What can plants teach us about a pandemic?

By Heidi Happonen

Lynn Ketchum photo


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At the start of the year, the United Nations declared 2020 the International Year of Plant Health.

"Fantastic!" we thought. "What a great opportunity for us to share our amazing stories of plant research. We have some of the top plant breeders and scientists in the nation, if not the world, doing amazing internationally collaborative work."

"It could even be a theme for the magazine," one person said in a late winter editorial meeting.

Enter COVID-19. In a matter of weeks, the entire planet became singularly focused on human health—and for very good reason. Maybe plant health would have to sit on the backurner.

Of course, plants get viruses, too. And considering there are nearly 400,000 known plant species in the world, the sheer magnitude of research in plant virology must have something to show us that could potentially shed light on our current crisis.

Visiting with a handful of the College's top plant scientists, our hunch proved to not only be true, but to underscore one of the most compelling strengths of our University system: interdisciplinary collaboration.

Take, for example, the work of Melodie Putnam, director of OSU's Plant Clinic.

The Plant Clinic has been described by some as the "Center for Disease Control (CDC) of plants." As its director, Putnam specializes in the diagnosis of diseases and disorders in plants.

"We solve mysteries," Putnam said, summarizing their work. "When commercial growers, or the people who work for them have problems with their plants, and they don't know what the problem is, they send the plants to us."

Associated with the National Plant Diagnostic Network, the OSU Plant Clinic is home to catalogues of diagnostic information and disease data that are continually mined for epidemiological information.

This clearinghouse of data is used to identify trends to help predict the behavior of pathogens. Hearing Putnam talk about the Plant Clinic, one can't help but see similarities between her work with plants and current conversations dominating the public sphere around our evolving understanding of the behavior of COVID-19.

We wondered if in fact there were conversations happening with scientists who studied different species of both plants and animals and how pathogens interact with them.

Enter Dr. Valerian Dolja, a professor in the Department of Botany and Plant Pathology who focuses on plant cell biology,

Previous: Melodie Putnam, director of the OSU Plant Clinic looks in on tissue cultured plants.

Right: Researchers diagnose disease on a blueberry plant sent to the OSU Plant Clinic.


Lynn Ketchum photo

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OSU Extension Communications photo

Valerian Dolja holding a plant in a greenhouse several years ago.

virology and biotechnology. This includes comparative genomics, and the evolution of viruses.

Seizing the opportunity to relate his classes to current events, Dolja is already teaching courses that explore how plants could potentially produce a vaccine for viruses such as COVID-19.

"We use real experiences with plant biotechnology so that students can learn about the virus with the goal to unlock the possibility of designing ways to make plants produce a vaccine."

"Right now," Dolja added "it's just amazing what's going on. There's a flood of new viruses being identified. Now the goal is to understand all of that. And the view of how we understand the virus world is changing. Until recently, we have lacked a comprehensive understanding of the virus world."

But now that is all changing. For the first time, virologists with specialties across species—humans, animals and plants, and microbes alike, are coming up with a unifying system of all viruses such as polio, foot and mouth disease, herpes, influenza, Ebola, HIV, and others—were studied subsequent to their emergence in humans.

Viruses are now being studied in all kinds of environments and organisms, including animal viruses prior to their potential transfer and infection in humans. So, there are vastly more viruses to study within a newly emerging taxonomic system that is based on four distinct realms, increasing our ability to make connections between virus groups, which

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will help to understand their long- and short-term evolution.

While theoretical in nature, it is based on science in viral taxonomy—the process of identifying viruses and placing them into a "taxa" or particular species using a common system.

Dolja further explained the unique nature of viruses and why it has been historically such a fragmented process to understand how they behave across plants, humans, and animals.

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Wait, what?

Viruses are microscopic parasites. Unlike other biological species, they cannot thrive and reproduce outside of a host body.

According to a 2008 Scientific American article titled "Are viruses alive?" the author summarizes viruses as being in the "gray area between living and nonliving."

based on data that compares genomes, analyzing deeply all of the known viruses.

