Self-defense for Trees and Shrubs

Arboretum study aims to understand how plants adapt to pests and disease

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Unlike most animals, plants for the most part stay in one place for the duration of their lives. This leaves individual plants vulnerable to changes in the local environment, and especially unable to escape from natural enemies like herbivores, parasites, and pathogens. However, plants have evolved a wide array of defensive traits to resist attack. These include physical traits like spines, hairs, and waxy coatings and a wide variety of defensive chemicals manufactured and stored in plant tissues. These defenses can be highly effective at deterring predators and providing resistance to infection by bacterial or fungal pathogens. Plant defenses are vital to plant survival in the face of natural enemies, and coevolution between plants and their enemies is thought to be a major driver of the abundant plant diversity we see in nature. Understanding more about the evolution of plant defenses across temperate trees and shrubs is the primary goal of my research as a Katharine H. Putnam Fellow in Plant Science at the Arboretum.

Although many plants rely on defensive traits for survival, these mechanisms come with a cost. Investment in defenses diverts energy and nutrients away from other key plant functions, especially growth. The most commonly attacked plant organs are leaves which, as the interface for photosynthesis, produce the raw materials for new growth. Plants thus face a major trade-off between producing lots of new shoots and leaves that are poorly defended, or a smaller amount of well-defended tissues. This trade-off may explain major aspects of variation in plant physiology including growth rate among species, and the balance between growth and defense may be strongly influenced by both leaf habit and environmental conditions. In deciduous species and environments with shorter growing seasons, theory predicts that natural selection should favor the evolution of higher leaf productivity and lower defense, while in evergreen species and environments with longer growing seasons the opposite pattern should hold. While theory predicts both the trade-off between productivity and defense and the link to leaf habit and environmental conditions, little empirical research has thus far tested these relationships among species.

With its extensive collections of trees and shrubs from very different habitats growing under common conditions, the Arnold Arboretum offers an ideal setting for this kind of comparative physiology research, aided by the detailed provenance data available to relate findings back to native environmental conditions. My Putnam Fellowship research examines the leaf physiology of over 500 species belonging to 16 genera, quantifying both the investment in physical and chemical defenses of leaves as well as traits that drive leaf productivity and are predictive of plant growth rate. This includes plants common to the forests of New England (like oaks, maples, birches, and ashes), those familiar to gardeners and landscapers (like roses, rhododendrons, honeysuckles, and hollies), some of agricultural importance (like apples and stonefruits), and a large number of their exotic relatives from around the globe.

Leaves gathered from individual plants of these genera in the collections are being analyzed for structural composition, physical defenses, and phytochemistry, with special focus on nutrients and major classes of defensive compounds. Uniting analysis of these different aspects of leaf physiology will not only create a large body of empirical evidence on the balance between growth and defense. [Continued on page 9]
Education Fellowship and a pioneer of many of the new teacher-focused activities piloted this year.

The Arnold Arboretum offers a rich and ever-changing environment to teach children about life science, biodiversity, and natural phenomena. While improving access to the landscape, these training and outreach opportunities will provide help and encouragement for BPS teachers to integrate their experiences with plants and wildlife into their curricula, creating powerful connections between study in the field and study in the classroom. Through this new component to a longstanding and fruitful partnership, the Arboretum lays the groundwork for more students across Boston to discover the natural world in this landscape designed for learning.

Arnold Arboretum by Lisa Pearson
Arnold Arboretum by Lisa Pearson, Head of the Horticultural Library and Archives, showcases the institution’s history through images drawn from its extensive collection of historical photographs. A new volume in the long-running series Images of America, the book will be published in late March. Featuring more than 200 historical images of the Arboretum, its plants, and its personalities from the 1880s to the 1980s, it includes some of the earliest glimpses of the landscape as it transformed from Benjamin Bussey’s farm to Harvard University’s living museum of woody plants. Each image is accompanied by detailed descriptive text, making the book a valuable guide to enjoying and understanding the rich history of the Arnold Arboretum, its landscape, and the living collections.

Self-defense for Trees and Shrubs
(continued from page 7)
across temperate trees and shrubs, it will also shed light on the evolution of this balance. While different genera likely employ different defensive strategies, I expect that within each genus there will be a range of variation in defense investment among species, and that higher overall defense will be evolutionarily correlated with reductions in leaf productivity. Additionally, I predict that evolutionary transitions from evergreen to deciduous leaf habit will have favored the evolution of reductions in leaf defense, as will historical shifts into environments with shorter growing seasons that favor more productive leaves.

Unravelling the evolution of plant defense improves our understanding of a major driver of global plant diversity, and sheds new light on plant adaptation to environmental conditions. Through shifts in temperature, rainfall, and growing season length, we expect climate change to alter species interactions across the ranges of many plant species, in many cases increasing insect and disease outbreaks. Understanding how closely-related species have adapted historically to contrasting environments improves our ability to predict both the short-term capacity of individual species to tolerate changing environments as well as the long-term evolutionary responses of species to future conditions.

A Gift for Growing
(continued from page 6)
notes. “While explaining the science behind plant propagation and adding in his own personal anecdotes, it is obvious that Jack is just as enthusiastic about propagation now as he was when he first started at the Arboretum.” Retirement will also offer Jack more time to devote to his diverse hobbies, which include flying airplanes, rebuilding vintage motorcycles, and spending time outdoors. Jack calculates that he and the Dana Greenhouses team have propagated approximately 6,500 plants for the Arboretum collections—nearly half the Arboretum’s living accessions have entered the collections during his tenure.

“When I take walks through the Arboretum now, my favorite trees are like old friends, reminding me of the people who worked with me to collect seeds, take cuttings, and help them grow,” Jack observes. In addition to his impressive legacy of plants grown, propagated, and hybridized, Jack also created a legacy of care and devotion to the Arboretum’s plants and the people who work, study, and visit its landscape. He retires with the good fortune of knowing that the fruits of his labor will continue to flourish here and throughout the world of horticulture for generations to come.

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