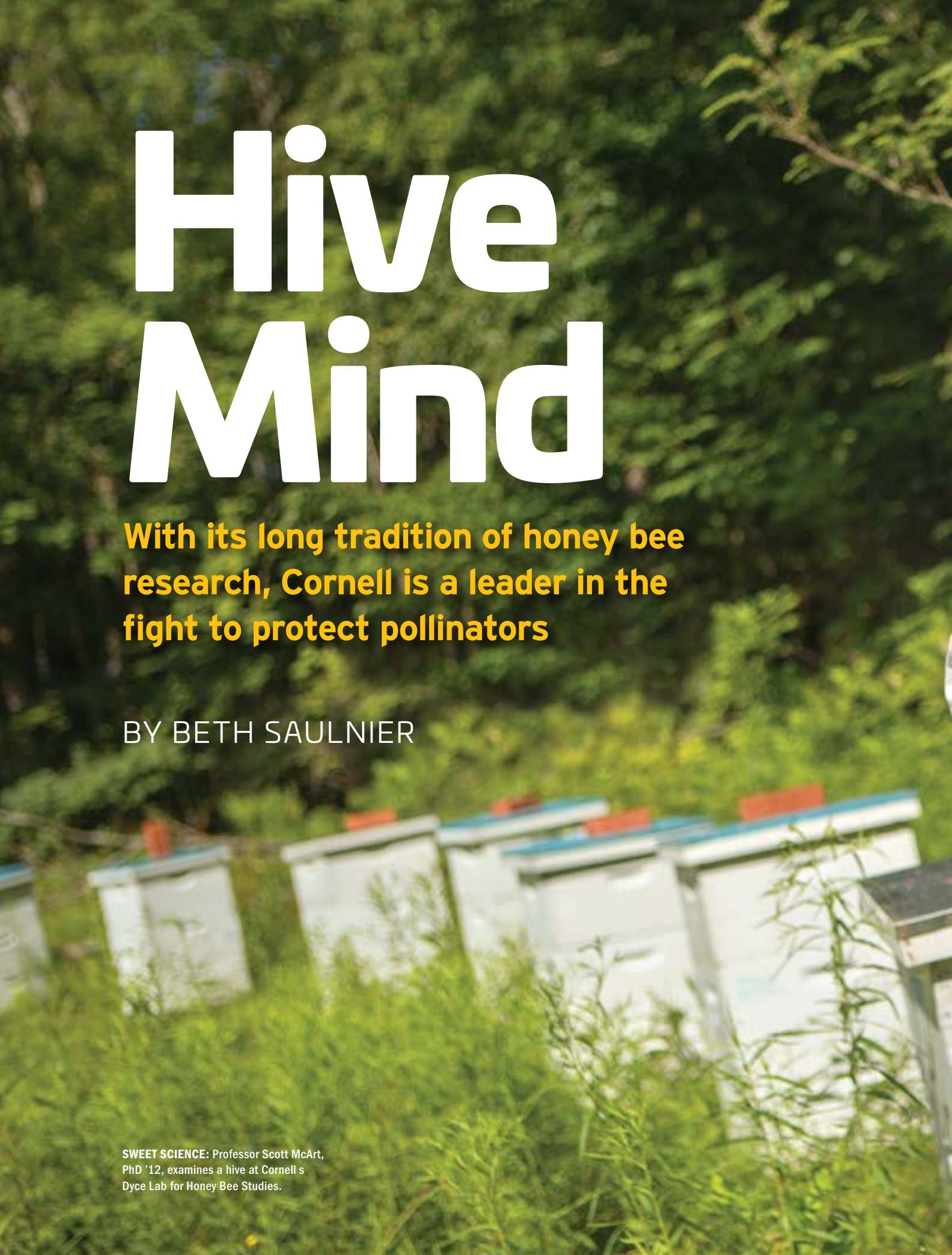
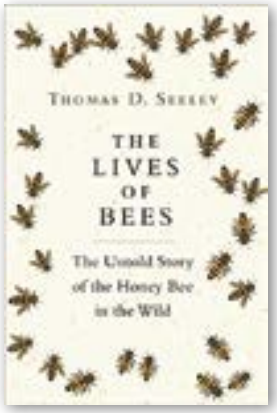
Hive Mind

With its long tradition of honey bee research, Cornell is a leader in the fight to protect pollinators

BY BETH SAULNIER



SWEET SCIENCE: Professor Scott McArt, PhD '12, examines a hive at Cornell s Dyce Lab for Honey Bee Studies.



