

It holds the empty tens place, so the 3 stays in the hundreds place. Without the zero the number would look like 35.

? 2. Why couldn't Brahmi numerals be called a place value system? ✓

They used separate signs for tens, hundreds and thousands instead of reusing nine digits in different positions, and they had no zero.

? 3. What did Brahmagupta do in 628 CE that made him famous? ✓

In the *Brahmasphutasiddhanta* he wrote the first known rules for zero as a number, along with rules for negative numbers ("debts") and positive numbers ("fortunes").

? 4. Why do historians say 'Hindu-Arabic numerals' instead of 'Arabic numerals'? ✓

The digits and place value began in South Asia, and scholars writing in Arabic developed and spread them to Europe. The double name credits both parts of the journey.

? 5. What changed about the Bakhshali manuscript's date between 2017 and 2024? ✓

In 2017, radiocarbon tests suggested some leaves were from the 3rd or 4th century CE. After other historians questioned this, a 2024 Oxford report said the early result was inaccurate and dated all five tested leaves to roughly the late 700s to early 1000s CE.

Exercises

Remember

1. Name the book Aryabhata finished in 499 and the book Brahmagupta wrote in 628.

 Answer

Aryabhata wrote the *Aryabhatiya*. Brahmagupta wrote the *Brahmasphutasiddhanta*.

2. What are the four "limbs" in the name chaturanga?

 Answer

Elephants, chariots, cavalry (horses) and infantry (foot soldiers), the four parts of an old Indian army.

Understand

1. Explain in your own words the difference between zero as a placeholder and zero as a number.

 Answer

As a placeholder, zero marks an empty position, like the tens place in 507. As a number, zero is a quantity you can add, subtract and multiply, the answer to 5 minus 5.

2. Explain why the work of the Kerala School is described as a "rediscovery" in Europe rather than a source for European calculus.

Answer

Gregory, Leibniz and Newton found the same series in the late 1600s, but there is no solid evidence that Madhava's results reached them. So historians say Kerala came first, but the Europeans found the series independently.

Apply

1. Use the Zero and Place Value MicroSim to build 2,026, 3,888 and 1,000. For each, write the Roman numeral and the number of symbols it needs. Which number is the most work to write in Roman numerals, and why?

Hint: count the letters, and think about which values have no single Roman letter.

2. Write your birth year in Devanagari, Bengali and Tamil digits using the table in Section 16.3 and the MicroSim. Then explain where the zero (if any) is doing its job.

Hint: the sim's digit menu shows all four digit sets.

Analyze

1. Compare how Aryabhata, al-Biruni and Fibonacci each helped the numbers you use reach your classroom. What role did each one play: inventor, explainer or carrier?
2. The Bakhshali manuscript's date changed after new tests. Analyze what this teaches about how to read a news headline that says "oldest ever."

Hint: who made the claim, who checked it, and what happened next?

Evaluate

1. A video online says, "Ancient Indians knew everything modern science knows." Evaluate this claim using at least three examples from this chapter, including one where an early scholar was wrong.

Hint: Brahmagupta's division by zero is a good place to start.

2. Your cousin says a home remedy "cured" her cold, so it must work. Evaluate this reasoning. What kind of evidence would scientists want to see?

Hint: colds usually go away on their own; think about how a fair test would work.

Create

1. Design a one-page "relay race" poster that shows how the digits 0 to 9 traveled from Brahmi inscriptions to your math textbook. Include at least five stops with dates and places from this chapter.

Hint: draw it as a route with handoffs, not a single inventor.

2. Write a short dialogue (150 to 200 words) between Ramanujan and C. V. Raman, imagining they meet as students. Have them each explain one idea from their field in simple words, without inventing quotes from real speeches.

Hint: keep the facts from Section 16.12 accurate, and make the conversation clearly imaginary.

Key Takeaways

- Brahmi numerals, from the 3rd century BCE, are the ancestors of the digits 0 to 9, but they were not yet a place value system.
- A place value system gives each digit a value by its position. Zero holds empty places, and South Asian mathematicians were the first known to treat zero as a number, with Brahmagupta writing its rules in 628 CE.
- The digits traveled from South Asia through Baghdad and North Africa to Europe, which is why they're called Hindu-Arabic numerals; al-Khwarizmi's name gave us "algorithm."
- Aryabhata, Brahmagupta, the Kerala School and Panini made real, specific contributions. Describing them accurately, including their mistakes, honors them more than exaggerating.
- Ayurveda, the Sushruta Samhita, Unani medicine and yoga are long healing traditions with real history; they are traditions, not proven cures, and this is not medical advice.
- Chaturanga is the ancestor of chess, and wootz steel from South India and Sri Lanka was prized across the world.
- Modern scientists from India, Pakistan and Bangladesh, including Ramanujan, Raman, Bose and Salam, continued the story into the 20th century.

You've cracked the code of zero!



You can now explain why a tiny circle changed math forever, and you know how to spot an overclaim when you hear one. Next, in Chapter 17, we tour the biggest country in the region, India, with its 28 states and 8 union territories.

Quiz: Science, Math, and Ideas

Test your understanding of Chapter 16. Choose the best answer, then click **Show Answer** to check.

Question 1

Who wrote the *Brahmasphutasiddhanta* in 628 CE, the first known text to give rules for zero as a number?

- A. Aryabhata
- B. Brahmagupta
- C. Al-Biruni
- D. Madhava of Sangamagrama

? Show Answer



The correct answer is **B**. Brahmagupta wrote the *Brahmasphutasiddhanta* at Bhillamala in 628 CE. Aryabhata is a common wrong guess, but he lived earlier (476 to 550 CE) and is best known for the *Aryabhatiya* and his value of pi.

