Herbaria's use and importance grows with climate change

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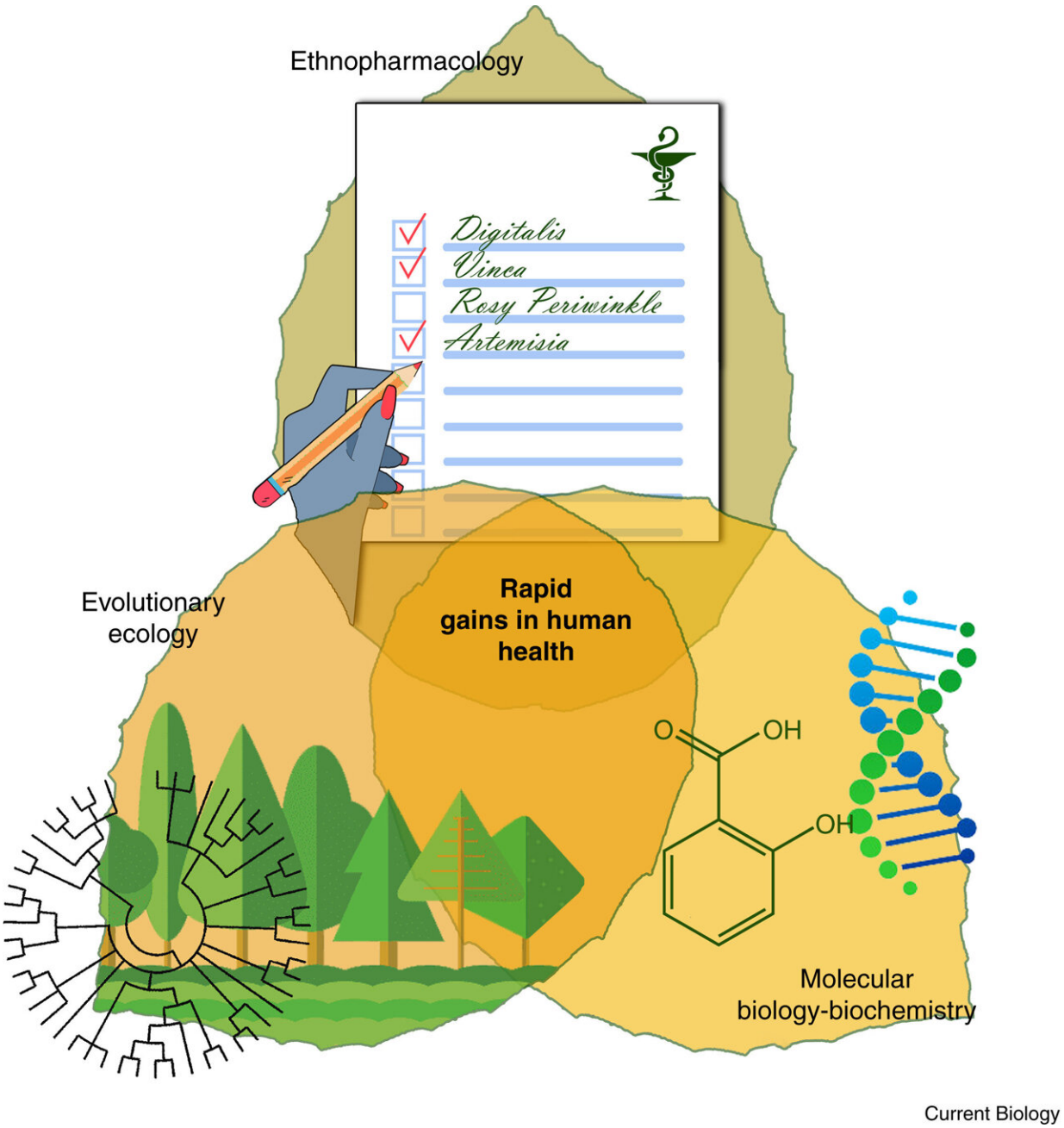

A framework for an emerging biodiversity science of medicinal plants. The combined insights from three interconnected disciplines of modern biodiversity science could lead to rapid improvements in human health and well-being. Credit: *Current Biology* (2024). DOI: 10.1016/j.cub.2023.12.038

There are more than 350,000 species of flowering plants on Earth, yet only 12 of them separate humans from starvation. And, Charles Davis says, 2 out of 5 plant species are likely to go extinct in the near future because of land use and climatic changes caused by people.

"We really don't know very much about most plant species," said Davis, professor of organismic biology and curator of vascular plants at the Harvard University Herbaria (HUH) and Libraries. "And this knowledge gap feels increasingly vast because species are disappearing rapidly."

