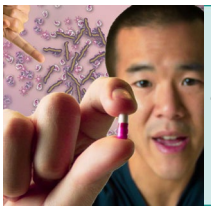

Superbugs That Resist Antibiotics Can Evolve in 11 Days

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Animated Short Transcript

[Intro music]

[Zoom in on extreme close-up of pill. Archival film look with circle insets of hand-drawn baby, tooth, and a scratch on the palm.]

Ed Yong: This is one of the great disruptors of the modern era. This changed everything. Before this, childbirth, getting a tooth pulled, even just a scratch could have been a death sentence. Antibiotics.

[The words "streptomycin, erythromycin, doxycycline, cephalosporin, amoxicillin" appear on screen.]

Ed Yong: There are many varieties, streptomycin, erythromycin, doxycycline, cephalosporin, amoxicillin. But they all share a common purpose. To eliminate bacteria.

[A series of military weapons within petri dishes. Archival photo of human hand over petri dishes and test tubes on a table.]

Ed Yong: They are weapons produced by microbes to kill other microbes. Antibiotics are natural substances that have been in use for billions of years, but humans only tapped into this ancient arsenal in 1928 and by accident.

[Archival footage of a drive in the country in a circle inset. Archival photo of Alexander Fleming. Petri dish with kill zone labeled. Another archival photo of Alexander Fleming with Ed poking his head up into frame.]

Ed Yong: On returning to his lab from a holiday in the country, British chemist Alexander Fleming noticed that a mold had landed in one of his bacterial cultures and had carved out a kill zone of slaughtered bacteria around it. And from that mold Fleming isolated the chemical that was killing the bacteria. He called it penicillin.

[Archival photo of penicillin in bottles labeled penicillin. Ed's head pops up in a circle inset. Archival photo of patients in a hospital. Archival footage of an assembly line of bottles.]

Ed Yong: Penicillin was among the first antibiotics to revolutionize medicine. And it saved millions of lives from infections, from war, from surgery, eating a bad oyster, scraping your knee. In fact, the need for penicillin was so great and the supply of it so small that patients' urine was filtered to extract the unused portion.

[Bacteria appear in a tube. Then bad bacteria pop up.]

Ed Yong: Bacteria. The vast majority of them in somewhere like your gut aren't doing you any harm and many are beneficial.

[A door opens onto antibiotics. Antibiotic bombs drop onto bacteria.]

Ed Yong: But most commercial antibiotics are shock-and-awe weapons.

Ed Yong: The antibiotic may have killed off the bad bacteria, but it also destroyed many of the other microbes living in the gut.

[Bad bacteria emerge among other bacteria. Ed talks to camera in front of an image of bacteria.]

Ed Yong: That rich, diverse microbiome crowds out more malevolent microbes.

[A human hand appears to point out bad bacteria.]

Ed Yong: Salmonella! Campylobacter! Terrible cramps. Clostridium difficile or C. diff. Crippling diarrhea. 30,000 deaths a year. It just makes you want to use more and more antibiotics. Kill! Kill! Kill!

[The bacteria are carpet-bombed.]

[A demon face made of pills appears over Ed. Circles appear behind Ed showing antibiotics and some of their uses as well as images of weapons.]

Ed Yong: The problem with antibiotics is not in their use, but in their misuse. And that creates a second problem.

[A "superbug" kicks over a pill bottle. Photos of Michael Baym, Tami Lieberman, and Roy Kishony appear in circles. Text: "KISHONY LAB OF HARVARD MEDICAL SCHOOL AND TECHNION - ISRAEL INSTITUTE OF TECHNOLOGY"]

Ed Yong: You've probably heard about invincible superbugs. Bacteria that have evolved to resist antibiotics. Well, three scientists, Michael Baym, Tami Lieberman, and Roy Kishony, figured out how to watch that happen.

[A big rectangle with 50 petri dishes inside appears. The text "MEGAPLATE" appears across multiple petri dishes. Microbial Evolution Growth Arena PLATE appears on screen. Footage of scientists in a lab with beakers of liquids and conducting experiment(s) that includes Dr. Kishony.]

Ed Yong: The first thing they do is to build a petri dish, but a giant petri dish. About 100 times bigger than the one Fleming used when he came across penicillin. They call it the Mega-Plate. They prepare a nutritious agar jelly that bacteria thrive in; but they've snuck a secret weapon into this agar: antibiotics. They pour it into nine separate bands, each with different concentrations of antibiotic. Then, they start growing bacteria: E. coli.

