The Marvelous Maples

Tracing origins of species diversity in the Arboretum's maple collection

Jacob Grossman, Putnam Research Fellow

When casually botanizing during a walk in the woods, we tend to simplify our observations, often at the level of the genus. And justly so: there are both superficial and profound differences between, for example, oaks (genus *Quercus*) and pines (*Pinus*). Yet a more focused look shows that there is a great deal of diversity within these genera, and that this diversity is of ecological consequence in our rapidly changing world. As a Katharine H. Putnam Postdoctoral Fellow at the Arnold, I have the good fortune of executing a research program of my particular choice and design for two years. In this case, my choice is to study maples (*Acer*) and my design is to explore the evolutionary context and ecological consequences of their biodiversity.

Local visitors to the Arboretum's maple collection may recognize a few familiar friends: dominant forest species like red (*Acer rubrum*) and sugar maple (*A. saccharum*); common urban trees such as silver maple (*A. saccharinum*) and box elder (*A. negundo*); and shade-tolerant understory acquaintances like the stripe-barked (*A. pensylvanicum*) and mountain maple (*A. spicatum*). These New England natives, along with three Western endemics, make up the North American maple flora: just nine species across the continent, compared, for instance, to more than 250 oak species. Yet a tour of the Arnold's maple collection, accredited by the Plant Collections Network of the American Public Gardens Association, will quickly evince the phenomenal biodiversity of the maple genus. For this unparalleled collection contains over 500 trees representing half of the roughly 130 maple species[1] described to date—the vast majority of which are native to East Asia. The proximity of five dozen maple species all growing in a common environment makes it possible for me to investigate the evolution and ecology of the genus.

The best estimates indicate that the modern maples split from their nearest relatives, the two-species Chinese genus of *Dipteronia* and, more distantly, the buckeyes (*Aesculus* spp.), beginning some sixty million years ago, in the middle of the Paleocene. From their origins in what is now central China, the trees that would become today's maples had begun to explore new environments. The breakdown of land bridges between North America and Eurasia ultimately gave rise to the disjunction, or separation, of the two realms' floras, and allowed for the development of distinctly New and Old World northern hemispheric species[2] such as the maples.

Jon Hetman

Putnam Fellow Jacob Grossman collecting branch samples from the Arboretum's Nationally Accredited maple (*Acer*) collection for his investigations of species diversity in the genus.

It is reasonable to assume that closely-related species will be more similar to each other. Maples show a strong family resemblance, or what biologists call phylogenetic conservativism—the tendency of traits to be retained in relatives. For instance, all maple leaves occur in "opposite" pairs across the stem, rather than alternately as in many other flowering plants. We can ask, then, whether particular species are still quite similar to their long-lost relatives across the disjuncture between North America and the maple biodiversity hotspot in East Asia. My earliest studies indicate that this is far from the case. In the ecologically important measurement of specific leaf area (a leaf's area divided by its dry weight), for example, closely related relatives are no more similar to each other than would be expected by chance. This finding of an absence of phylogenetic conservativism, which keeps cropping up as I survey additional morphological and physiological traits, suggests that some other factor causes even relatively closely related maples to differ.

This hidden factor might be the celebrated and infamous force of adaptive evolution—the capacity of populations to innovate and thrive in new environments. After all, maple evolution has taken place over many extreme fluctuations in climate, the formation of the continents as we know them, and the coincidental evolution of diverse plant competitors, microbial symbionts, and animal pollinators and predators. Perhaps the New World maples have adapted in order to thrive in their current range, developing traits that differ from those of their East Asian relatives.

To assess interpretations such as this one, I am making full use of the Arnold's maple collection, taking leaves and branches back to the lab to record a variety of measurements including drought and freezing vulnerability, leaf morphology, and wood density. My goal is to provide a clearer picture of how both family resemblance and adaptive innovation have shaped the biodiversity of the marvelous maple genus—and to use this information to predict how maples will respond to the warming and less predictable climates that will shape their fate in the millennia to come.

[1] Because what counts as a species is not always clear, these numbers are subject to change. By a different standard, the Arnold's maple collection includes 141 of the world's 230 described maple taxa—including varieties and subspecies.

[2] With the exception of *Acer laurinum* in Southeast Asia, maples have not successfully crossed, or even meaningfully approached, the equator.

Legacies

Remembering George Putnam (1926-2019)

Through six decades of leadership and philanthropy, George Putnam (Harvard AB49, MBA51, LLD85)—who passed away at 92 on March 25—left an indelible legacy across Boston, from championing public health and higher education to science and the arts. The former chairman of Putnam Investments received three degrees from Harvard including one in biochemistry, and stayed deeply involved with his alma mater through his life, serving on the Board of Overseers and later as Treasurer of the university.

Putnam's wide-ranging community interests also extended to horticulture and plant science at the Arnold Arboretum, where he created the institution's flagship opportunity for collections research. In 1998, Putnam made a $1 million gift to establish and endow the **Katharine H. Putnam Research Fellowships**, named in memory of his mother, an avid horticulturist. Putnam Fellowships fund original research at the Arboretum by graduate students, post graduate scholars, and mid-career professionals interested in using the living, herbarium, and archival collections to generate new knowledge and practical applications for horticulture, landscape architecture, and plant conservation. Putnam Fellows work for up to two years as a member of the Arboretum staff, participating and collaborating fully as a member of the research community.

Since 1988, thirty-five scientists have served as Putnam Fellows, many of whom have continued to work with the Arboretum and its scientists as career academics and researchers. Some alumni of the program, like Arnold Arboretum Keeper of the Living Collections Michael Dosmann, have become leaders in the botanical garden community. The program continues to engage the best talent from across the globe and across disciplines. George Putnam will be remembered by succeeding generations of scientists who have advanced their careers—and the world's understanding of the plant kingdom—through his foresight, generosity, and thirst for knowledge.