Profile of Xinnian Dong

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A pioneer in the field of molecular plant pathology, Xinnian Dong has elucidated multiple plant immune mechanisms over the past three decades. Her research has advanced understanding of the processes by which an entire plant may become resistant to a pathogen when only one part of it is infected. Dong and her colleagues also determined that daily cycles affect plant immune responses, and that plant DNA damage repair machinery plays a fundamental role in immunity. Because certain plant compounds, such as the hormone salicylic acid, can benefit the health of both plants and people, her research holds promise for improving agricultural crop yields and developing treatments for human diseases. In recognition of these and other achievements, Dong was elected to the National Academy of Sciences in 2012.

Family of Scholars

Dong was born in 1959 in Wuhan, Hubei Province, China. She grew up during the Cultural Revolution, when many schools and universities throughout China were closed. Dong's parents encouraged the intellectual pursuits of their children. Her father, Fureng Dong, was an economist with a broad interest in science. Her mother, Ainian Liu, was an ophthalmologist. "My parents were my earliest mentors," Dong says. "The question that my father asked me the most was, 'What do you think?'" Her younger brother, Xinzhong Dong, was yet another scholar in the family. He is now a neuroscientist at Johns Hopkins University.

Science books published before the revolution also influenced Dong. To the delight of her students at Duke University, she sometimes uses the children's book series *The Magic School Bus* (1) in her teachings. She explains, "This book brings back both their and my childhood memories, and reminds us of the time when our curiosity about the world was still intact."

Mesmerized by Molecular Genetics

Dong entered her parents' alma mater, Wuhan University, in 1978, the year after it reopened following the revolution. She credits *Molecular Genetics: An Introductory Narrative* (2) with affirming her decision to become a scientist. "I was completely mesmerized by the early molecular genetic experiments described in this book," she says. "They were so simple in logic, yet absolutely brilliant. I wanted to know how scientists came up with these ideas, and realized that the best way to find out was to become a scientist myself."

Dong received her bachelor's degree from Wuhan University's department of microbiology in 1982. From 1983 to 1988, Dong studied molecular biology at Northwestern University, where her graduate advisor was Robert Rownd. After earning her doctoral degree, she did her postdoctoral fellowship from 1988 to 1991 at Harvard Medical School, with Fred Ausubel as her advisor. Dong says that Ausubel, whose work concerns plant host and microbe interactions, is the mentor who had the biggest influence on her career. It was in his laboratory at Massachusetts General Hospital that she began to study plant immune mechanisms.

Arabidopsis as a Model for Plant Immunity

While she was at Harvard, Dong published one of the earliest papers describing the plant pathogen system of *Arabidopsis thaliana* and the bacteria *Pseudomonas syringae* (3). *Arabidopsis* was the first plant to have its genome sequenced, and is a popular model species for understanding the molecular biology of many plant traits.

In 1992, Dong became an assistant professor in the department of botany at Duke University, where she is now a professor in the department of biology and a Howard Hughes Medical Institute–Gordon and Betty Moore Foundation investigator. Her husband, Xiao-fan Wang joined the Duke faculty at the same time and, is a professor in the university's school of medicine. One of her first experiments at Duke was to use an antimicrobial gene identified in the earlier work to screen for genetic mutants involved in the regulation of plant pathogen-related genes (4). These genes exhibit elevated expression when levels of salicylic acid—the active ingredient in aspirin—increase in plants as part of their defense response. In what she says was one of the most exciting experiments of her career, she and her team discovered a genetic mutant that is highly susceptible to many different pathogens (5). This mutant, which compromises a host plant's ability to respond to attacks, was later linked to the gene *NPR1* (6). Dong has been studying the function of this gene ever since.

Xinnian Dong. Image courtesy of Guoyong Xu (Duke University, Durham, NC).

NPR1 as a Master Immune Regulator

Dong and her team discovered that when a plant is under attack, NPR1 reduced to a monomeric form, allowing it to bond chemically to other molecules and to activate gene expression (7). A subsequent study determined that release of NPR1 in its monomeric form is dependent upon the activity of antioxidant-like proteins known as thioredoxins (8). Proteasome-mediated degradation of NPR1 not only prevents untimely gene activation but also plays a critical role in stimulating gene expression during plant immune responses (9). This helps to ensure that responses are effective only against invading pathogens, and are not harmful to the plant itself.