[A sequence of rectangular boxes appears with numbers 0, 1, 10, 100, and 1000. Scientist pouring liquid that dissolves to graphic effect. Graphic effect dissolves to footage of the mutant strain spreading.]

Ed Yong: On the outside bands, there's no antibiotic. Just the agar. The next bands in have just enough antibiotic to kill most E. coli. Inside those, 10 times as much. Then 100 times. And finally the center band has 1000 times as much antibiotic. On day one, you can see E. coli reproducing just fine in the area with no antibiotic up until they reach the border with the one times zone, where they normally can't survive. But then a mutant strain appears. It has evolved a way to avoid being poisoned, and it spreads until it reaches the next boundary with the 10 times zone. Now, new mutants with even stronger resistance begin to spread across the 100 times zone, and then finally the hardiest E. coli mutants of all make it into the 1000 times zone. And the time it took for this population of E. coli to evolve this super resistance: eleven days.

["11 DAYS" appears in text.]

[Archival footage of bacteria reproducing.]

Ed Yong: When we watch the plate, really we're watching evolution happening at warp speed. One of the reasons for that is that bacteria reproduce much faster than we can. *E. coli* can divide in as few as 20 minutes.

[Archival footage of bacteria becoming a circle inset that disappears into a family tree graphic effect. Two human hands appear to guide us to what Ed is talking about.]

Ed Yong: So here's a family tree that shows the relationships between the strains on the plate, and it shows us how resistance to antibiotics evolves. Over the course of 11 days, this strain continued to acquire mutations that made it ever more resistant to the antibiotic all the way to the 1000 band. But this one did not.

[Retro video game of bacteria mutating in response to antibiotic use.]

Ed Yong: When bacteria are exposed to antibiotics, those with mutations that allow them to survive the attacks

are the only ones left standing. And when those mutant microbes reproduce, they create a population of super-resistant bugs. So what's happening on the plate is a really good illustration of what's happening at a much larger scale all around the world.

[Archival footage of bacteria spreading.]

[Still photos of heads of cow, chicken, and pigs. Ed talks to camera in front of animated images of farm animals with resistant bugs, with Ed finally fading into an image like the livestock in the background.]

Ed Yong: And it's not just when we use antibiotics on ourselves. We also put these drugs in animal feed and water to stop outbreaks of livestock disease before they have a chance to happen. Those antibiotics can cause resistant bugs to evolve in animal populations and then spread into crops or even into humans.

[A cascade of pills falls behind Ed. Archival footage of bacteria multiplying. Archival video of Alexander Fleming. Archival photo of hospital ward with patients and nurse.]

Ed Yong: So when we use antibiotics, we are actually driving the evolution of resistant bacteria, which is not a new problem. Bacteria have always been evolving ways of resisting the things that try to kill them. And now the overuse of antibiotics is exacerbating that problem. In fact, Fleming himself was aware of the risk. He said that when we overuse antibiotics we are "morally responsible for the deaths of those who succumb to infections."

Ed Yong: Now I am not suggesting that we stop using antibiotics all together. We just need to get smarter about when and how we use them. For example, antibiotics are meant to treat bacterial diseases. They are useless against viral diseases like colds and flu. So using antibiotics to treat a cold is like using a hammer to fix a leak. It won't work and it'll probably make matters worse.

[Silhouettes of a woman sneezing and man coughing appear behind Ed. Ed holds a hammer and a leaky faucet appears. Screen is splashed with water.]

[Soaps and hand gel bottles appear on opposite sides of Ed. A toy train drives through.]

Ed Yong: And this trend of killing anything bacterial goes way beyond just antibiotics. We also put antibacterial chemicals in soaps and hand gels and toys. Even socks.

[Ed talks to camera when a sock drops into his right hand.]

[Archival footage of Alexander Fleming. Fleming's "microbe art" photos.]

Ed Yong: And I don't think that's something that Alexander Fleming would have approved of. To him, bacteria weren't just things to be destroyed. Amazingly, he created this "germ art" using microbes as his medium. Even though he discovered the most effective weapons against bad bacteria, he understood that bacteria could be beautiful – sometimes helpful and certainly, everywhere.

[Ed explodes into microbes.]

Ed Yong: If you're especially curious about the story behind this episode, check out the link below for an article that dives even deeper into these amazing microbes. And don't forget to follow us on Facebook and subscribe to our channel for more weekly videos. Thanks for watching.

END OF EPISODE