Scientists join forces to bring plant movement to light

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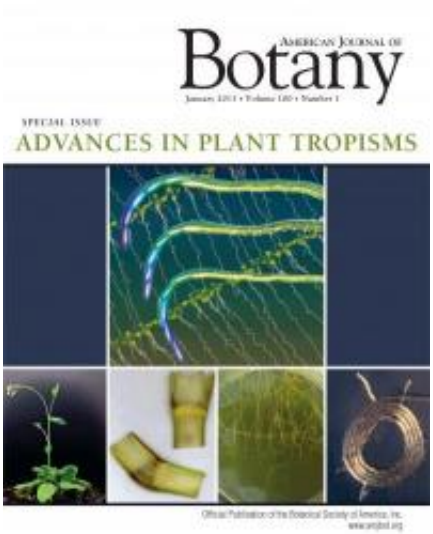

This is the *American Journal of Botany* cover of January 2013 Special Issue: Advances in Plant Tropisms. Credit: Images courtesy of multiple contributors

Elementary school students often learn that plants grow toward the light. This seems straightforward, but in reality, the genes and pathways that allow plants to grow and move in response to their environment are not fully understood. Leading plant scientists explore one of the most fundamental processes in plant biology—plant movement in response to light, water, and gravity—in a January Special Issue of the *American Journal of Botany*.

Plant movements, known as tropisms, are crucial for plant survival from

the second a plant germinates to how a plant positions its flowers for pollinators and seed dispersal. "They are basic processes that underlie all of plant physiology and growth," says Sarah Wyatt, Associate Professor in the Department of Environmental and Plant Biology at Ohio University. Plants adapt and acclimate to their surroundings using tropisms, including moving in response to light (phototropism), water (hydrotropism), and gravity (gravitropism).

To inspire cutting-edge research on plant tropisms, Sarah Wyatt and plant biologist John Kiss, Dean of the Graduate School at the University of Mississippi, co-edited the special issue and invited plants scientists worldwide to write 24 articles that advance and summarize the field. (Their introduction to the issue is available at http://www.amjbot.org/content/early/2013/01/01/ajb.1200591.full.pdf+html.) "Tremendous progress has been made in the field of tropism research in the past decade," comments Kiss. "This issue was an opportunity to bring the community together," adds Wyatt, "and highlight some truly incredible science that has been ongoing 'under the radar' if you will and often under difficult circumstances."

Research in outer space is just one difficult circumstance by which scientists study how plants move. Growing plants in space has become a reality. "The International Space Station is now complete and the U.S. is committed to its utilization until at least 2020," Kiss says. Food and replenishing breathing air are vital functions plants can play on the ISS, and space flight experiments help scientists understand basic mechanisms plants use to grow and move because of gravity, or lack thereof.

Back on Earth, work on gravity and other tropisms is important for understanding plant growth, development, and responses to changing climates. Basic tropistic mechanisms in response to water and light could also enhance agricultural practices, explains Kiss, since crop plants

experience environmental stressors like drought and overcrowding.

Tropisms have captured the interest of scientists for centuries. The way plants move can appear so eerily human that in the late 1700s and early 1800s, Dr. Erasmus Darwin, Charles Darwin's grandfather, predicted that plants have multiple brains that can communicate with muscles to tell plants how to grow.

From Erasmus and Charles Darwin to modern-day scientists and techniques, the biology of plant tropisms has come a long way. Some of the special issue articles review the history of plant tropisms to the present day, whereas others move the field forward through new research. New genetic and molecular tools, for example, are used to shed light on the mechanisms plants employ to respond to water and gravity. Many articles focus on the famous model organism in plant science, *Arabidopsis thaliana*. Other articles on gravitropism include work on cereal grasses important for agriculture as well as the aquatic-dwelling fern *Ceratopteris richardii*.

The issue kicks off with a broad review article about how roots revolve and bend, known as circumnutation. Vines that wrap around objects as thin as wooden stakes or as thick as tree trunks all use circumnutation to climb. Research on circumnutation in stems is common, points out Dr. Fernando Migliaccio of the Institute of Agro-Environmental and Forest Biology in Italy. But as in all plant sciences, rigorous work about what goes on below the surface of the soil is scarce, even though root behavior below ground could be essential for understanding how plants establish and survive in agricultural and natural settings.

Time-lapse photography has popularized the most famous tropism—phototropism, or how plants move toward light. Phototropism may be the most well-studied tropism, but one relatively unexplored area of phototropism is how plants grow and move in green light, as studied

by graduate student Yihai Wang and his advisor Kevin Folta at the University of Florida. Light becomes greener when it passes through nearby plants. A plant growing in a shady spot under a tree receives less sunlight, and it also receives different wavelengths of light that change its growth patterns. Scenarios like this happen every day in the natural world, explain Wang and Folta. "Oftentimes a plant cannot possibly compete by out-growing or over-reaching a neighbor, and it must adopt a new program of acclimation," they say. Wang and Folta explore new findings about how plant species use gene expression and physiology to cope and survive in green-enriched environments.

The special issue continues with articles tackling how gravitropism works. Recent discoveries of plant hormones and the proteins that transport them have reinvigorated scientists to investigate the pathways plants use to perceive gravity. Original research in this special issue begins to "untangle the complex interactions" of plant growth regulators like plant hormones, proteins, and organic compounds, explain Wyatt and Kiss.

Wyatt and Kiss hope to inspire young scientists to conduct research on the fundamental field of plant tropisms on Earth and in space. "Remember the seed in the Styrofoam cup: the roots go down and the plant goes up and nobody really knows how or why," quotes Wyatt of Robert Fulghum's *All I Really Need to Know I Learned in Kindergarten*. "This is the wonderment that is inherent in tropistic responses—-tropisms capture the imagination."

More information: Migliaccio, F., P. Tassone, and A. Fortunati. 2013. Circumnutation as an autonomous root movement in plants. American Journal of Botany 100(1): 4-13.

Wang, Y., and Folta, K.M. 2013. Green-light contributions to plant growth and development. American Journal of Botany 100(1): 70-78.

Wyatt, S.E., J.Z. Kiss. 2012. Plant tropisms: from Darwin to the international space station. American Journal of Botany 100(1): 1-3.

Wyatt, Sarah E. and John Z. Kiss. 2013. Plant tropisms: From Darwin to the International Space Station. American Journal of Botany 100(1): 1-3. DOI: 10.3732/ajb.1200591