ON THE WING (opposite page): Professor Thomas Seeley in the field. Above: Seeley's new book on wild bees. Below: The NYS Beekeeper Tech Team tests an apiary's hives.

It's a one-story building, clad in blue-green siding and utilitarian in design, located on a country road about three miles from central campus. Completed in 1968, the humble structure has zero architectural flourishes and little to hint at what goes on inside, save for the cluster of hives in the side yard. But for half a century, Cornell's Dyce Lab for Honey Bee Studies has been an epicenter of research on a tiny creature that has not only satisfied our sweet tooth for millennia, but plays an essential role in feeding the human race.

According to the USDA's Natural Resources Conservation Service, three-quarters of the world's flowering plants and some 35 percent of the food crops require animal pollination. While that doesn't include staples like wheat and rice, by some estimates pollinators—which comprise not only bees but also flies, ants, moths, bats, and more—still enable one out of every three bites of food we put into our mouths. "If you want to live on bread, oatmeal, and corn, great," says entomology professor Bryan Danforth, an expert on bees and their evolution. "But if you want to have berries on your cereal or squash with your dinner, you probably should care about pollinators."

Over the past decade, the fate of honey bees has been the subject of global headlines, as scientists and policymakers have grappled with myriad threats to their survival. At Cornell—home not only to the Dyce Lab but to faculty studying wild bees and their own contributions to pollination—researchers are investigating ways to protect bees and to help the apiculture industry best manage hives. Through extension activities, the lab works with many of New York State's 3,000 beekeepers—from backyard hobbyists to mid-sized operations to large-scale commercial apiaries that keep hundreds or even thousands of colonies. "Honey bees are not stationary animals," says Emma Walters, an extension associate based at the Dyce Lab. "If you have a couple of goats, the way you manage them doesn't impact how other people manage theirs. But honey bees fly about two to three miles from their own colony, so how a beekeeper manages their colony can impact others around them."

The Dyce Lab is named after Elton Dyce, Cornell's second professor of apiculture, who patented the process for making creamed honey—the revenue from which helped fund the building that now bears his name. Its entryway is decorated with generations' worth of knickknacks: bee-themed salt and pepper shakers, a set of cufflinks decorated with actual bees, vintage beekeeping equipment, and even the mummified corpse of a hapless snake that slithered into a hive and got stung to death. "Humans have a long relationship with honey bees," biology professor and honey bee expert Thomas Seeley observes. "We've been working with, exploiting, and stealing the honey of honey bees for as long as we've been humans."

While protecting pollinators is a pressing modern issue, bee studies on the Hill stretch back to the University's early days. CALS' Mann Library houses one of the world's leading collections devoted to beekeeping. Famed naturalist Anna Botsford Comstock, one of Cornell's first female faculty, penned *How to Keep Bees: A Handbook for the Use of Beginners* in 1905. Comstock Hall is home to the Cornell University Insect Collection, whose 7 million specimens include more than 150,000 bees representing about 3,700 species. One of Dyce's students, Roger Morse '50, PhD '55, joined the faculty in 1957 and became a legend in the world of apiculture—doing groundbreaking work on bee parasites and authoring *The Complete Guide to Beekeeping*—and other alumni have populated apiculture

PHOTOS: PREVIOUS SPREAD, JASON KOSKI/UREL; THIS PAGE, PROVIDED

faculty at research universities around the country. "Cornell has such a rich history," Seeley says. "It has produced most of the bee experts in the U.S.—most of the PhDs in apiculture by far." In 2015, it also produced the winner of an Ig Nobel Prize, given for absurd-yet-insightful research; Seeley's student Michael Smith, PhD '18, won for a study in which he induced bees to sting him on twenty-five body parts to ascertain which was most painful. (The top three: the upper lip, the nostril, and what some media outlets delicately termed "the male sex organ.")

The son of a Cornell horticulture professor, Seeley was a high school student doing fieldwork for a plant breeder when he came across a swarm of bees—a queen and her workers who'd left their hive looking for a new abode. "I caught the swarm and brought it home," he recalls, "and I got hooked." In 1969, Seeley got a job at the Dyce Lab—"as a flunky, sweeping the floor and scraping and painting hives." After undergrad at Dartmouth, a doctorate in biology from Harvard, and a stint on the Yale faculty, he joined Cornell's Department of Neurobiology and Behavior in 1986. Working out of Liddell Field Station—just down the road from the Dyce Lab—he has become a leading authority on bee behavior. Seeley's 2010 book, *Honeybee Democracy*, describes how colonies make decisions—for example, how scouts fly out from a swarm to identify possible new homes, then return to make their case for each location before the group comes to a consensus. Last spring he published *The Lives of Bees: The Untold Story of the Honey Bee in the Wild*, which explores the lessons that keepers of domesticated bees can learn from their wild counterparts. "The bees are the best beekeepers—and more and more beekeepers are starting to learn this," he says. "A lot of my work has been comparing the health of colonies in the wild versus in bee yards, and it's very different. Whereas the beekeepers are losing on average 40 percent every year that die over the winter, in the wild it's only 15 percent."

