Medieval China: Crash Course History of Science #8

Crash Course: History of Science
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Look at this map of China and tell me if, from what we've learned so far, you can tell me about the Chinese civilization.

Yep, rivers, big ones… and from them ran the bureaucracy and technology necessary for controlling water. Like Egypt, Sumer, and Mesoamerica, ancient China represents a hydraulic civilization—one that maintained its population by diverting rivers to aid in irrigation—and one that developed writing thousands of years ago.

In fact, there is an unbroken Chinese literary and scientific tradition from this time on—not true of Egypt, Sumer, or Mesoamerica. And from writing, Chinese scholars naturally developed a critical invention in knowledge transmission and state control: you know it, you probably hate it, the standardized test. Today, we're going to focus on the time of the Northern and Southern Song Dynasties, a time of great technical innovation.

But, before we get to the Song, let's take a tour through the ages and explore key elements of Chinese scientific culture. [Intro Music Plays] From the beginning, science in China was a product of the state. The very first Chinese dynasty, the Xia, supported astronomical research to create more accurate calendars. Later, between 400 and 0 BCE, Chinese scholars measured the length of the solar year to 365.25 days, predicted eclipses, recorded supernovas and sunspots, founded a Bureau of Astronomy, and even determined the 26,000-year cycle of the precession of equinoxes!

Alongside this research, Chinese culture developed a grand model of the cosmos: in an infinite, empty space—enclosed by the great celestial sphere—celestial bodies float around, directed by a h"hard wind." This mysterious force explained how the stars and planets moved around. The earth sits, still, at the center of the system. On the earth, in a zone between the four points of the compass, stretches the Middle Kingdom—China.

The cosmos revolved around not just earth, but China itself. And in the symbolic center of China stands the Son of Heaven—the emperor. The ancient Chinese states, like others governing large populations, developed complex ideas about human society.

The most prominent early Chinese thinker was Confucius, whose philosophy emphasized the importance of tradition, etiquette, respect for elders, and for the patriarchy. Confucianism's focus on an orderly human world conflicted both with Buddhism's transcendental orientation toward a reality beyond this one, and the proto-scientism of Mohism and Legalism, which were contemporary schools of thought that privileged rational laws. Despite competition from these other schools, Confucianism influenced a lot of later thought.

The official state ideology of the Song was neo-Confucianism. China was first unified in 221 BCE, in the Qin Dynasty. But it was the succeeding Han Dynasty that instituted an imperial university and the state examinations, also called the civil service or imperial examinations.

The state exams, which were open only to men, were a way of ensuring that the central administration had enough trained civil servants to oversee the collection of taxes and building of roads, maintain a large standing army, and roll out agricultural reforms. For the examinees, it also meant a chance to jump from a lower class to a higher one. Passage of even the first level of exams led to exemption from corvée labor, which was part-time unpaid work for the state.

Science, however, did not figure much into these state examinations. The exams mostly tested memorization and recitation from the important government and Confucian texts. These shaped the values of the country: examinees were well-rounded and shared a common culture focused on law and order.

So while the Chinese state did support research, especially on topics such as agriculture, meteorology, and astrology, and while there was a large state system for educating people and getting things done, these two threads never quite entwined as they did at the Museum of Alexandria or the House of Wisdom in Baghdad. This brings us to the Song Dynasties. The Song state produced a lot of infrastructural and social change across China, starting with the key to everyone's heart, their stomachs.

During the eighth century, rice cultivation took off in southern China and the Yangzi Basin. Then, in 1012, the Song state introduced new early-ripening and winter-ripening rice from the Champa kingdom in what is now Vietnam that allowed rice to be produced faster with less water The Song state reclaimed rice field plow and paddle chain water-lifting devices. These agricultural changes led to the growth of a leisured middle class, increased trade, and a growth in manufacturing.

Within a century, urbanization skyrocketed: urban population reached twenty percent of the total even as population jumped from fifty million to one hundred and fifteen million. And we moderns know what hegemonic powers want, right? A gigantic state bureaucracy!

In medieval China's case, this meant the highly centralized mandarinate, a term referencing Mandarin, the dialect of Chinese employed in the imperial court. The bureaucrats who oversaw the imperial exams became known as "mandarins." The mandarinate provided social stability and, thanks to the exams, some insulation against corruption. Systematic knowledge production in abstract natural philosophy was never unified.

But Chinese technÄ" was another story. Whereas scholars had high status, craftspeople had low status. The state controlled most industries, and the state was responsible for programmatic improvements.

The list of Chinese "firsts" or true technical inventions is so long that it could be its own episode. The wheelbarrow, silk production, earthquake monitors, lacquer, gunpowder, the crossbow, porcelain, umbrellas, fishing reels, suspension bridges, and paper money. As fascinating as this list is, it's of somewhat limited analytic value, because it doesn't tell us anything about the social and political context of technological invention.

