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Cracking the Code Between Bacteria and Grapes

By John Zakour and Linda McCandless

GENEVA, NY: Imagine armies of disease-causing bacteria that communicate with each other. Imagine plants-like tobacco-that sense the foreign invaders and respond by inducing cell death. Imagine plants-like grapes-that can't and die. Imagine scientists working in lab and vineyard to give grapes an advantage by enhancing their ability to "listen," or inhibiting the bacteria's ability to "talk" to each other.

Don't think science fiction or a project from the defense department.

Think cutting-edge biology in the 21st century.

Researchers from China, Hobart and William Smith Colleges, and Cornell University's New York State Agricultural Experiment Station in Geneva, are studying types of bacteria called *Agrobacterium* that have the ability to signal each other. The scientists want to use these signals to control interactions with plants.

"The real purpose behind the work is to identify processes that are used by bacteria when they interact with plants, and then enhance or inhibit the communication, depending on which plant is hosting the invading bacterium," says plant pathologist Thomas Burr, at the Experiment Station.

The research team has been studying the interactions between the pathogenic bacterium *Agrobacterium vitis* and two plants: its natural host-grape-and tobacco. Tobacco is successful at evading infection by *A. vitis*, but grape is not. The bacterium causes two diseases in grape: necrosis, or lesions, on the roots, and crown gall, or tumor-like growths, on the vines. Both diseases reduce the productivity of the grapevine and eventually cause the plant to die.

"Grape is an important crop plant in wine-producing areas, including New York, so the control of *A. vitis* infection is of great interest," says Sigrid Carle, the William Smith biologist

Agrobacterium vitis strains cause a hypersensitive response when infiltrated into tobacco leaf panels, whereas *A. tumefaciens* strains, such as C58, do not. CREDIT: NYSAES/Cornell

Crown gall commonly develops on the lower trunks of grapevines (arrow) that are injured by exposure to cold temperatures. CREDIT: NYSAES/Cornell

Researcher Michele Holden, at the NYS Agricultural Experiment Station, examines also working on the problem. "The team is interested in learning as much as possible about the infection process, and then, with that knowledge, being able to genetically engineer a defense response to *A. vitis* in grape that would protect the it from infection," she says.

transgenic grapes for evidence of disease resistance. CREDIT: F. Hickey/NYSAES/Cornell

Plant pathologists at the Experiment Station Desen Zheng, Guixia Hao, Michele Holden, Cheryle Reid, Yaxin Li, and Hongsheng Zhang from Nanjing Agricultural University in China are also working on the project. Their first paper on quorum-sensing in *A. vitis* was published this summer in the journal "Molecular Plant-Microbe Interactions."

"We have determined that *A. vitis*, like some other bacteria, produces signal molecules called autoinducers, or bacterial pheromones, that allow the bacterial cells to communicate with each other when they are together in high numbers," says Burr. Microbiologists call the communication process "quorum-sensing." The chemical signals are detected by surrounding bacterial cells and result in selective gene expression.

Other Cornell scientists have also helped with the work. "We are fortunate to have scientists in Ithaca like Stephen Winans and Anatol Eberhard who are world-renowned in the area of quorum-sensing," said Burr. "Eberhard first discovered autoinducers that regulate light production by marine bacteria. He has been instrumental in helping identify specific compounds produced by *A. vitis* ."

In the case of grapes, bacterial genes regulated by quorum-sensing result in necrosis of the roots. A different autoinducer in *Agrobacterium* regulates the transfer of pathogenicity associated genes between bacterial cells, thus making a non-pathogen into a crown gall pathogen. In tobacco, quorum-sensing regulates genes in *A vitis* that when expressed cause a hypersensitive response (HR) that scientists believe is related to disease defense.

A HR-responsive plant senses the foreign invader, and responds by inducing cell death. Plant cells in the locality of the bacteria, as well as the bacterium itself dies, but the plant lives, and overcomes the invasion. Biologists want to be able to induce the same self-defense response in grape and other commercial crops.

"Some strains of *A. vitis* do not cause crown gall but, in fact, prevent crown gall from forming on grape," said Burr. The team recently discovered a single quorum-sensing gene in a strain called F2/5. When mutated, it leads to total loss of the necrosis, HR, and biocontrol phenotypes. "This suggests that the underlying mechanisms associated with these responses are related. It offers an excellent system for studying important plant-bacterial interactions," said Burr.

Burr and Carle's team is working on different methods to genetically modify *A vitis* to help regulate the communication process. Their research has shown that modifying certain genes in *A vitis* can potentially inhibit or enhance the communication process, which offers exciting possibilities for the future. In addition to being able to affect how plants defend themselves against bacterial diseases, scientists and growers hope to be able to use quorum-sensing to inhibit the growth of detrimental bacteria and encourage the process of biological control

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