Seeley's book includes a list of twenty-one differences between wild and managed bees. For example, wild colonies space themselves far apart from each other, while commercial hives are stacked close together; wild colonies choose their own queens, while commercial queens are ›

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PHOTO: PETER ESSICK

NATURE'S WAY: A pollen-covered bee visits a flower. Opposite page: The invasive mite *Varroa destructor* on a honey bee.

As Professor Scott McArt, PhD '12, explains, pollinators face five main threats, all of them man-made. Of those, he says, 'it's not any one in isolation. It's the combination.'

reared by humans. Another major difference: insulation. Domesticated hives, designed to maximize honey production and portability, are made of thin wood so they're light and easily stackable. But when bees choose their own homes in the wild—say, in an empty cavity in a tree—they tend to choose a site that has thick walls. Seeley and Robin Radcliffe, a senior lecturer in wildlife and conservation medicine at the Vet college who's also a home beekeeper, have been conducting an experiment on Radcliffe's property, hollowing out a maple tree to specifications that Seeley's research has found are ideal for bees. They're taking regular temperature readings in the cavity (which has been blocked off to keep bees from entering) as well as in an empty commercial hive next to it. "In that one the temperature fluctuates with the outside temperature, but in the tree it's very stable," Radcliffe says. "So the bees don't have to commit resources to temperature and humidity, whereas in the box they have to warm it or cool it."

Seeley's studies of wild bees may also offer insights in the battle against the mite *Varroa destructor*—a creature that he notes "is aptly named." An invasive species from Asia, varroa was a leading suspect in the "colony collapse" crisis of a decade ago, when bees mysteriously abandoned their hives and vanished in alarming numbers. The parasite had jumped hosts from Asia's *Apis cerana* (the eastern honey bee) to *Apis mellifera* (the western honey bee), which is native to Europe and had been imported to the New World in the seventeenth century. While *cerana* had evolved defenses against varroa, *mellifera* had none and was decimated by them—not so much because of the mites themselves but because of the viruses they transmit. Through the use of miticides and other measures, varroa—while still a major threat—has been brought under control in managed hives; honey bees living in the wild, however, have had to fend for themselves.

For four decades, Seeley has been studying wild bees in the Arnot Teaching and Research Forest, a Cornell nature preserve near campus; his long-term data show that after colonies crashed due to varroa, they began to rebound thanks to natural selection. "Varroa got to Tompkins County in the early Nineties, and until we learned how to treat it, 80 percent of [domesticated]

PHOTO: CHRIS KITCHEN PHOTOGRAPHY

colonies would be dead the next year," he says. "A beekeeper would recover by ordering more queens, but in the wild it was just hard selection on the bees. They have evolved the ability to resist the mites; they bite the legs off, disrupt the mites' reproduction, and probably have other tricks we're still learning about."

David Peck, PhD '18, a postdoc in Seeley's lab, recently traveled to Madagascar to work with an NGO that has been training women to be beekeepers—but whose efforts have been stymied by the parasite, which has been devastating hives. "These bees have never seen anything like a varroa mite," says Peck, who helped found Cornell's undergrad beekeeping club in 2011. "They are completely evolutionarily naive to them." While miticides can help control varroa, they're not an ideal solution—in part because they can become less effective over time as the mites develop defenses to them. Peck studies the traits that the Arnot Forest bees have evolved to resist varroa, and how they might be replicated in a breeding program to help populations in Madagascar and elsewhere. "Breeding resistance to varroa is generally regarded by honey bee scientists and beekeepers as the goal," he says. "It's a zero-cost solution, because the bees are keeping themselves healthy."

Professor Scott McArt, PhD '12, spends much of his time at the Dyce Lab, and he essentially holds the faculty position previously occupied by apiculture legends Dyce and Morse. But his job description—assistant professor of entomology, with a focus on pollinator health—reflects that his work goes beyond honey bees to the wider issue of pollinators in general. As he explains, they face five main threats, all of them man-made. There's the use of pesticides in agriculture; the introduction of parasites such as the varroa mite; loss of habitat, including control of "weeds" that bees use as food sources; climate change, which has spurred drought and affected when flowers bloom; and management practices, which can promote disease and put stress on bees. "Of those five main factors, it's not any one in isolation," McArt says. "It's the combination."

