A New Discovery About Ancient Land Plants

By Rachel Sargent Mirus

A long time ago, not so far away, freshwater plants partnered with fungi and moved onto land from lake and river shores. Since that time, land plants have evolved many sophisticated strategies for terrestrial life. Yet to this day, growing in damp forests and on foggy mountainsides, are plants that embody ancient botanical history.

Liverworts are the closest living analogs to the first plants that arrived on land, almost half a billion years ago. These primitive plants lack structures to control water loss, are very small, and grow mostly in damp habitats. There are two main types: thallose liverworts, which grow as leathery green patches on bare soil and on rocks in streams, and leafy liverworts, many of which superficially resemble mosses.

One example of a leafy liverwort is the rare Hooker’s flapwort (Haplomitrium hookeri). In New England, this species’ only known habitat is on Mt. Washington, where it grows on wet, north-facing rocks in Tuckerman Ravine. It’s a stubby, bright green plant, about a millimeter tall. Jeff Duckett, emeritus professor of botany working at the Natural History Museum, London, has observed Haplomitrium on six continents. “If you have a trained eye, it can immediately be recognized by its distinct bright green color, even though it’s very small,” he said.

Duckett’s research on Hooker’s flapwort has made important contributions to the study of plant evolution. Scientists already recognized that liverworts – like most other land plants – have relationships with Glomeromycotina, a group of mycorrhizal fungi that form branched structures inside the root cells of their host plants. These “gloms” help the plants access phosphorus and nitrogen in the soil in exchange for carbohydrates.

But Duckett and collaborators discovered a relationship between liverworts and a previously overlooked group of fungi that may have played an essential role in plants’ colonization of land.

Like other leafy liverworts, Hooker’s flapwort grows as a network of underground axes, or stem-like structures, that put out small, photosynthesizing shoots above the soil. Looking at these subterranean stems using an electron microscope, Duckett noticed a symbiotic fungus that he described as an “odd fungus that looked like nothing anyone had seen before.”
Duckett was curious about the fungus, so he teamed up with Martin Bidartondo, a molecular ecologist working at Kew Gardens. Initially Bidartondo was at a loss, reporting back that he couldn’t identify the fungus’s DNA. Eventually, using new techniques, he found that the mystery symbiont belonged to the Mucoromycotina, or “mucs,” an ancient lineage of fungi previously known only as free-living decomposers.

Mucs can form a variety of structures inside their host plant’s cells but have finer hyphae than the gloms. Work by Katie Field at Sheffield University, Silvia Pressel, senior researcher at the Natural History Museum in London, and one of her students, William Rimington, showed that Hooker’s flapwort was indeed gaining phosphorus and nitrogen from the mucs species, and giving carbon in return. Since that discovery, they have found that mucs form symbiotic relationships with numerous other plants, including some crop species, and often coexist with gloms.

These discoveries have prompted many new questions about plant evolution that researchers have yet to answer. How do plants, gloms, and mucs work together to balance each partners’ nutritional needs? Do mucs share unique benefits with their partners, such as access to more nitrogen through their role as decomposers? And how did each of these fungal relationships offer plants different advantages as they moved onto land?

These questions are so wide ranging and interconnected that no one person has all the expertise to answer them. “This is why science today is teamwork,” Duckett said.

They’re also fun questions to ponder, as you walk through the woods this summer. When you notice green patches on rocks in a stream, or if you spy a patch of stubby plants during a hike in Tuckerman Ravine, pause for a moment. You’re in the presence of ancients, and a venerable, still mysterious partnership that carried life from the water.

Rachel Sargent Mirus is a teaching artist and writer. Illustration by Adelaide Murphy Tyrol. The Outside Story is assigned and edited by Northern Woodlands magazine and sponsored by the Wellborn Ecology Fund of the New Hampshire Charitable Foundation: www.nhcf.org.