India: Crash Course History of Science #4

Crash Course: History of Science
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You might have recognized some of the names of the Greek natural philosophers. They were individuals with quirky theories, and we have records about them. But they weren't the only people making knowledge back in the day.

India had major urban centers, centralized administrative states, and complicated metaphysical traditions long before the Greeks had anything big. Just goats, which are small, and olive trees, which are bigger than goats but still small, and a few gods and goddesses doing normal stuff like cheating on each other. In Indian scriptures, thousands of gods and demons made perpetual war, destroying and recreating reality itself.

Ancient Indian thinkers didn't give rise to the same natural philosophy as the Greeks. India presents a convenient counterpoint to Greece because knowledge-making in India was inseparable from a long religious tradition, sponsored by the state and focused on applications. At the same time, both regions exchanged ideas with each other, and with the wider world.

Today we'll dive into a couple of major aspects of Indian natural philosophy, underlying philosophy philosophy, and math. Ah, and we will talk about everyone's favorite large mammal, the elephant.

[*Crash Course History of Science* intro]

Ancient India was home to several schools of thought, including what would become Hinduism, its more austere rivals Buddhism and Jainism, and a super fatalistic faith called Ajivika that isn't around anymore.

The most important Hindu texts were the vedas. The word "veda" literally means knowledge. These sacred texts are passed along orally even today, but they had also been written down for centuries by the time Alexander the Great invaded western India in 326 BCE.

Science and religion were entangled in both Greece and India. True, the Greek natural philosophers began to break with the mythological tradition, or at least repurposed it, proposing new ways of thinking about nature. Even so, we can never neatly separate out science from religion. They mutually affect one another.

In India, knowledge systems were essentially, well, Vedic. The vedas were written in a sacred language, Sanskrit, which was standardized around the time of the first Greek natural philosophers. The greatest Sanskrit scholar, Panini, wrote a book on grammar listing almost 4000 rules.

These covered phonetics, meter, semantics, etymology, everything about the language and how it should be used. In fact, Panini's theory of how words are formed was so advanced, that it was directly studied into the 20th century. So you can say that the first science in India was linguistics. And this tradition of memorizing the vedas and trying to understand words eventually led to the study of acoustics and musical tones.

But is studying language - which is a very human thing - the same kind of knowledge-making as studying fire or gravity? Yes, totally! Linguists make hypotheses, take careful observations, and put together testable theories about how languages change. They might be frustrated by the seeming randomness of their subject, but, then again, so are quantum physicists and medical doctors.

Some parts of the vedas concerned math and astronomy, but mostly they concerned gods and rituals. The vedas taught that the cosmos is clearly ordered, as is human society. What happens in the reality you perceive is the result of a complicated ethical algorithm running in the background, so you have to sacrifice a lot of animals and stay in your social position. Thus the vedas functioned not only as a basis for a whole language but as a way of teaching people how a society should be - a mirror of an orderly cosmos.

And so we arrive here at the present year, 321 BCE. It's not actually 321. But it was, at one point. At that time, in Greece, Aristotle had been dead for only one year; over in Babylon and what is now Iraq, Aristotle's former boss Alexander the Great, had been dead for two years.

But in eastern India, a young adventurer named Chandragupta Maurya was very much alive. That year, he became emperor of nearly the entire subcontinent. Alexander had only recently invaded India, wisely choosing not to start a beef with the powerful kingdom of Magadha.

When Alexander died, India consisted of a lot of small kingdoms. Maurya, inspired by the model of Alexander and coached by a brilliant older adviser, lead a coup in Magadha. From there, Maurya conquered the weaker kingdoms one by one, forging them into a giant, powerful state called - wait for it - what name, ah, did he name it? Who knows? It's the Maurya Empire.

The dynasty that Maurya founded lasted from 322 to 180 BCE. It sponsored research into astronomy, hydraulic engineering, and forestry.

Chandragupta's grandson, Ashoka, became one of the most powerful and culturally influential rulers of India, as well as a serious convert to Buddhism. He outlawed hunting and other unnecessary acts of violence toward animals, and opened public hospitals and spread Buddhism as far as Athens.

When the Buddhist monk Faxian visited India from Jin dynasty china starting in 399 CE, he favorably compared the two empires. Both were civilized societies where Buddhism could flourish. Increased travel between states brought increased trade in goods as well as ideas.

Under the Maurya empire, more than half of the arable land in ancient India was irrigated, producing two harvests a year. That sustained a lot of people and required a lot of planning. Thus, Indian states developed whole government departments to supervise the building and maintenance of irrigation systems. They controlled a vast system of canals and sluices funded by taxes. Breaching a dam was punishable by death.

The centralized Maurya empire - like the Egyptian, Sumerian, and Chinese ones - was a hydraulic state. Its control of water allowed harvests stability, keeping large populations alive. To control nature, the people running these big states needed to know lots of things about the lands, plants, animals, and especially rivers they controlled, and most especially about the people who owed them taxes. The first rule of history: nobody ever, ever liked paying taxes.

Another key to running a big state in India was the elephant. Training hundreds of war elephants was important to continued military power. So the Maurya created a forestry department, because elephants lived in the forests, and made the slaying of elephants punishable by - you guessed it - death! Forestry management and regulating land and water would eventually develop into sciences in their own right.

