Green Immunity – How Do Plants Fight Infection?

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For this year's lecture series, I am trying a different format of transcript. Rather than a long-form written document, which has been largely rendered obsolete by the ability to transcribe from the YouTube recording, this handout is a brief summary of the key topics in the lecture, together with some more extensive suggestions for extra reading. As ever, we would be delighted to hear your thoughts on this new approach!

Look around you. It's a fair bet that somewhere you will spot a green plant: a houseplant, garden border, or even an apple in the fruit bowl. We are surrounded by plants and yet we very rarely think of them as needing to fight off infections even though – just like us – plants are assaulted by an incessant wave of infectious bacteria, viruses, and fungi. And, just like us, they have evolved a remarkable immune system to help them repel these infectious invaders.

For many decades, the study of plant immunity lagged far behind that of animal immune systems. However, over the last thirty years or so, the power of genetic technology has lifted the lid on plant defences and revealed how astonishingly complex they can be.

The first major step in 'plant immunology' came in the 1940s, when the agricultural scientist Harold Henry Flor proposed the 'gene for gene' hypothesis. Working with the fungal pathogen flax rust, Flor realised that some strains of the fungus could infect some varieties of flax whilst others could not. But this relationship varied – a fungal strain that could infect flax variety A might not cause disease on variety B, whereas a different strain of the fungus might show the opposite pattern. Flor proposed that this was due to a gene product (such as a protein) in the fungus being recognised by another gene product in the flax and thereby triggering an immune response to fight off the infection.

Flor was correct, but it would take another 50 years before technological advances enabled plant scientists to demonstrate the molecular basis of this process by identifying the specific proteins involved. When they did so, they revealed a remarkable similarity with animal immunity. In both cases, proteins produced by the pathogen are bound by a cognate receptor in the host species, which triggers a series of gene expression events to ramp up defences. In both animals and plants, a key line of defence is also cellular suicide, or apoptosis – a process in which infected host cells kill themselves in order to prevent the infection from spreading.

But plants also engage some remarkable immune responses that have no known parallels in animal immunity. For instance, they are able to release volatile signals that warn neighbouring plants of impending infection. They can communicate via underground fungal networks, called mycorrhizae, enabling other plants growing at considerable distances to engage immune processes ahead of a spreading disease. And they can 'learn' from a narrow escape, bolstering their own defences after exposure to a pathogen in order to make secondary infections less likely.

In recent decades, the power of genetic modification has highlighted the massive potential of plants to tackle some of the major challenges of the 21st century. Plants have been genetically modified to grow in extreme climates, produce specific nutrients or vitamins, or remove toxins or allergens. But perhaps one of the most exciting untapped areas is the application of plant genetic technology to immunity. In the final part of this lecture, we will consider how plants can be used to bolster human immunity by producing antibodies or other therapeutic molecules. But we will also imagine a future in which more extensive application of these approaches could produce crops that are completely disease resistant, or even 'sentinel plants' that are primed to detect animal pathogens before they cause disease.

Perhaps the naturalist John Muir (1838-1914) was more accurate than he realised when he said, "*Nature in her green, tranquil woods can heal and soothe all afflictions*".

Key topic in the lecture	**Further reading**
Flor and the Gene-for-Gene hypothesis	From Gene-for-Gene to Resistosomes: Flor's Enduring Legacy | Molecular Plant-Microbe Interactions
Hypersensitive Response	Hypersensitive response; the centenary is upon us but how much do we know? | Journal of Experimental Botany | Oxford Academic
Salicylic Acid and Acquired Resistance	Systemic Acquired Resistance and Salicylic Acid: Past, Present, and Future | Molecular Plant-Microbe Interactions
Volatile Signals for Immunity	Microbe-induced plant volatiles - Sharifi - 2018 - New Phytologist - Wiley Online Library
Stomatal Closure During Infection	Stomata–pathogen interactions: over a century of research - ScienceDirect
Mycorrhizae as Signal Transporters	Plant–Plant Communication Through Common Mycorrhizal Networks - ScienceDirect
Plantibodies	Plantibody - Wikipedia
Pikobodies	The Sainsbury Laboratory | Pikobodies: A new hope for made-to-order…