The New Anatomy: Crash Course History of Science #15

Crash Course: History of Science
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In the 1500s and 1600s, the work of Copernicus and Galileo, among many others, reshaped how natural philosophers in western Europe thought about the question, where are we?

But there's another question to consider that's at least equally daunting, what is life? And to try to answer that question, three tools stand out as being especially useful: ...a really long book full of beautifully grotesque illustrations based on dissected bodies… ...experiments about blood pumping through living animals… ...and the microscope. [Intro Music Plays] You could call Andreas Vesalius the Copernicus of anatomy: his name has become synonymous with a revolution of its own, and his major book even came out in 1543, the same year as De rev.

Vesalius was born in Brussels in 1514. He studied at the Universities of Leuven, Paris, and Padua. He wrote his thesis about al-RÄ•zÄ«, the famous and prolific medieval physician who wrote Doubts About Galen.

And Vesalius did some Galen-doubting of his own. After conducting years of medical research, Vesalius wrote up his findings in a gigantic, seven-volume book with 273 illustrations. It was published in 1543 under the name De Humani corporis fabrica, or On the Fabric of the Human Body.

And it redefined the long Hippocratic–Galenic–Arabic–Persian medical tradition. It didn't just tweak Galen's ideas. Fabrica was a new way of doing medicine—a new paradigm.

The seven books of Fabrica cover the bones and cartilage, the ligaments and muscles, the veins and arteries, the nerves, the heart, the brain, and "the organs of nutrition and generation"—meaning most of the stuff in the body. And along the way, it brims with observations that were new to Vesalius's world. Vesalius accurately described the sternum, the bones of the arm, the skull, and the entire muscular system.

Importantly, he also wrote that the brain and nerves are the center of the mind. This overturned the Aristotelian idea that the heart was the center of thought and feeling. And, despite possible religious objections, Vesalius disproved the belief that men had one rib fewer than women.

He even disproved the idea, from Galen, that men have more teeth than women. Seems like fairly easy things to do! No one had thought to look inside of a woman's mouth.

That's just way too weird! How are you gonna study a woman??? Where are they?

In fact, Vesalius realized that many of Galen's observations, made back in Roman times—when human dissection was illegal—had actually been observations of animals, not humans. Galen incorrectly thought the human lower jaw was made of two bones, like it is in some animals. He thought the major blood vessels started in the liver.

And he thought the human body had a network of blood vessels at the base of the brain, called a rete mirabile, that are actually found in dolphins and sheep. But Vesalius was able to correct a lot of this misconceptions, thanks to the big innovation he used in his lectur-at

Padua: dissection. Instead of hiring a surgeon to do his dirty work, Vesalius—a scholar—conducted dissections himself. Thought Bubble, Show us the wonder of hands-on medical observation.

Fabrica is written as a sort of guide to dissecting someone. Vesalius clearly explains the order in which you have to dissect a body to observe each muscle. He lets you know what tools you need. So Fabrica shows how important instruments are to scientific knowledge-making. And over the course of its thousands of pages, you see that Vesalius began to think about the human body as a composite of physical, mechanical, interlocking systems—and not a bag of humors. In some ways, "anatomy" in the modern sense begins with Fabrica. The book wasn't just an encyclopedia of diseases and treatments. It was a guide for seeing the body anatomically instead of humorally. And Vesalius wanted others to see what he saw. His book's illustrations were made possible by advances in artistic techniques and the improvement of detailed woodcut engraving as a technology. And Vesalius supervised the whole process carefully. He wrote out such specific instructions for his printer that the printer included them in the text. Chances are you've seen some of the dissection-inspired woodcuts from Fabrica: flayed human bodies traipse through a stylized Italian countryside, making dance-like motions, demonstrating how their muscles and bones connect, and looking… not too bad for people with no skin. Thanks Thought Bubble,

Where Vesalius helped readers of his book see the human body differently, they would still have had many questions about what life is and how it functions. William Harvey answered one of the big ones—how does blood work? Harvey was born in Kent, England, in 1578. He studied in Italy, was a fellow of the Royal College of Physicians in London, gave popular lectures on anatomy, and served as physician to King James the First. He also was a major skeptic when it came to witchcraft, which was the source of much freaking out at the time. So, as an official examiner of witches, which was a thing you could be back then, he acquitted the accused rather than having them burned alive.

But William Harvey is most famous for his theory of blood circulation, which Galen and Vesalius both got wrong. Like Vesalius, Harvey learned a lot about bodies through careful observation, AKA getting gettin' all gross. He did this specifically through vivisection, or cutting open live animals. He watched their hearts slow down and finally stop beating as they died, and he estimated the amount of blood that left those exposed hearts. And he used those measurements for a reason: to help him formulate medicines. In doing so, Harvey helped bring the the idea of rigorous measurement to medical investigation. And by 1618, Harvey had arrived at the conclusion that arterial and venous blood vessels form a single, connected, closed circulatory system.

