Science Forward--Evolution

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[0:01] [music playing]

Old Newsreel Voice: [0:09] Runny nose, headache, achiness, very often a slight fever. You see, what you think is a simple cold could really be the first symptoms of some other disease, such as influenza.

Flora Lichtman: [0:26] For most of us the flu conjures up feelings of fear, loathing, self pity. At least for me. But for some biologists the flu is a fascinating case study in evolution. Like for Elodie Ghedin, a professor for biology and public health at New York University.

Elodie Ghedin: [0:42] Viruses in general are the perfect model to ask evolutionary questions because evolution in a virus is like hitting the fast forward button if you compare it to human evolution, or even bacterial evolution is quite fast. But viruses are even faster.

Flora Lichtman: [1:00] The intersection between evolution and public health is the focus of this video. Because public health relies so heavily on clear communication, we're also talking to scientists about how they get their work out there, how they communicate their research.

[1:14] Elodie Ghedin's focus is on the genomics of pathogens that make us sick, like the flu.

[1:19] Our genes are coded in DNA. Dr. Ghedin studies the flu virus. Its genetic material is encoded in RNA. This, she says, is key to how the flu evolves.

Elodie Ghedin: [1:29] What viruses do is that being RNA encoded they make a lot of mistakes when they're being replicated, but that's their way of having a lot of diversity. But some of these mistakes are actually making what we say the virus is more fit. That means if there's something that will target them, so let's say a drug, an anti-viral drug. If the virus has evolved a mutation that is drug resistant, all of the sudden those viruses with that mutation will then continue growing. That's evolution. Actually accumulation of mutations that are then fixed in the population is evolution.

Flora Lichtman: [2:15] As we heard from Dr. Ghedin, viruses and bacteria make good models for studying evolution because the genetics of the population can change quickly.

John Dennehy: [2:23] One of the reasons for instance we don't have a particularly good remedy for flu is because the microorganisms that are responsible for it change rapidly. Whatever we come up with, natural selection makes sure that there is a new variant that survives it.

Flora Lichtman: [2:43] What's it like to be a bacterium? What's it like to live in the habitat of the human body? Think about how you move around and sense the environment. Now imagine you're microscopic. The rules can be different.

Laura Broughton: [2:55] Bacteria on average are about 50 times smaller than the cells in your body. When we think about how a microorganism lives its life, it doesn't have to worry about up and down the same way we do. It has to worry about whether it's going to be swept away by a current, or whether it's capable to sticking to something.

[3:15] Think about something like streptococcus that can cause strep throat. In this case you have a microorganism that wants to stay stuck to the back of your throat. You don't want it there. You have a bunch of cells that are in the process of trying to move things away from it. You have a lining of mucous to keep the bacteria cells from sticking to it. The bacteria have basically a sticky outer coating, and little tiny projections that help them stick to surfaces.

Flora Lichtman: [3:45] But your throat, like the rest of your body, is a complicated place. That's why scientists often study antibiotics within the controlled environment of a petri plate. Here's how it can work. The swap delivers a dollop of streptococcus. The plate, the bacteria's new habitat, has the nutrients required for them to grow and survive. Add an antibiotic to the plate, the environment changes.

[4:10] Broughton says the antibiotics work by attacking a molecule in the bacteria's cell wall.

Laura Broughton: [4:15] They have a molecule called peptidoglycan in their cell walls. Antibiotics, which we use to fight off infections, the way they work they attack the peptidoglycan and they make it fail, which is what makes the cell walls fail, which is what kills the cells.

[4:29] This is why we can use antibiotics to fight off bacterial infections without harming ourselves. We don't have this molecule.

Flora Lichtman: [4:36] When we add antibiotic to the plate, the new environment exerts a selective pressure on this population of cells, and some will die.

Laura Broughton: [4:45] The thing is, sometimes there are bacteria that won't die when they're subjected to the antibiotics.

Flora Lichtman: [4:49] If this resistance has a genetic basis, then the population starts to shift. Those cells that carry the resistance genes will survive and produce many more offspring that also carry that genetic material. Those that aren't resistant will die, or produce fewer offspring. After a few generations of exposure to the antibiotic, a higher and higher proportion of cells carry this resistance, and the antibiotic becomes less effective on this population.

Laura Broughton: [5:17] That's actually the definition of microevolution. When you go from one population to the next population, one generation to the next, and change the frequency of different traits in that generation.

Flora Lichtman: [5:27] Immune systems and antibiotics aren't the only threats to bacteria. Bacteria kill bacteria, and viruses and bacteria can engage in epic microscopic battles.

[5:38] John Dennehy studies the evolution of viruses that attack bacteria at Queens College.

John J. Dennehy: [5:43] Experimental evolution is where we can take an organism and evolve it so that we can actually observe the effects of evolution in real time.

[5:53] In the lab we design experiments to test hypotheses that we have about how viruses evolve. Much of our work here from day to day is trying to figure out exactly how to test those hypotheses.

[6:10] The end product of what we produce is usually a manuscript describing some result. Usually it takes even years to come up with that result. One of the most important skills that I use as a biologist is the ability to write well and to communicate my ideas.

Flora Lichtman: [6:28] Writing well is fundamental to the job, Dennehy says, but so is visualizing data.

John Dennehy: [6:33] When we produce the results of our data, we often look at them in a graphical form. This very much helps me. I'm a very visual thinker. To determine a relationship between multiple complex variables, it's very helpful to look at them graphically. If you can see the picture you can determine trends that you might not have been aware of if you're just looking at a series of numbers.

Flora Lichtman: [6:59] One of the reasons viruses are powerful is because they evolve so fast. From a biological point of view that's also partly why they're interesting. They give scientists an opportunity to study evolution in real time.

John Dennehy: [7:13] One of the issues that we face is that there are continually new viruses arising to infect human population. HIV being a primary example, but there are plenty of others that are threatening to invade human populations. While we will continually face viruses, there is an amazing amount of creativity in humans that should allow us to continue to confront viruses and bacteria in the future.

Flora Lichtman: [7:47] In this video we've talked a lot about evolution in terms of viruses and bacteria, but there are certain ingredients that are required for evolution at any scale. Dr. Pigliucci sums it up.

Massimo Pigliucci: [7:58] The basic idea is that you need a certain number of fundamental ingredients. You need variation. You need a population of organisms to be different from each other, otherwise it cannot be selection. You need that variation to be heritable. There has to be a correlation between the way the parents look and behave and the way in which the offspring looks and behaves. Usually that correlation, of course is through genetic inheritance.

[8:25] If you have limited resources, variation in the population, that variation is inherited, so what you have now is that the organisms that have the best variance, that are more appropriate for whatever the environment happens to be, are the ones that are more likely to pass on their genes to the next generation. That's basically the formulation of the theory of evolution. It is very simple. It's surprisingly simple, even though it took a lot of time to articulate the idea in terms of empirical evidence.

[8:53] Darwin referred to the origin of species famously as one long argument. The actual structure of the argument is very short. It takes a lot of time to provide the evidence for it.

[9:03] [music]

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