Mathematical physics reveal nature's formula for survival (w/ Video)

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(Phys.org) -- The vascular system of a leaf provides its structure and delivers its nutrients. When you light up that vascular structure with some fluorescent dye and view it using time-lapse photography, details begin to emerge that reveal nature's mathematical formula for survival.

When it comes to optimizing form with function, it's tough to beat Mother Nature.

"If you begin looking at them in any degree of detail, you will see all of those beautiful arrangements of impinging angles and where the big veins meet the little veins and how well they are arranged," says Marcelo Magnasco, a mathematical physicist at Rockefeller University in New York.

With support from the National Science Foundation (NSF), Magnasco and his colleague, physicist Eleni Katifori, analyze the architecture of leaves by finding geometric patterns that link biological structure to function.

They study a specific vascular pattern of loops within loops that is found in many leaves going down to the microscopic level. It's a pattern that can neutralize the effect of a wound to the leaf, such as a hole in its main vein. Nutrients bypass the hole and the leaf remains completely intact.

"Something that looks pretty looks pretty for a really good reason. It has a well defined and elegant function. We can scan the leaves at extremely high resolution and reconstruct every single little piece of vein, who talks to who, who is connected to who and so forth," explains Magnasco.

Magnasco and Katifori digitally dissect the patterns, level by level. "It was very hard to get to a unique way of actually enumerating how they are ordered. Then we hit on the idea that what we should do is start at the very bottom, counting all of the individual little loops," recalls Magnasco.

"This research is a unique interdisciplinary partnership in which physics is used to address biological problems, and it is our belief that the mathematical and physical sciences will play a major role in biomedical research in this century," says Krastan Blagoev, director for the Physics of Living Systems program in NSF's Mathematical and Physical Sciences Directorate, which funded the research.

Magnasco says this research is a jumping off point for understanding other systems that branch and rejoin, including everything from river systems to neural networks and even malignant tumors. "When a tumor becomes malignant it vascularizes, so understanding all of this is extremely important for understanding how these things work," says Magnasco.

Provided by National Science Foundation

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