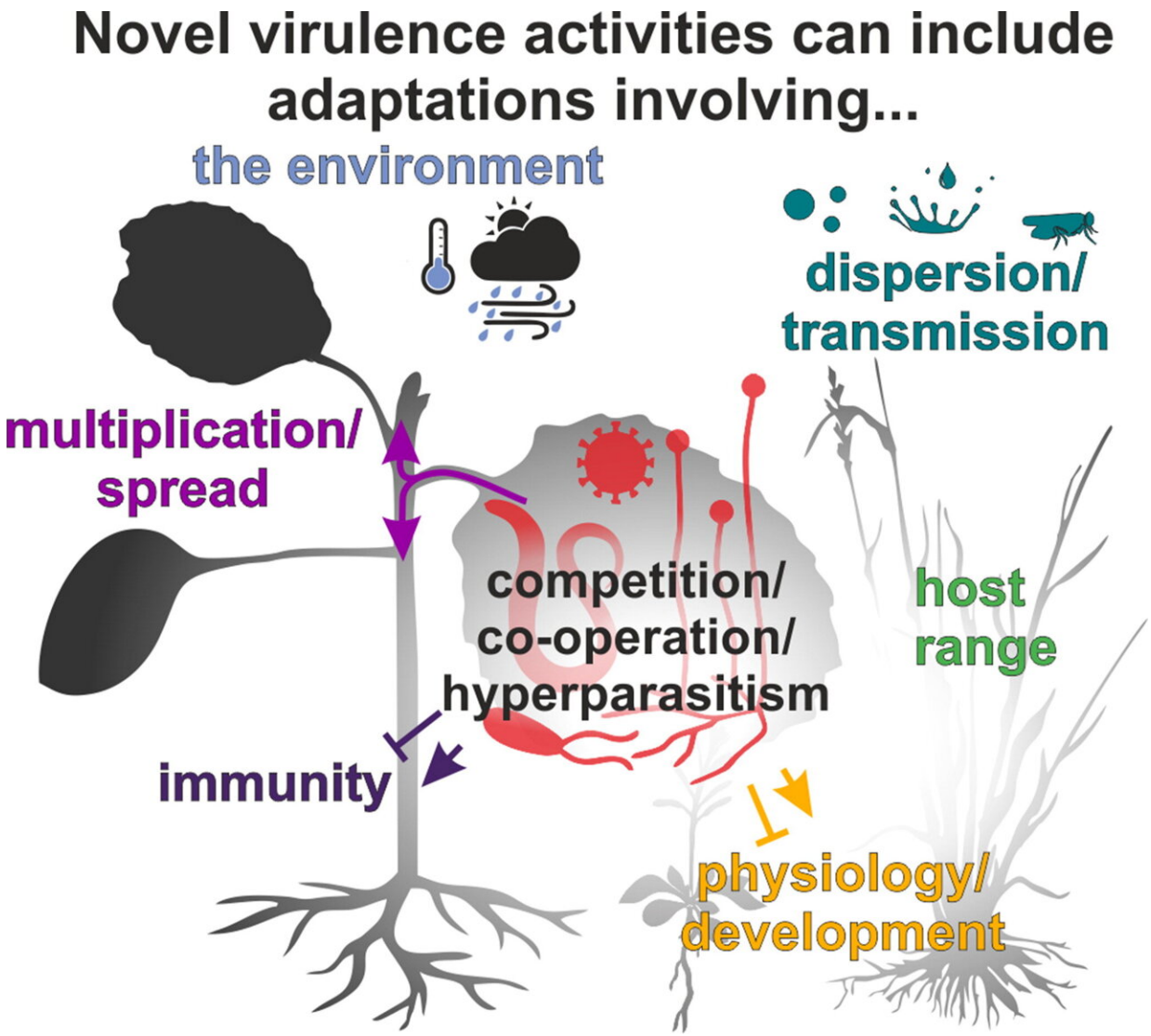
How do pathogens evolve novel virulence activities, and why does it matter?

September 7 2021



Novel virulence activities can include adaptations that alter how pathogens interact with the host immune system (dark purple) or with host physiology and

development (orange), the ability to multiply and spread within the host (light purple), how they disperse and are transmitted to other hosts (turquoise), their host range (including host expansions and host jumps, green), how they interact with the environment (blue), and how they interact with other pathogenic and nonpathogenic microorganisms (red). Credit: Soledad Sacristán, Erica M. Goss, and Sebastian Eves-van den Akker

Understanding how pathogens evolve is a fundamental component of learning how to protect ourselves and our world from pests and diseases. Yet we are constantly underestimating pathogen evolution, such as in the case of the COVID-19 pandemic, which some believed had been conquered until the arrival of the Delta variant. Similarly, we are often a step or two behind plant pathogens, which is why the question "How do pathogens evolve novel virulence activities?" was voted by scientists in the molecular plant-microbe interactions field as one of their Top 10 Unanswered Questions and explored in a review article recently published in the *MPMI* journal.

"Some people think that this is an old question and that we already have the answers," said Soledad Sacristán, one of the authors of review article. "However, the more we know, the more we see how many different paths or strategies that pathogens use overcome our efforts to control them. In our combat against pathogens, we are still far from winning."

A major consideration in considering pathogenic evolution is the larger world: Climate change and global trade result in dramatic alterations in the geographic distribution and spread of pathogens. These global changes can favor the emergence and reemergence of diseases and lead to the spread of aggressive epidemics. These changes make it even more important for scientists to understand how pathogens adapt to changing conditions.

"We know a fair amount about the mechanisms of pathogen adaptation to particular host immune responses, such as pathogens overcoming plant resistance that relies on a single gene," said Erica Goss, another author. "However, other aspects of pathogen adaptation with more complex genetics are less studied."

For example, we still don't fully understand the genetic changes required for a pathogen to switch from one host to another, in a move scientists call "a host jump," nor do we understand how, once a pathogen overcomes the first defenses of a plant, it becomes more or less deadly to the plant and more or less able to spread from one plant to another.

The good news is scientists have better tools than ever, thanks to the development of "big data" technologies and computer programs that can handle and process such data. These tools have allowed scientists to discover that dramatic events such as hybridization between pathogen species can result in genome rearrangements that lead to rapid evolution of virulence on new host plants. Genome sequencing has also made it possible for scientists to discover that gene content in bacterial pathogen chromosomes is highly dynamic and likely responsible for host range.

"How do pathogens evolve novel virulence activities?" is a large question that includes many smaller questions—and the answers discovered often bring even more questions. However, scientists continue their quest to find the answers as they can help in the design of more efficient strategies to control plant diseases.

"Combining sources of resistance that require very different mechanisms of evolution to overcome, or that cause a loss of the efficiency of other functions, are likely to be more robust in the field. As we learn more about how pathogens evolve virulence, we can better understand which pathogens are greater risks for overcoming host resistance," explained Sebastian Eves-van den Akker, the third author involved in this review.

"How Do Pathogens Evolve Novel Virulence Activities?" is part of the Top 10 Unanswered Questions in *MPMI* invited review series, which explores the big, unanswered questions in the field today.

More information: Soledad Sacristán et al, How Do Pathogens Evolve Novel Virulence Activities?, *Molecular Plant-Microbe Interactions* (2021). DOI: 10.1094/MPMI-09-20-0258-IA

Provided by American Phytopathological Society

Citation: How do pathogens evolve novel virulence activities, and why does it matter? (2021, September 7) retrieved 23 June 2024 from https://phys.org/news/2021-09-pathogens-evolve-virulence.html

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