What are the characteristics of a given society that lead to new ideas? Does the state help or hinder this work? Let's look at some examples.

Sometimes a practical invention led to new scientific knowledge after the fact. For example, the Chinese had tinkered with magnetic compasses since 300 BCE, but the concept of attraction to the North Pole was not understood for another two hundred years. Other times, cultural desires drive lots of little iterations that lead to major breakthroughs.

For instance, Chinese artisans made paper since the second century CE, although it may have been developed even earlier. And by 700, the Chinese also made use of a printing press involving carved wood blocks. In fact, the first Song emperor ordered the printing of a compilation of Buddhist scripture that included 130,000 two-page wood blocks in 5048 volumes!

But printing really took off in 1040, when Song artisans introduced the first movable-type printing presses using wood and, later, ceramic characters. These helped standardize writing and unify

Song culture. Finally, sometimes the state would directly support the creation of new knowledge.

Sponsored by the state, Chinese artisans created complex astronomical clocks and orreries, or mechanical models of the heavens. During the Song Dynasty, civil servant Su Song refined these techniques to construct a gigantic machine that would replicate planetary movements and allow the government to correct the official calendar. Alchemy—or a systematic investigation of “what is stuff?”—also took off with state support, starting in the Han dynasty.

Thanks to this work, the Chinese had gunpowder as of the mid-ninth century. But it took until roughly the twelfth century, under the Song, to perfect the military application of such a volatile substance. But as fascinating as medieval gunsmithing is, the real achievements of Chinese technology were in infrastructure.

This includes everything from taking raw ore and making it into usable iron, to moving vast quantities of water around. Medieval China saw an infrastructure revolution. Show us what it looked like, Thought Bubble!

Iron production in China had been a state enterprise since 117 BCE. But under the Song, iron production skyrocketed, increasing by sixfold from CE 800 to 1100. In 1078, for example, the Song state foundries produced 125,000 tons of iron!

How did they do it? Knowing more about the chemical properties of stuff! Specifically: coal.

By the late Song, households used coal for heating, which was much more efficient than charcoal. Coal burns hotter, for longer, and doesn’t require deforesting the lands around cities. This allowed iron production to scale up without destabilizing society.

And iron workers used water-powered bellows by the eleventh century, smelting ore with coke—a powerful fuel made from coal which burns hot and clean. The Song state made 32,000 suits of armor, 16 million arrowheads, not to mention loads of agricultural implements, every year! In addition to metallurgy-backed military might, hydraulic engineering is vital in running large states.

But the Grand Canal took infrastructure into a new scale. Completed in 1327, the Grand Canal stretched eleven hundred miles, from Hangzhou in the south up to Beijing in the north. This is about the distance from New York to Florida.

The Grand Canal allowed merchants to ship up to four hundred thousand tons of grain every year. The Great Wall is pretty wondrous, as far as long-term engineering projects go, but the Grand Canal was not only a technical project—necessitating the water-level-adjusting pound lock (a technology we still use in canals to this day) —but a social and economic one. Thanks, Thought Bubble!

The efficient moving-around of goods is characteristic of the Chinese world by the time of the Song—when economic activity and population boomed alongside the ability to grow more rice. The Canal also represented the powerful Chinese state’s ability to engineer vast regions: they connected smaller waterways to main rivers, opening up where goods and people could travel. But—as political winds shifted—certain sections were expanded or left to silt in.

So centuries later, during the Ming Dynasty, the Grand Canal had to be massively restored. The Ming repaired 40,987 reservoirs and planted a billion trees. Billion… With a B.

The story of natural philosophy in China is similar to the story in other early states: useful science was prioritized, not science for its own sake. Given its resources, state support of research, population, and impressive track record regarding technical innovation, some historians have asked why a “Scientific Revolution” didn’t occur during Song Dynasty China. But is this question useful in helping us make sense of past systems of knowledge-making?

For one, many revolutionary technical achievements in medieval China were made over long periods of time by anonymous, lower-class artisans, not individual, named scholars. Two, in another sense, a “Scientific Revolution” did happen! Coal, water-powered bellows, gunpowder, compass-assisted navigation, centuries-long hydraulic engineering schemes, movable-type presses, massive urbanization, and research-driven agricultural intensification—added up, these sound pretty revolutionary!

And many of these inventions traveled well beyond China. But! The Song state fell to—wait for it—the Mongols… ….so these achievements didn’t all persist in time.

The more important point is that changes in how cultures have understood and manipulated the natural world don’t follow a single predictable model. Chinese historians have seriously challenged the assumption that a so-called “Scientific Revolution” is a necessary path for all civilizations. Next time—we’ll zoom in on the field of medicine and compare systems of making knowledge about health across Eurasia and north Africa.

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