The Maurya's administrative, or "useful", science, such as their pioneering work in land management, was not the same as the abstract theorizing of the Greek natural philosophers. The Greeks left behind their names, thanks to their writings and their cults - I mean, I mean their schools. The work of those who maintained early hydraulic states tended to be anonymous.

A debate about the relative merits of applied versus pure science -- knowledge of the immediately useful versus the abstractly true -- is still raging today. Just compare a scientist applying for a grant to study, say, lichen versus an engineer working on computer guidance for missiles. But useful and abstract systems are not diametric opposites, and they were never fully separate.

India had been open to Persian and Chinese influences before Alexander. The Chinese had already introduced alchemy, or systematic questioning about what is stuff, to Indian thought. But India definitely became more Greekish when a bunch of Greeks - some trained by Aristotle himself - pranced in talking about elements and perfectly circular star paths.

Astronomy was important to all of the ancient states. This is because, alongside their war-making and tax-taking, states were also religious institutes which cared about astrological schedules. Because if you're a god, you can fly around the heavens, you have houses in different parts of the sky, and you want to be worshipped when you're in the right house.

In India, as all over the ancient world, religion and science were not separate ideas in the way we might think of them today. Practicing astrology meant carefully observing stars and planets and thus also practicing astronomy. People who knew a lot about the night sky made up a high-status professional class.

These star-gazers were part priest, part astronomer, and part mathematician. As astronomers, they divided solar year into months, crafting calendars to regulate religious ceremonies. They developed a calculation for adding a leap month when necessary to keep the religious calendar in sync with the solar one, and they investigated the moon's cycles, as well as constellations.

As mathematicians, they came up with names for very large numbers, such as 10 to the 40th, related to the very long cosmic cycles in Hinduism, Buddhism, and Jainism. In fact, astronomy and related math really took off in ancient India. But let's take a closer look with the Thought Bubble.

During the Gupta empire, which lasted from 319 to 605 CE, families of professional astronomer-mathematicians passed down their teachings about the stars. And they competed with each other. Six regional schools of thought all fought for state patronage.

This period also saw the rise of the siddhantas, or the "solutions" - meaning high-level astronomy textbooks. Two of the major siddhanta writers were Aryabhata and Brahmagupta. They were both brilliant polymaths, but unfortunately they disagreed about astronomy. Which was really too bad, because these guys would have made a team of unbeatable geniuses.

Written around 500 CE, Aryabhata's book of solutions includes a place-value system, decimal notation, the familiar numbers that we call "Arabic" today, the number zero, and the irrational number pi calculated to four places.

And Aryabhata famously postulated that the earth rotates daily on its axis. This idea was a major breakthrough in astronomy. Egyptian, Greek, and earlier Indian thinkers argued that the sky rotates around the earth. Aryabhata figured that the apparent movement of the stars is actually caused by the rotation of the earth itself.

But Brahmagupta thought a rotating earth defied common sense -- just look at all the birds, not flying off into the heavens. Meanwhile, in his own siddhanta, Brahmagupta calculated the circumference of the earth with astonishing precision, and he worked with negative and irrational numbers. Thanks, Thought Bubble.

Indian mathematicians were working on many topics that writers in Greece were not. But the most advanced branch of natural philosophy in ancient India was more founded in Vedic teachings.

Ayurveda - literally "life knowledge", or "the science of life", began with oral traditions about sacrificial animals. By the 6th century BCE, it was a standardized system of medicine and a way of answering the question, "What is life?"

Ayurvedic approaches to diseases and cures were rational. There were reasons for every choice. Good physicians didn't believe in strictly divine cures, but practiced medical judgment based on years of study and then more years of experience.

The influential medical textbook *Charaka Samhita*, for example, calls for physicians to apprentice with a master then get royal permission to treat patients. It also lists 300 bones, 500 muscles, 210 joints, and 70 vessels within the human body. This was written sometime before 200 CE, and today's med school students complain about organic chemistry.

Ayurveda, which is still around today is so complex and important that we're devoting another episode to it alongside ancient European medicine. For now, just note that Indian medicine and surgery was probably the most advanced of any contemporary ancient civilization.

Rich in people and faiths, India was not a single culture, even under the highly successful Mauryas and Guptas. But certain features of ancient Indian natural philosophy stand out.

The ancient vedas, literally, the "knowledges", influenced a wide variety of thinkers across a large geographic region. There were no sharp breaks with Vedic ways of knowing, although Buddhism and influences from China and Greece added new layers of philosophy on top of the Vedic one.

And the Maurya and Gupta states were wealthy and well-administered, known for their skilled artisans and able to control vast plains in order to feed teeming cities.

As ancient states exchanged goods and proto-scientific ideas, Indian ideas spread far and wide. We have accounts of ayurvedic physicians, or "vaidyas", working in 8th-century Baghdad, then one of the largest cities on earth and a center of knowledge production.

Next time we'll travel to the Americas to ask questions like, "When are we?", "What is time?", and "How do we measure it?"

Crash Course History of Science is filmed in Dr. Cheryl C. Kinney studio in Missoula, Montana, and it's made with the help of all of these nice people, and our animation team is Thought Cafe.

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