

# Chloroplasts do more than photosynthesis: They're also a key player in plant immunity

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Experimental seedlings in the laboratory. UC Davis plant biologists have discovered how chloroplasts, responsible for photosynthesis in green plants, also play a key role in plant immunity to infections. Credit: Sasha Bakhter, UC Davis College of Biological Sciences

Scientists have long known that chloroplasts help plants turn the sun's

energy into food, but a new study, led by plant biologists at the University of California, Davis, shows that they are also essential for plant immunity to viral and bacterial pathogens.

Chloroplasts are generally spherical, but a small percentage of them change their shape and send out tube-like projections called "stromules." First observed over a century ago, the biological function of stromules has remained enigmatic.

Previous studies have shown that [chloroplasts](#) produce more stromules when a plant detects an infection. Stromules aid in clustering chloroplasts around the nucleus and function as conduits to transport pro-defense signals from chloroplasts to the nucleus. Despite these findings, researchers have not been able to determine the role of stromules in immunity, as no genes involved with the formation of stromules have been identified.

In the new study, Savithamma Dinesh-Kumar, professor and chair in the Department of Plant Biology, graduate student Nathan Meier and colleagues have identified a key protein involved in stromule biogenesis during immunity. Their findings were [published](#) Oct. 25 in *Science Advances*.

## **A hidden player in immune defense**

In order to test the stromules' role in immunity, researchers need to switch them off and then observe how stromule-less plant cells fare when faced with a pathogen. However, without knowing which genes are involved with the creation of stromules, researchers have had no way to know which genes to switch off.

To overcome this roadblock, Dinesh-Kumar and his colleagues turned to kinesins, proteins that function as tiny motors that allow molecules and

organelles to move around a cell. This intracellular movement usually involves the cell's cytoskeleton, which is made up of two different types of fiber: large microtubules and smaller actin filaments.

The researchers wanted to investigate a type of kinesin that is unique to plants and capable of binding both microtubules and actin filaments. The researchers found that overexpression of one of these kinesins, KIS1, induced stromule formation in the absence of pathogen infection.

When the researchers manipulated tobacco and Arabidopsis plants so that they could not produce the KIS1 kinesin, they found that neither plant was able to form stromules, and their chloroplasts did not migrate toward the nucleus. This left the plants unable to defend themselves from introduced pathogens.

## **Secrets of chloroplast movement**

To disentangle the roles of microtubules and actin, the researchers engineered one set of KIS1 variants that could only bind to microtubules, and another that could only bind to actin. Expression of these variants in tobacco showed that KIS1 needs to bind to microtubules in order for chloroplasts to form stromules, but in order for chloroplasts to move toward the nucleus, it must also bind to actin.

The team also wanted to know how stromules fit into the bigger picture of [plant immunity](#). By using [genetic manipulation](#) to switch different immune signals off, they found that stromule formation is triggered by molecular signaling and that an intact immune signaling system is needed in order for stromules to form.

"If we remove any of the known immune signaling genes, the chloroplasts lose the ability to make stromules, which suggests that these structures are an integral part of the immune signaling pathways that

activate defense," said Dinesh-Kumar.

## New light on plant immunity

This study is the first evidence of a plant kinesin directly involved in plant immunity. It's also the first time that scientists have identified a gene—KIS1—involved in chloroplast stromule biogenesis, which opens the door to understanding the role of chloroplast stromules and why chloroplasts cluster around the nucleus during plant [immune defense](#).

"If we can better understand at the [cellular level](#) how organelles like chloroplasts help cells to defend themselves, we could help to engineer resistance to the pathogen," Dinesh-Kumar said.

**More information:** Nathan Meier et al, Calponin-homology domain containing kinesin, KIS1, regulates chloroplast stromule formation and immunity, *Science Advances* (2023). [DOI: 10.1126/sciadv.adi7407](https://doi.org/10.1126/sciadv.adi7407).  
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