The researchers next identified NPR3 and NPR4 as receptors for salicylic acid (10). The salicylic acid concentration-dependent degradation of NPR1 supports the transient nature of immune induction and triggers programmed cell death in local infected cells.

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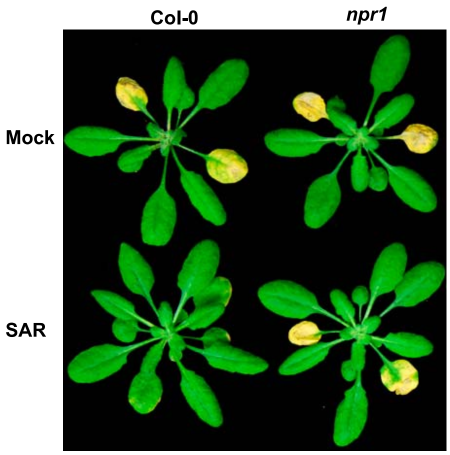

NPR1 is an immune regulator of systemic acquired resistance (SAR). Both wild-type (Col-0) and the *npr1* mutant *Arabidopsis* were inoculated with *P. syringae* after treatment with H_2O (mock) or an inducer of SAR. SAR induction in wild-type plants prevented infection by the pathogen, whereas in the NPR1 mutant, induction of resistance was compromised. Image courtesy of Raul Zavaliev (Duke University, Durham, NC).

This, and other plant immune mechanisms revealed by Dong and her team (11–13) help to explain how plants benefit from systemic acquired resistance, which usually occurs several days after the initial pathogen attack and protects the plant against secondary infection.

Circadian Clock and Plant Immunity

In a functional genomic study, Dong and her laboratory members discovered that *Arabidopsis* defense genes guarding against the pathogen *Hyaloperonospora* are expressed in the morning, even when the pathogen is absent (14). She says, "We found that this allows anticipation of infection at a time of day when conditions are the most favorable for pathogens."

A more recent study found that yet another biological clock, one that relies upon the rise and fall of reactive oxygen molecules formed as natural byproducts of metabolism, works with the plant's circadian clock to support immunity (15). NPR1 links the two clocks, sensing changes in a plant's metabolic rhythm that result from pathogen challenges and reinforcing the circadian clock. The discovery helps to explain why plants and other organisms have both clocks, and how the two clocks are connected.

DNA Damage Repair and Plant Defenses

Dong says, "Immunity is a double-edged sword: You cannot live without it, but you cannot have too much of it." DNA damage is like this, as well. Normally, such damage is detrimental to living organisms. Dong and her team however, demonstrated that it could also serve as a signal to promote immune responses in plants (16). Once activated, DNA damage repair machinery may facilitate gene expression as well as help to maintain genome stability. Because salicylic acid can lead to activation of this repair system in plants, Dong wonders whether it has the same effect in animal cells. If so, that could help to explain the various human health benefits associated with long-term use of aspirin.

Dong's Inaugural Article identifies two transcription factors, NTL9 and CHE, which are required for the biosynthesis of salicylic acid during different immune responses (17). Regulation of the biosynthesis occurs in a spatial and temporal manner. Dong's study shows that this is accomplished by differential engagements of these two, as well as three other previously identified, transcription factors. Because CHE is a component of the plant circadian clock, the study once again ties immunity to this clock.

Intensely Curious

Dong recalls how, as a child, she related to a cartoon character named "Question Mark," who was always curious and observant. That driving curiosity, which Dong now infuses in her students and colleagues, is evident as she describes her current research:

"We discovered that cell cycle regulators and DNA damage repair machinery play important roles in plant defense. We are currently trying to elucidate the specific mechanisms. The main question we are interested in addressing is why the DNA damage repair machinery is engaged in the regulation of defense gene transcription. Is this engagement important for preventing transcription-associated DNA damage? Is the activation of the DNA repair machinery responsible for the evolution of new immune receptor genes?"

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