One practice that can be especially stressful to bees, Seeley notes, is trucking them long distances to provide pollination services—a major source of revenue for many commercial beekeepers. Arguably the single most demanding crop is California almonds, which he says draw 1.5 million colonies to the groves each year. "You've got beekeepers from all over the country putting their hives close together in these holding yards," he says. "If you've got one beekeeper who's not good and has more disease in his hives, it's a perfect way to spread it." Just being hauled for thousands of miles in tractor-trailers can put major stress on bees in ways that researchers are just beginning to understand. "The vibration of these trucks causes bees to climb up in the hive, and often the brood [the eggs and developing pupae] at the bottom can get chilled," Seeley says. "Their brains don't develop properly, they become poor learners, and they often get lost on their first flight." Due to these factors, he says—plus the pesticides they may encounter in the groves, a lack of forage if they arrive before the trees bloom, and other stresses—"about 50 percent of colonies die coming out of the almond orchards." ›

PHOTO: PROVIDED

ALL ABUZZ

Bee education is blooming on campus and beyond

To enroll in the Dyce Lab's master beekeeper program, students need at least three years of beekeeping experience, often gleaned through a local club. Launched in 2017, the program consists of four online courses that take about fifteen months to complete; then students visit the lab for a written exam, field evaluation, and oral presentation. After the first class of fifty sold out and the next one got booked even faster, extension associate Emma Walters expanded it to 125—and it sold out again. While half of the students hail from New York State, roughly a tenth are international—coming from as far away as Australia and New Zealand to complete the in-person portions. "There's a lot of media attention out there about issues with pollinator health and honey bee declines," says Walters, who aims to launch an introductory version of the course in 2020, "so it's sparked a lot of people's interest to try beekeeping."

Since 2014, entomology professor Marina Caillaud has taught an undergrad course for non-majors entitled Honey Bees: Their Intriguing Biology and Interactions with Humans. She initially planned on forty students and later increased the cap to eighty; when she raised it to 150, it still filled up. "Humans have been fascinated with honey bees for thousands of years," says Caillaud. "It's one of the few social animals on the planet, just like us."

Over at the Vet college, senior lecturer Robin Radcliffe has introduced an elective on how to manage honey bee diseases; one of the first of its kind in the country, it comprises an online portion and hands-on demonstrations at the Dyce and Liddell labs. The course, which Walters helped design, was spurred in part by a 2017 FDA requirement that honey bees—as a food-producing animal—be governed by the same rules as other livestock in requiring a doctor's prescription for antibiotics, with the aim of curbing the rise of drug-resistant bacteria. The course covers not only honey bee biology and threats like pesticides and parasites, but practical skills like how to open and inspect a hive. "The only way a beekeeper is going to call a veterinarian to help them with a problem," Radcliffe says, "is if they feel like the veterinarian has a clear understanding of what it is to work on a colony of honey bees."

SOCIAL ANIMALS (above): Extension associate Emma Walters examines a frame of bees. Opposite page, clockwise from top: One of the solitary bee species that entomologist Bryan Danforth studies; his new book; Danforth with a drawer of bee specimens from Cornell's Insect Collection.

The ongoing threats to honey bees have prompted some researchers to explore the role of other bee species as pollinators. Danforth has been studying bees that live in the wild—particularly species that are solitary, meaning that they live not in a hive but in a nest consisting of an egg-laying female who's both queen and worker. As Danforth points out, these solitary bees make up about 70 percent of all bees on Earth—and as his research has found, they do a significant amount of pollination. In a ten-year study of apple orchards in New York—the nation's second-largest grower of the fruit, where it's a $300 million-a-year industry—he found that wild (and mainly solitary) bees are often more abundant than honey bees, and more effective pollinators. "We put that all together and realized they're doing a lot of apple pollination in New York," he says, "and at many sites they're doing most of it." Danforth aims to convince growers that they could save money—and potentially avoid the spread of pathogens—by not having bees trucked in to provide pollination services. That could also apply to other produce like blueberries, watermelon, squash, and strawberries. "We're learning more and more," Danforth says, "that a lot of these crops may not need the honey bee."

Danforth has also been collaborating on a project to track wild bee abundance over time, based on about 120 years of data from insect collections at museums and universities, including Cornell. "There's good evidence that there are many species of bees that are in decline," he says, "and we don't necessarily know the reasons." His latest book, *The Solitary Bees: Biology, Evolution, Conservation*, published in August by Princeton University Press, includes an in-depth discussion of the threats facing bee species worldwide. As he and his co-authors note, in Europe 45 percent of bumble bee species are in decline, seven more are endangered, and eight are vulnerable; in North America, one may have already gone extinct. "It is becoming increasingly clear," they write, "that honey bees are not the only bees that are having problems."

