Cathedrals and Universities: Crash Course History of Science #11

Crash Course: History of Science
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Hi, I'm Hank Green, this is Crash Course, and today I wanna explore two sites of knowledge production in Europe during the medieval period.

This is the story of the cathedral and the university. [INTRO MUSIC PLAYS] First, let's agree to call the general time period in Eurasia and North Africa after the birth of large states but before colonial empires the medieval: a "middle age" that lasted from roughly CE 500 to 1400. So we've got our working definition established!

Across a large part of the medieval world, people traded knowledge, and many folks practiced different forms of humoral medicine and alchemy. The majority of these explorations of nature were conducted by individual elites—nobles and other rich people who happened to take an interest in the world around them. In a few places, however, knowledge production was highly centralized.

As we've seen in Baghdad, Delhi, Beijing, and Bologna—lots of medieval people were making knowledge systematically. The north of Europe was a different story. Until roughly 1100, there were relatively few places of knowledge-making.

Monasteries and abbeys had special rooms called scriptoria where monks copied manuscripts by hand. But the biggest places where knowledge was made were the Gothic cathedrals. Cathedrals were great stone churches that took years, sometimes many decades to build.

They weren't simply places to go on Sunday to worship. A cathedral was the seat of a bishop, or regional church leader, and the administrative, spiritual, and educational center of the bishopric or diocese—the district under the bishop's control. And if you wanted to go to one of these places, that didn't make you a christian, just like going to taco bell doesn't make you a taco.

And, unlike castles, cathedrals are still used today for their original purposes. Choosing a site for a cathedral was high stakes. While secular rulers paid for cathedrals, bishops often chose where to build them.

This redrew the map of Europe and made some cities vastly more important: once a cathedral was there, a city grew economically. As populations grew, bishoprics split. New cathedrals were needed.

While the first cathedrals date back to Constantine the Great, the high age of cathedral building lasted from roughly 1000 to 1500. This was an era of frantic economic growth in Europe. The French, for example, built eighty cathedrals between 1050 and 1350, moving more stone for these projects, in total, than was moved to build the great pyramids!

The construction of these vast, soaring spaces required immense technical knowledge. What made a cathedral such a technical wonder? Help us out, Thought

Bubble: The height of the cathedral was important: narrow and tall, cathedrals drew the eyes of worshippers up, inside and out. Inside, a Gothic cathedral generally featured spacious arched vaults, lots of narrow windows casting light muted by stain glass, and a big round "Rose" window in the front. Stained glass was not only an artistic achievement, but a highly technical one. Medieval artisans discovered through alchemical experimentation that adding gold chloride to molten glass resulted in a red tint, and adding silver nitrate turned the glass yellow. Recently, scientists analyzed stained glass from this era and discovered that this technique, possibly dating back to the tenth century, worked because of nanotechnology! Analysis of the stained glass revealed that gold and silver nanoparticles, acting as quantum dots, reflected red and yellow light, respectively. Historians still have no idea how medieval artisans made this glass. Outside, towers and spires, guarded by gargoyles, stood tall above the small buildings of the medieval city. Perhaps the most striking architectural feature of the cathedral were its flying buttresses— arches leaping off the side of the building, distributing weight down, allowing the great stone mass to move up and up. The physics of flying buttresses reveals how innovative they were. High, stone-ceilinged cathedrals generated heavy outward thrust, a force that had to be directed safely down to the ground. Added to this was the problem of strong winds, which presented a danger to the tall, skinny bodies of cathedrals. One solution would have been to make the walls of cathedrals gigantic and thick and ugly. But that's not what the cathedral builders did! To move thrust out and down and resist the wind, buttresses were connected to the main building with arms, making them look as though they were "flying." Capped by intricately carved pinnacles, these arched supports allowed much light to stream in through the stained-glass windows. They also used less stone, reducing the cost of materials and labor. Thanks Thought Bubble! This strategy worked pretty well for many cathedrals… Although the one at Beauvais—with an incredibly tall choir and a slightly misaligned arched vault—partially collapsed in 1284. For the most part we do not know who designed the cathedrals. But we know that economic opportunities in cathedral cities attracted many skilled artisans. Each cathedral project was led by a master builder. Rough masons cut, mortared, and laid the heavy stones. Freemasons completed the more intricate work, such as the tracery around the rose windows. These artisans were the engineers of medieval Europe. And having large numbers of them move from location to location was very unusual for a time when most people died in the same village they were born. These flying-buttressed monumental spaces didn't only motivate earthly activity. They were representations of Paradise on earth. This Paradise was part of a complex theoretical system for answering the question "where are we?" The medieval Christian cosmos looked a lot like the Aristotelian–Ptolemaic one: an earthly sphere bounded within a series of planetary spheres, and beyond that, an ultimate heavenly sphere. But this heaven was literally Paradise, the home of God. And below the earth was Hell. (Dante strikingly detailed this Christianized model of the Aristotelian cosmos in his Divina Commedia.) You might wonder why the medieval Christians were so obsessed with death and Hell… Well, we don't want to accuse medieval Europe of having been some uninteresting "dark age." But it could be a pretty rough time and place to be alive. A striking example of this grimness is the Black Death, a plague that swept across Europe from 1348 to 1350. Perhaps spread by flea-ridden merchants traveling the Silk Road, the plague bacterium, Yersinia pestis, killed anywhere from 75 to 200 million people—which was 30 to 60 percent of Europe's total population, in two years. aaaaahhhhh... And the plague came back periodically until the nineteenth century… when cholera pandemics arrived! Before the Black Death, Europe had grown a lot. And it was during this pre-plague period that universities took off. Between 1100 and the mid-1300s, population growth and urbanization led to rise of the university: there were more secular conflicts, so they needed more lawyers. There were more religious arguments, so they needed more theologians. And there were more people—and more were sick!—so they needed more physicians. The proto-university in Europe was Charlemagne's palace at Aachen or Aix, in what is now Germany. Charlemagne and his successors centralized knowledge production at the palace. From around 800 until about 855, Aachen was an important site for the production of manuscripts including religious and legal texts. The first true European universities included Salerno, Bologna, Padua, and Naples in Italy; Oxford and Cambridge in England; Paris and Montpellier in France; and Valencia in Spain. Still looking good, U. Salerno! Eleven hundred is the new thirty. Although they all feature impressive old buildings today, medieval European universities started off as self-governing associations of people with a common function. The places where those people taught and learned could change, but the legal entity of the university stayed the same. In