In a paper recently accepted for publication by Nature Microbiology, Dolja and peers were able to double the number of all known RNA viruses from the study of just 10 liters of water in the East China Sea. The significance of this is that our ability to detect, define, categorize and understand seemingly unrelated viruses is rapidly evolving.

"It's a real revolution in virology, the patchwork of isolated virus families found in all kinds of organisms is now replaced by a unified, evolution-based taxonomy including the entire virus world," Dolja noted. "Better yet, this 'megataxonomy' proposed in our recent paper published by Microbiology and Molecular Biology Review is now accepted by the International Committee for Taxonomy of Viruses and an entire virology community."

Historically, viruses were studied only when they were found to be infecting a host. The first virus was detected 130 years ago—a plant virus found in tobacco. Most other viruses affecting humans—

"We've moved from knowing a few hundred viruses to tens of thousands of viruses," Dolja added.

Thinking about the emerging classification of viruses across all species they infect begs the question: How prevalent is horizontal virus transfer between different species? We know bat viruses can infect humans, but can plant viruses? Could a salad infected with a virus spread that virus to a human that ate it?

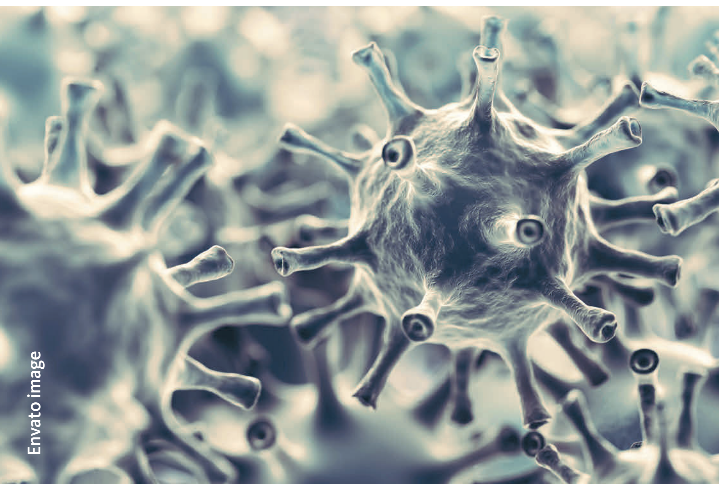
With the patience of a professor who has taught countless students over many years, Dr. Dolja replied:

"Yes and no."

The majority of plant viruses that are affecting agriculture originated from animal viruses. Some of them are capable of infecting both insects and plants. The evolution of those viruses can be traced back to invertebrates such as shrimp and mollusks from 500 million years ago. Today, for example, an aphid that feeds on a plant may acquire and transmit a virus to the next plant. This is what is known as ‘vector transmission’ and accounts for much of the spread of plant viruses in nature and agriculture.

So, while theoretically it is conceivable that an aphid could infect a crop that is then eaten by a pig that is then eaten by a human, there has yet to be any known transfer of a plant virus to a human.

Bats, on the other hand, are an ideal breeding ground for viruses to spread, mutate, and evolve. Living in densely populated dark places, viruses can move



3D Illustration of a Coronavirus.

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easily throughout a bat colony. As more bats live in urban areas or as humans increasingly encroach on bat habitats, the spread of those viruses from bats to humans is inevitable.

“This is where I think we really lucked out with the COVID-19 virus,” Dolja said. “There are other transmittable viruses, like bird flu, with an 80% mortality rate. Imagine if those viruses evolved to be as easily spread as COVID-19.

Dolja went on to explain that this pandemic was our “practice round.”

“It’s only a matter of time before we see a virus with high mortality rates spread with the ease of COVID-19.”

And with that sobering thought, it seemed only fitting to seek out further understanding from one of OSU’s premier epidemiologists, Dr. Christopher Mundt. A professor in the Department of Botany and Plant Pathology, Mundt’s research in plant disease epidemiology has led to breeding disease-resistant crops and the development of strategies to increase the durability of host plant resistance to pathogens.

