Micro-Biology: Crash Course History of Science #24

Crash Course: History of Science
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What makes beer?

Single-celled organisms. What makes us cough and feel like sleeping for twelve straight hours Straight?

Single-celled organisms. AKA microbes, germs, the tiny machines that allow us to digest—and can kill us. “What is life?” Turns out, life is relentless, everywhere on earth! [Intro Music Plays] Microbes are invisible: they’re single cells. So to understand microbes—that is, to do microbiology—scientists first needed to study cells.

German botanist Matthias Schleiden and physiologist Theodor Schwann proposed a modern cell theory around 1837: every living thing is made up of one or more cells. So the cell was the fundamental unit of life, the thing that gives structure to all forms of life. Amazingly, Schleiden—who studied plants—and Schwann—who studied animals—both noticed tiny dots in the middles of the cells they looked at under their microscopes.

These nuclei must somehow be important to all life, they figured—correctly. Darwin’s chief public defender, Thomas Henry Huxley, also wrote a article called “The Cell–Theory” in 1853. Where the Germans were cataloging different microscopic forms, Huxley proposed a mechanistic model: cells are little factories with different parts that have different functions.

Their functions make the parts add up into an organic whole. Not every scientist believed cell theory right away, but many came around, as microscope-enabled evidence mounted. And yet, being able to observe single-celled organisms didn’t immediately lead scientists to connect them to disease.

In fact, medicine in the early 1800s mostly worked the way it had hundreds or even a thousand years earlier. It was still all about liquids called humors. But some diseases were understood differently.

These were caused by a kind of invisible badness in the environment called a miasma. According to miasma theory, diseases were caused by foul-smelling airs that came from rotting meats, swamps, and other putrefying sources. Before you knock it, think about it: this theory mostly works.

Dangerous microbes grow on smelly, dirty stuff. The smell is a byproduct of the microbes’ eating organic matter. But even today, we can’t see these microbes without instruments.

So following our unaided senses is still smart: don’t eat gross trash! Sniff the turkey before you eat it. And then, just eat it anyway like I did this morning.

By the mid-1800s, however, a few scientific rebels were pushing a germ theory of disease. This holds that germs, or pathogenic microorganisms, cause infectious diseases. [Snow] Around this time, a nasty germ called Vibrio cholerae provided an opportunity to test the theory out.h Cholera had ravaged England since the germ started to travel widely out of south Asia in the early 1800s, hitching rides on the expanding armada of merchant ships. Empire had all kinds of unpredicted downsides.

In 1854, a bad cholera epidemic hit Broad Street in the Soho neighborhood of London, killing over six hundred people. One doctor named John Snow had a hunch about what was going on. Snow created a map of the outbreak and noted that the cases seemed to cluster around one public well.

He hypothesized that cholera microbes were rapidly multiplying in its water. So he convinced the Soho council to remove the well’s pump handle. People went elsewhere for water, and the cholera infections decreased.

John Snow became a hero! Saving Lives! Even though, it turned out, the outbreak was already in decline when he removed the handle.

Thus proving that some John Snows, do know somethings. Snow’s quick thinking didn’t really prove germ theory. For germs to replace miasmas in their minds, scientists would require a better model of what germs are, and how they behave.

For that, we turn to one of the first experimental microbiologists and a dude whose name you probably should know from milk labels: Louis Pasteur Born in France in 1822—the same year as Galton—Pasteur was a chemist, not a physician. But he is known for his work on germs and health. Pasteur is credited as the co-founder of microbiology and the founder of modern zymology, the science of fermentation.

Fermentation is the biological and chemical process needed to make beer, wine, yogurt, cheese, bread, and many other foods. Thought Bubble, show us what that means. Chemically, fermentation is the conversion of sugar molecules into ethanol, or alcohol, and carbon dioxide.

In food, this usually happens thanks to bacteria or yeast. Looking good, Saccharomyces! Pasteur first connected yeast to the fermentation of wine in 1857.

He observed that microscopic yeast on grape skins makes grape juice ferment into wine. If you sterilize the skins, killing the yeast, fermentation won’t happen. Pasteur even made the the analogy that the microbes growing in wine and beer were similar to the microbes causing diseases in humans and animals.

He hypothesized that microbes are everywhere and must be responsible for all kinds of phenomena, like making food spoil. So in 1865, he patented a process in which liquids such as milk were heated to a temperature between sixty and one hundred degrees Celsius in order to kill microbes. This became known as pasteurization.

It may sound kinda simple, but this was revolutionary! Earlier, Nicolas Appert had invented canning to make foods safe, so Napoleon could fight wars for longer. But Pasteur’s method used a lower temperature, thus preserving tastes and textures.