fact, the Latin word universitas even means "Corporation." Which is... maybe... accurate today? Joining this corporation required swearing a Christian oath. University curricula, or book lists, had to approved by the Church. This was paradoxically freeing, though, because it meant that cities and kings had to recognize universities as self-governing: if the Pope said that the faculty of a university were cool with him, then kings and nobles couldn't boss them around so easily. They could teach and research what they wanted to, as long as it was vaguely Catholic enough. Plus, universities became tax exempt! Let's say we are well-off medieval students ready to make campus visits. First, our medieval parents lay out our options: doctor, lawyer, or priest. Those are real jobs. If we can't hack it at one of those, we can instead study something called the "liberal arts." Again, here we ware! Traveling around, we encounter two kinds of university: in the "Northern" model, such as at Paris, the most important discipline is theology. The University of Paris was incorporated as an association of these "masters," or teachers. In the "Southern" model, at Montpelier and the Italian universities, medicine and law are the most important subjects. These universities were incorporated as associations of students, who had to pay the salaries of their teachers. No matter which school we choose, we'll need books. Our Scholastic curriculum revolves around a few core texts, including some names we've already encountered: the famous physicians, Aristotle—especially the Physics—Euclid, Ptolemy, and Archimedes. And did I mention Aristotle? Which books we buy depends on what we'll study. The artis liberalis, or liberal arts, are divvied up into a group of three, the trivium— or tools for thinking, which are grammar, rhetoric and logic—and a group of four, the quadrivium—or specific subjects, which are arithmetic, geometry, astronomy, and music. If we decide to study medicine, we'll read and reread sayings attributed to Hippocrates, Aristotle, Galen, Ibn-Sina, Al-Razi, Ibn-Rushd and a few Latin writers— maybe Trota and an amazing abbess named Hildegard of Bingen. She taught about human health as connected to the "green" health of the living environment. Hildegard was way ahead of her time! Our teachers' lectures serve as commentary on the canonical texts. And there is also some emphasis on learning from experience—by visiting apothecaries, shadowing doctors on their rounds, and attending anatomical dissections… of criminals. Dissection is everyone's favorite class! Although our liberal arts or medical curricula are taught as more or less finished sets of knowledge, this is not to say that no one can make new knowledge. It just has to enter the classroom as part of an ongoing discussion with the long-dead "masters." And enter it does. By 1200, translations of classical Greek works lost to the Latin- and Romance-speaking northwest of Eurasia came back into the libraries of universities and monasteries. These were Latin translations of the Arabic translations we mentioned back in episode seven. What was the result of all this book learnin'? For one, medieval Christians had to work harder and harder to reconcile scientific works by their favorite Greek and Arabic masters with a Christian worldview. Increasingly, the faculty—thinking systematically about thinking as separate from the Bible—ran afoul of the Church. In 1277, the bishop of Paris officially condemned 219 Aristotelian "errors," meaning that anyone teaching certain ideas from Greek philosophies would be excommunicated. Historians are split on how this affected science: on the one hand, the suppression of Aristotle's ideas sounds bad. But on the other, this condemnation freed up medieval thinkers in continental Europe to look beyond the so-called "masters." Thought experiments about how Nature might really work, regardless of the Bible or Aristotle, flourished. Separating the study of a thing called "Nature" out from that of a perfect God, even hypothetically, helped set the stage for a secular scientific program. Nature became God's delegate, an intermediary force between God and humanity—something to study… and, ultimately, control. Control of nature meant first putting it in the right order: head before toes, first causes before final ones, universals before specifics, and abstractions before particulars. This neat Aristotelian order, married to a Christian interpretation of the world based on scripture, would soon come up against theories drawn from meticulous record-keeping regarding natural phenomena… such as astronomical data… such as how heavenly bodies move… But that's for next time, when we'll meet a certain mathematician who attended four great universities— Krackow, Bologna, Padua, and Ferrara—Nicolaus Copernicus! Crash Course History of Science is filmed in the Dr. Cheryl C. Kinney studio in Missoula, Montana and it's made with the help of all this nice people and our animation team is Thought Cafe. Crash Course is a Complexly production. If you wanna keep imagining the world complexly with us, you can check out some of our other channels like Scishow Kids, The Art Assignment, and The Financial Diet. 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