Concept Tested: Brahmagupta **Bloom's Level:** Remember

Question 2

The word "chaturanga," the name of the ancestor of chess, refers to which of these?

- A. The four seasons of the year
- B. The four directions on a compass
- C. The four corners of the board
- D. The four divisions of an old Indian army

 Show Answer

The correct answer is **D**. Chaturanga means "four limbs," the elephants, chariots, cavalry and infantry of an old Indian army. The game was played on an 8-by-8 board, but the name is about the army, not the board's corners.

Concept Tested: Chaturanga **Bloom's Level:** Remember

Question 3

Panini, author of a famous grammar of Sanskrit, came from a town near Attock on the Indus River. In which present-day country is that?

- A. Pakistan
- B. Nepal
- C. Bangladesh
- D. Sri Lanka

 Show Answer

The correct answer is **A**. Panini came from Shalatula, near Attock on the Indus, in present-day Pakistan. Many people assume all early Sanskrit scholars lived in today's India, but the Indus region was a major center of learning.

Concept Tested: Panini's Grammar **Bloom's Level:** Remember

Question 4

Why did the place value system need a symbol for zero, while Roman numerals did not?

- A. Roman numerals were only used for small numbers, so zero never came up.
- B. Place value uses fewer symbols, so it needed an extra one to reach ten.
- C. In place value a digit's worth depends on its position, so an empty position must be marked; Roman letters keep their value wherever they sit.
- D. The Romans had a zero symbol but chose not to write it on clocks.

Show Answer

The correct answer is **C**. In 507, the 0 keeps the 5 in the hundreds place; without it the number would read 57. Roman numerals add up fixed-value letters (DVII), so there is no empty position to hold. Option A is wrong because Romans wrote large numbers too, using letters like M and D.

Concept Tested: Place Value System **Bloom's Level:** Understand

Question 5

Why do historians use the name "Hindu-Arabic numerals" instead of "Arabic numerals"?

- A. Because the digits were invented in Arabia and later adopted in India
- B. Because the system began in South Asia and was developed and passed to Europe by scholars writing in Arabic

- C. Because Hindu and Muslim mathematicians invented the digits together on the same day
- D. Because the digits are only used in India and the Arab world today

 Show Answer

The correct answer is **B**. The digits and place value began in South Asia, and scholars such as al-Khwarizmi spread them through the Arabic-speaking world to Europe. Option A reverses the direction of travel, which is the very mistake the double name is meant to correct.

Concept Tested: Hindu-Arabic Numerals **Bloom's Level:** Understand

Question 6

What is the best description of how the Kerala School's infinite series relate to European mathematics?

- A. Madhava found series for pi, sine and cosine centuries before European mathematicians rediscovered them independently.
- B. Madhava's notebooks were carried to England, where Newton copied them.
- C. The Kerala School invented the complete system of calculus, including derivatives and integrals.
- D. European mathematicians found the series first, and Kerala scholars learned them from traders.

 Show Answer

The correct answer is **A**. Madhava (about 1350 to 1425) found these series, and Gregory and Newton found them again in the 1600s. Option B is a popular claim, but there is no solid evidence that the Kerala results reached Europe, so historians call the European work a rediscovery.

Concept Tested: Kerala School **Bloom's Level:** Analyze

Question 7

Why are Ayurveda, Unani medicine and yoga described in this chapter as "traditions" rather than proven treatments?

- A. Because they are no longer practiced anywhere
- B. Because they come from religious texts, and science cannot study them
- C. Because they were banned by governments in South Asia
- D. Because few well-designed studies support their health claims, and some products have even been unsafe

 Show Answer

The correct answer is **D**. The US National Center for Complementary and Integrative Health reports limited scientific evidence for most Ayurvedic treatments and warns that some products contain lead, mercury or arsenic. Option A is wrong: these traditions are widely practiced today, and Unani is officially recognized in India and Pakistan. This is not medical advice.

Concept Tested: Ayurveda **Bloom's Level:** Understand

Question 8

Using the Zero and Place Value MicroSim, Ben builds the number 3,008 and ticks "Hide the zeros." What number does it appear to become?

- A. 308
- B. 3,800
- C. 38
- D. 3,008 (nothing changes)

? Show Answer



The correct answer is **C**. Removing both zero symbols squeezes the 3 and the 8 together, so 3,008 looks like 38. Option A only removes one of the two zeros; both the hundreds and tens places are empty.

Concept Tested: Zero **Bloom's Level:** Apply

Question 9

Zara's Nanu writes a number on a recipe card in Bangla digits: ২০৫. Using what you learned about Bengali digits and place value, what number is it?

- A. 205
- B. 25
- C. 250
- D. 502

 Show Answer

The correct answer is **A**. २ is 2, ० is 0 and ५ is 5, and they are read left to right in the hundreds, tens and ones places, just like our digits. Option B forgets that the zero is holding the empty tens place.

Concept Tested: Brahmi Numerals **Bloom's Level:** Apply

Question 10

In 2017 the Bodleian Library announced that the Bakhshali manuscript might date to the 3rd or 4th century CE. In 2024, new radiocarbon results dated the tested leaves to roughly the late 700s to early 1000s CE. What is the best conclusion?

- A. Radiocarbon dating is useless, so the manuscript's age can never be known.
- B. Testing and re-testing corrected an early claim, which is how good science and history are supposed to work.
- C. The 2024 results prove that zero was invented in Europe.
- D. The manuscript must be a modern fake.

 Show Answer

The correct answer is **B**. Experts questioned the 2017 result, the lab tested more leaves, and the date was revised. Option A goes too far: the method worked when applied carefully. The manuscript is still a genuine early text; it just isn't older than the Gwalior inscription of 876 CE.

Concept Tested: Zero **Bloom's Level:** Analyze