Related to this idea of killing bad germs, Pasteur also helped develop hygienic medical practices, along with British surgeon Joseph Lister. No germs in the operating room! Most importantly for the history of biology, Pasteur got tangled up in a debate with a fellow scientist named Félix Pouchet who believed that living things spawn naturally from certain environments.

This widely held belief was called spontaneous generation. Pasteur, based on his observations of grapes, reasoned that living things can only grow from other living things. So he created an ingenious experiment to prove the theory of biogenesis, or life from life.

Pasteur showed that no germs would grow in sealed, sterilized long-necked flasks full of beef broth. But in sterilized but open flasks, microbes would eventually show up. Thanks Thoughtbubble.

After proving biogenesis, in the 1870s, Pasteur worked on immunology and vaccination. Pasteur’s work with the rabies and anthrax microbes supported the germ theory and its use in medicine: if you could identify a microorganism, you could give someone a weakened version of it, or vaccine, and the patient taking the vaccine would develop immunity to the real bug. And in

1879, Pasteur developed the first lab-manufactured vaccine, for chicken cholera.

It was around this time that germ theory was finally widely accepted, in part due to Pasteur's work. But Pasteur's ethics were questionable: when rabies vaccines for humans rolled out, Pasteur kept his data on their effectiveness secret. He even kept secret mortality data, or how many people his vaccines didn't help.

So unlike today, in Pasteur's time, it wasn't necessarily a norm that useful medical research should be shared publicly. But Pasteur was not the only notable germ wrangler. Born in 1843, the German physician Robert Koch painstakingly worked at a microscope to definitively establish the germ concept of disease.

He identified different microbes, becoming the leader of a large research team in Berlin. They founded the discipline of bacteriology, or the study of bacteria, particularly in relation to human health. In the late 1880s and '90s, Koch and his team traveled into areas experiencing epidemics, including India and Egypt, to identify the microbes causing diseases there.

By ID-ing these microorganisms, they hoped to create vaccines. First, Koch proved that the anthrax germ causes anthrax-the-disease. Later, he identified the bacterium that causes tuberculosis or TB, which was a very widespread disease.

Koch also characterized cholera, vindicating the work of John Snow by showing that the bacterium lives naturally in the small intestine of humans. Snow wasn't just high on ether: he'd correctly guessed how cholera spreads! Eventually, Koch's team contributed to the identification of the germs that causes diphtheria, typhoid, pneumonia, gonorrhea, meningitis, whooping cough, tetanus, plague, leprosy, and syphilis. …I would not want to borrow this dude's lucky microscope!

It's been through a lot! Through this work, Koch developed the four postulates or steps for identifying infectious diseases. One, the microorganism must always be present, in every case of the disease.

Two, the germ must be able to be isolated from a host containing the disease and grown in a lab, in a "culture." Three, samples taken from the culture must cause the same disease when introduced into a healthy model animal like a mouse. Four, the germ must be isolated from that new animal, meaning it is the same organism that caused the disease in the original host. So structure matters: in all infections, germs grow out of hand, throwing the body out of whack and causing inflammation.

These bad germs, or pathogens, develop and live within us, and can kill us. But with Pasteur's vaccines and Koch's scientific method of ID-ing bacteria, humans could now develop medicines to fight jerk-sauce germs. Go team us!

Back in the world of multicellular organisms, another scientist at the intersection of biology and medicine was exploring the structure of living things. In 1892, German-American physiologist Jacques Loeb began his experiments on embryonic development, or how organisms grow from single-celled embryos into whatever they're supposed to look like. So he started dunking sea urchin embryos into different salt solutions.

And, in 1899, he got one to give birth… just from being salty! Loeb's artificial parthenogenesis, or birth from the self, was mega-astounding news. It raised basic questions, such as what is sex?

Could a human one day give birth by herself… or him-self? Causing sea urchins to give virgin births made Loeb a celebrity. But for the history of biology, it was revolutionary that Loeb's sense of scientific understanding of life was tied to his ability to control it.

His work with sea urchins can be seen as an early form of bioengineering, or treating cells and tissues as machine-parts to be used constructively by a human designer. Loeb's notable students included the behavioral psychologists, B. F. Skinner and J. B. Watson, and a creator of birth control, Gregory Pincus.

Biology, like other scientific disciplines, shows a historical arc from observations to experiments, and from less control to more. From the mid-1800s to the early 1900s, scientists moved from mostly believing that living things spontaneously appear out of nowhere to controlling fermentation on a massive scale. Cheers to that!

Next time—we'll add the missing mechanism to this crazy Rube Goldberg machine we call biology: it's time for a monk named Mendel to accidentally figure out genetic variation—in mice, men, and peas. 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, Eons, and Sexplanations.

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