Although some of the current threats to bees can be traced to agriculture practices, Cornell experts stress that farmers are keenly aware that they have a vested

HONEYED WORDS

The Hill is home to a famed library on beekeeping

Everett Phillips, who became Cornell's inaugural professor of apiculture when he joined the faculty in 1924, was a major force in beekeeping in the early twentieth century. Previously head of the USDA's bee program, he'd overseen a 400 percent increase in beekeeping and honey production in the U.S. during World War I. Among his innovations shortly after arriving on the Hill was establishing a beekeeping library, later named in his honor. To fund it, he asked the beekeepers of New York State to designate the profits from one hive to support the library; once they donated $50 they'd receive a brass plaque (above right) that they could proudly affix to the hive.

Now part of Mann Library, the collection is overseen by Michael Cook, head of collections at Mann and himself an avid amateur beekeeper. "The beekeeping library is the only one where we collect comprehensively; everything we're aware of that's being published on beekeeping, we add it to the collection," says Cook, who's been known to sport bee-themed neckties at the office. "We also have some of the rarest materials in the world here. A lot of things we have, I know the Library of Congress doesn't have."

The library's extensive and varied holdings include a 1623 copy of *The Feminine Monarchie* (above left), one of the earliest books to describe bee behavior; a comprehensive collection of beekeeping magazines and academic journals from around the world; a 1903 children's book, *Adventures in Hiveland*, about kids who are magically shrunk down to bee size; and a recipe pamphlet courtesy of the 1990 Pennsylvania Honey Queen. One of its jewels is what Cook calls "the holy grail of beekeeping": the journal of Lorenzo Langstroth, the father of modern beekeeping. Handwritten on onion skin pages, it includes his sketches for the moveable frame beehive—the ingeniously designed system of boxes (patented in 1852) that maximizes honey production and lets keepers harvest it without harming the insects. "The point where he figures this out," Cook says, "is a pivotal moment in beekeeping."

PHOTOS: PROVIDED

interest in protecting them, due to the vital role that pollinators play in producing crops. "Most growers are very interested to know what kind of pesticide risk to bees they're causing," says McArt, who is currently working on a USDA-funded project to study fungicide levels in New York apple orchards to assess how they affect managed and wild bees, including how they may interact with other pesticides. "Growers need to keep the pollinators there and keep them healthy. But if all their apples get apple scab, they're not going to be able to sell them. So there's this interesting tradeoff that's occurring in a grower's mind all the time."

The Dyce Lab's extension efforts include working with growers to protect pollinators by educating them in best practices regarding pesticide application, cooperation with nearby beekeepers, and more. On the apiculture side, the lab is home to the NYS Beekeeper Tech Team, a state-funded effort to support New York beekeepers by improving colony health, reducing losses, and increasing profitability; its services include business advice, testing to evaluate pesticides in beeswax, and recommendations on coping with pests like varroa. Among those to tap the Tech Team's services is Jonathan Ryan '75, a longtime commercial beekeeper based in the Cayuga County town of Venice, half an hour north of Ithaca. Ryan has been in the bee business since shortly after graduation; as an undergrad studying natural resources in CALS with no clear career in mind, he took Morse's course on bee biology and stumbled on a calling. "I found out what amazing animals they were and thought, I want to get a hive," Ryan recalls. "It was a hobby that got out of hand."

On an afternoon early this summer, Ryan drives his 1974 Ford pickup out to one of his bee yards, located a short drive from his honey house. Ryan has about 300 hives in some twenty locations; in recent years his bees have produced between 22,000 and 33,000 pounds of honey, which he sells to a Baltimore-based company that supplies raw honey to supermarkets and health food stores. "I do love beekeeping," he says. "Bees are interesting to work with, and what they can do is fascinating." As thousands of them buzz about, Ryan and his partner open up each hive and assess whether the bees need more space; if so, he'll add an additional hive box atop the existing stack. As he explains, everything above the bottom two boxes will ultimately be harvested. "Honey bees do not need people at all; they'd be better off without us," Ryan muses. "But it's kind of a synergistic relationship. I give them a home and try and take care of them, make sure they have enough food for the winter, and protect them from disease. In return, they give me honey." ■

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PHOTOS: BEE, ALBERTO LOPEZ; OTHERS, PROVIDED