Specifically, Dr. Mundt is an expert in the spread of disease.

His work began nearly 20 years ago, while teaching an advanced epidemiology class using classic plant pathology texts. One day he had what he describes as an epiphany and decided all those texts were “nonsense.”

He was able to secure grant funding to reexamine pathogens with long-distance dispersal. And to do that, he looked across different species, including animal systems and the West Nile virus.

“When the West Nile Virus moved from New York to the West Coast in 1999, the medical industry was shocked at how fast it was moving. Based on our modeling, I looked at it and said, that’s exactly what I’d expect.”

As more integration and cross-disciplinary research evolves around epidemiology, similar to how it is with virology, Mundt is finding opportunities to bring people together who are studying different systems.

In Oregon, he is working with wheat stripe rust, the number one disease on wheat in the Pacific Northwest. Because he has old pathogens stored in liquid nitrogen and maintains seed stocks of antiquated wheat varieties, he can do “real world” experiments in addition to computer modeling.

He also works with researchers at the University of Warwick in the United Kingdom, which is deeply involved in foot and mouth disease.

Because that disease wreaked such havoc and devastation on the United Kingdom’s cattle industry in the early 2000s—ending in the slaughter of nearly four million head of cattle—Mundt noted that they have reliable theoretical modelers and an amazing set of data in terms of where the epidemic was and what happened when they tried to control it.

Another partnership includes the study of viral disease spread by insects with an avian intermediary in both livestock and humans at Kansas State University.

Still another is with North Carolina State; taking a deep dive in Sudden Oak Death disease which primarily impacts California and Oregon.

“Biologically, these things are entirely different. Everyone assumed that there should be nothing in common. But, in fact, they follow very similar patterns in terms of spread.”

The speed of spread is measured by its R0 (or R-Naught) which indicates how contagious an infectious disease is.

“Everyone gets scared when they hear COVID-19 has an R-Naught of 2.5. But wheat stripe rust has an R-Naught of 70 or even greater.”

With a higher R-Naught, timing is everything, according to Mundt.

“Once you see a bunch of cases, it’s already too late to get it under control.”

He went on to explain how when you have an epidemic that’s spreading fast, the infections that happen in those first few days can set the trajectory of the lifecycle.

Chris Mundt, a plant pathologist at Oregon State University, looks at a diseased leaf of wheat at a field day at OSU's Hyslop Farm.

For example, with wheat stripe rust, the infections that happen in the first three days account for 85% of the total number of infections for the next 60-day period.

"If you don't jump on things quickly, you'll never get ahead of it without something like a fungicide for plants or a vaccine for humans."

Mundt echoed Dolja's description of the current pandemic as our "practice run."

"One of the things we'll get from this experience is some additional data about what happened, in addition to what we already know from the 1918 epidemic of influenza."

In the plant world, Mundt noted, we have the ability to go out and run experiments and try to make comparisons with different systems. We can conduct experiments that are not possible with humans.

"We've been looking at data for individual diseases, but now we're bringing it all together. Similar to what climate modelers do, we examine three or four different models, using data for different diseases of different origin."

Applying this work across different systems, improves understanding of pathogen behavior generally.

"What we're all realizing is that there's so much to be gained working across traditional disciplines. I've been amazed that everyone has been going after the same thing in different systems. Now it seems there is much more of an effort to work together."

So, while plants are not people and viruses are not technically "alive", there are certainly scientific principles and critical insights being discovered in how we manage and share disease data.

The OSU Plant Clinic already houses data and information on countless viral pathogens. Connecting that to the emerging interdisciplinary understanding of previously unrelatable viruses across a defined taxonomic system deepens our understanding of that data. And when we are able to study the spread across multiple systems, including animal and human systems, our understanding of pathogen evolution strengthens, and allows us to begin constructing better defense strategies.

If COVID-19 was in fact our pandemic scrimmage, it will require an interdisciplinary approach to truly prepare us for game time.