This was a brand new idea! Harvey published his findings in 1628, in another Latin-language classic which sounds a little bit like you're casting a spell when you say it: Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus, or On the Motion of the Heart and Blood. Which historians tend to shorten to De Motu Cordis. Which is the name of my new metal band. De Motu Cordis was, again, a revolt against the old Aristotelian–Galenic system. It's also a great early example of comparative anatomy: Harvey compared the hearts and arteries of many cold-blooded animals in order to understand the basics of how a heart pumps blood—or, really, that heart does pump at all -- as opposed to the blood "diffusing" through the system as Galen thought.

Through his quantitative experiments, Harvey disproved the Galenic idea that the liver creates the blood found in veins. And Harvey figured out that blood flows in one direction at a time, thanks to valves. Also not part of Galen's system. But, while Harvey's De Motu Cordis was a more accurate theory of how blood circulates than Galen's, Harvey also fudged his data in order to make his point. When he measured a heart, Harvey estimated the volume of liquid it could hold, how much blood it moved each time it beat, and the number of beats it made in half an hour. And Harvey made each of these estimates intentionally low, so that people could easily see how wrong Galen's liver-based system was. The liver simply couldn't make enough blood, fast enough, for the diffusion theory

to work. But he made sure that the numbers didn't come close. Now, still, to his credit, Harvey did all of that observational and experimental work without a critical instrument that would soon be developed over in the Low Countries—the microscope.

Anton Philips van Leeuwenhoek was born in Delft, in what was then the Dutch Republic, in 1632. The inventor of the microscope became the so-called "father" of microbiology, because you can't have a "microbiology" without a microscope -- another example of the importance of instrumentation to scientific knowledge-making. We don't have all the details of what process Van Leeuwenhoek used to create his invention. But we do know he made hundreds of magnifying lenses and at least twenty-five proper microscopes. Somewhere along the line, Van Leeuwenhoek told a doctor friend about his investigation of the very small, and that friend told the Royal Society over in England. In 1673, the Philosophical Transactions of the Royal Society published van Leeuwenhoek's microscope-enabled observations.

A few years of debate ensued about whether van Leeuwenhoek was pulling everyone's collective natural–philosophical chain, but members of the Royal Society eventually confirmed his findings. Using his invention, van Leeuwenhoek discovered an entire world of amazing forms in miniature. He found single-celled organisms living their best lives at an entirely different scale than our own. He called these "animalcules" or "little animals," many of which aren't actually animals. For example, in 1677, van Leeuwenhoek observed spermatozoa. And in 1682, he observed muscle fibers. Over the years, he wrote hundreds of letters to the Royal Society and similar institutions to share his observations. But he never divulged the secret of his microscope-manufacturing. ... Jerk!

Another Dutch natural philosopher combined the work of van Leeuwenhoek and Vesalius. Jan Swammerdam was born in Amsterdam, in the Dutch Republic, in 1637. And, yes, I said that without laughing. He delicately dissected animal and plant tissues under a microscope, learning in the process about both the structure and the development of life. This was a critical turn in the life sciences. Swammerdam observed, for example, how an insect changes from an egg into a wriggly larva, then a hibernating pupa, and finally an adult, often capable of flight. Four different bodies from one animal! Swammerdam also experimented on muscle contraction. And, in 1658, he was the first to observe red blood cells. All told, seventeenth-century Holland was a rad time to be a natural philosopher, asking "what is life?" As long as you can get your hands on one of Van Leeuwenhoek's microscopes... which apparently only 26 people could.

But perhaps the greatest early microscopist was the English polymath Robert Hooke, born on the Isle of Wight in 1635. Hooke became the curator of experiments of the Royal Society and did a whole bunch of amazing work in science that we'll have to explore some other time. For now, just google "Micrographia." This is the book Hooke published in 1665, which was the first book of microscope-enabled observations of the natural world, and arguably the first scientific bestseller. It's also the first instance of the word "cell" being used to describe a single chamber within a living tissue—like the cell, or small, confined quarters inhabited by a monk. Like Vesalius, who was obsessed with woodcuts, and van Leeuwenhoek, who was a manic letter writer, Hooke wanted others to see the living world how he saw it.

So Micrographia is full of beautiful, tattoo-worthy illustrations, including a famous one of the homely flea. In fact, it's so beautiful that it's easy to forget that, even though it was a scientific rendering, it was still highly subjective. After all, seeing nature through a device like a microscope or telescope doesn't make you free from your biases. And the microscope raised more questions than the slightly older telescope, because it required even more subjective interpretation. With only a few good microscopes around in Hooke's day, most readers of Micrographia couldn't have confirmed the accuracy of Hooke's drawing of a flea, or of anything else in that book. They just had to trust in the authority of the professional scientist—one of the first in his society.

Next time—we'll follow so-called "explorers" from Eurasia as they travel throughout the Americas and Africa, pillaging, classifying, and… mostly pillaging. Stay tuned! 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 Healthcare Triage, How to Adult, and Scishow Psych. And, if you'd like to keep Crash Course free for everybody, forever, you can support the series at Patreon; a crowdfunding platform that allows you to support the content you love. Thank you to all of our patrons for making Crash Course possible with their continued support.