Formerly, the study of collections like the Herbaria was the endeavor of individual scientists in pursuit of a better understanding of taxonomy, Davis said. Now, thanks to genomics and digitization, teams of researchers working collaboratively around the globe can simultaneously access herbaria and other natural history collections to tackle big questions, such as whether nature is resilient to a rapidly warming world. And an innovative project at Harvard will add to that effort, particularly with plants of medicinal purposes.

"Understanding what species are and where they live remains fundamental to biological knowledge, but in the face of intensifying land use and climatic changes, we're now using herbarium collections in many new and important ways," Davis said.

Of the 450 million specimens held in some 3,000 herbaria around the world, more than 5 million can be found in the metal cabinets in a four-story brick building on Divinity Avenue known as the Harvard University Herbaria, where a team of researchers and archivists oversee their curation and digitization.

Harvard's Office of Technology Development recently coordinated a three-year research agreement with LVMH Recherche, Parfums Christian Dior, and Harvard that will support genomic analysis and digitization of medicinal plant collections in the Davis Lab at Harvard's Herbaria. A paper framing the newly funded project was published Feb. 26 in *Current Biology*.

"We're generating massive resources to really go at big-picture sorts of questions that relate to these important plants of human use, which have been central to human expansions and cultural trajectories," said Davis.

"We've developed a new method for 'barcoding' species, which leverages these samples and cutting-edge DNA sequence technologies plus artificial intelligence to improve identification of medicinal plants in the field. And the digitization process will allow researchers to do everything from reconstructing ancient ecosystems and targeting microscopic invasive pathogens that affect agriculture to describing new species."

When Davis turns the compacting handle on one of the cabinets, which are as likely to hold water lilies found in New England as Aframomum angustifolium (wild cardamom) that grows in Africa and Madagascar, he is as excited as he was 30 years ago when he first walked into the herbarium at the University of Michigan.

"I've been working with herbarium collections for a long time and, fundamentally, their main use has been to store a permanent record of the plant species with which we share the planet and understanding

where they live. And that's still really important.

"But these collections can now be used in a whole variety of ways that get at a lot of questions related to conservation, genomics, and biochemistry, and many others related to plants of human use. And those are, in many ways, the areas that I'm now most excited about, having taught in this area at Harvard for nearly two decades," he said.

He points, as an example, to plants commonly found in New England whose flowering times are closely tied to Earth's warming.

"When spring comes earlier, these plants start flowering earlier. But for the vast majority of plant species growing in other parts of the world—especially in the tropics—we have no idea how they're responding to global warming. And so, what we've been trying to do is to bring in crowdsourcing and machine learning to gather these data and combine them into a 'global meta herbarium' of Big Data," he said.

Research assistant and project manager Jackson Kehoe '22, who was a student in Davis' class on plant diversity, waxed enthusiastically about the project, which will mobilize a collection of key plant species from around the world that have been used throughout human history for medicinal purposes.

"We all have different ideas of what it means to be healthy and how the human body system interacts with plants to heal disease. And exploring that has been an interesting part of the work," he said. "The massive amount of data we're generating is even more exciting. As the weeks go by, the possibilities for research are multiplying."

Davis noted that of the 35,000 known species of medicinal plants, most have not been evaluated for their therapeutic value in a more conventional, Western-centric sense. "Jackson and I have been looking

for connections between traditional pharmacopeia, including not only Western Europe's De materia medica but also ancient texts from India and others from China.

"So, the idea here is that if you're in India, you may use species X, but in Southeast Asia, where species X doesn't grow, one of its close relatives is used in a similar way. And then we can start to piece together the kind of evolutionary hot zones of medicinal plants."

"What most people don't understand is that at least 75% of the developing world relies on natural medicines, most of which are either whole plants, plant parts, or compounds extracted from plants. Yet despite their importance, there are not many large-scale efforts aimed at discovering new drugs from plants or other species."

Using digitized specimens to construct geographic and eco-evolutionary models will also allow scientists to forecast how species' distributions will change under different climate-change scenarios: "How safe are the important species that have shaped cultural trajectories and human migrations, and have we adequately gathered and preserved the genetic material that will allow us to prevent future catastrophes?" Davis said.

"Plants form the matrix for all life on Earth, providing food, shelter, and medicine to humans and countless other species, but 40% of them are on the fast track to extinction," he added. "We don't have all the results yet, but my guess is that we have done a pretty poor job protecting many of these important species."

More information: Charles C. Davis et al, Medicinal plants meet modern biodiversity science, *Current Biology* (2024). DOI: 10.1016/j.cub.2023.12.038