Herbarium staff member Viola Frei explains the classification system: these mobile shelving units contain more than 2.4 million plant specimens.

A treasure trove of plants

Once the pride and joy of princes and universities, botanical collections are enjoying a renaissance thanks to modern research questions and methods. We paid a visit to the United Herbaria of the University of Zurich and ETH Zurich.

TEXT Martina Märki IMAGES Stephan Huwyler

The path through the botanical garden is far from inviting on this bitterly cold January morning. All the plants are still deep in hibernation, and the signpost to the tropical greenhouses offers the only tempting respite from the weather. Our destination, however, lies in the basement of the building towering above us, which houses the University of Zurich's Department of Systematic and Evolutionary Botany. Here is the largest facility of what is officially known as the United Herbaria of the University of Zurich and ETH Zurich, or "United Herbaria Z+ZT" for short.

With its functional stairwell and long corridors, it looks much like any other office building – apart from the many photographs of plants on the walls and office doors. Equally striking are the warning signs on the glass doors in the basement, which depict a small insect alongside the words "We're not allowed in!" We, on the other hand, are permitted to enter, and after passing through another two glass doors we find ourselves standing in a large room that appears to be full to the rafters. Long rows of grey mobile shelving units tower above us on both sides, and there is a faint odour of paper in the air. We have reached our destination: the vascular plants collection of the United Herbaria Z+ZT.

The rows of shelving are filled to the ceiling with folded sheets of paper stacked one on top of the other – modest little envelopes containing a treasure trove of pressed flowers, leaves, roots, dried fruit, and branch fragments. This facility is home to more than 2.4 million specimens, stored on some 1,000 square metres of mobile shelving under controlled atmospheric conditions of 50 percent humidity and a constant temperature of 19 degrees Celsius, explains ETH curator Alessia Guggisberg, who manages the collection together with University of Zurich curator Reto Nyffeler. "If we stacked all our holdings on top of each other, they would form a tower 3,000 metres tall!" Comprising objects from the University of Zurich and ETH in almost equal amounts, this makes the vascular plant collection the largest component of the United Herbaria. Other components include a fungi and lichen collection, which is stored on the ETH Zentrum campus, as well as a collection of bryophytes, kept at the University of Zurich. The merging of

Left: a water lily collected and prepared by Hans Ernst Hess.
Right: the book on the table contains the oldest plant specimens in the collection.

Curator Alessia Guggisberg

"If we stacked all our holdings on top of each other, they would form a tower 3,000 metres tall!"

Alessia Guggisberg

the herbaria also explains the rather peculiar abbreviations in the United Herbaria's name. The Z refers to records held by the University of Zurich, while ZT refers to those held by ETH. In total, the United Herbaria contain almost four million specimens, making them the second largest herbarium in Switzerland after Geneva and the fourth largest university-based herbarium in the world.

Native and exotic flora

Guggisberg takes us to a long table in the centre of the room. A brown book lies open, its pages crinkled with age and curled up like bark. Plant samples are pinned to the pages, surrounded by handwritten slips of paper containing barely legible scribbles. This behemoth of a book contains the oldest vouchers in the collection. They were sampled by Swiss physician and naturalist Johann Jakob Scheuchzer (1672–1733) over the course of his life and preserved in the bound herbaria of Johannes Gessner (1709–1790), founder of the Zurich Society for Natural Sciences.

Next to it on the table are specimens of other plants, neatly arranged and mounted on white sheets of paper. Each object is an aesthetic marvel, featuring typewritten descriptions and a map showing where the material was found. These vouchers come from tropical Central Africa, primarily from Angola. They were collected by Professor Hans Ernst Hess in expeditions conducted between 1950 and 1952, including a Ciba mission. Although samples of Swiss flora make up around half of the vascular plant collection, the Hess herbarium is an example of how important holdings of foreign material are as well. On one particularly eye-catching sheet, a pressed water lily, has maintained its dazzling violet hue. "The only way to preserve a flower's colour that vividly is by pressing and drying it very quickly," says the curator. Hess typically set to work as soon as evening drew in at the mission outposts where he spent the night. Guggisberg explains that she herself has achieved excellent results drying plants on a hot car roof in the Mediterranean region.

Climate and genetic research

Guggisberg has helped shape the development of the herbarium since 2016 in her role as curator. "It takes years to really get to know a collection like this," she says modestly. Her goal is not just to preserve the collection but also to steadily expand it and make its contents as accessible as possible to researchers and academics. She splits her time evenly three ways between teaching, research and the herbarium, and she regularly embarks on botanical excursions with her students. She believes that botanical collections are likely to take on increasing importance again as a result of modern-day concerns such as global warming and the development of new research methods. "One example is our ability to use cutting-edge molecular biology techniques to investigate genetic changes caused by global warming in the DNA of herbarium specimens. And, of course, herbarium records contain not just plant material, but also microbial tissues and substances such as heavy metals from their habitat that we can analyse."

Guggisberg also carries out these kinds of studies herself. Recently, for example, she explored the question of whether the ability of plants to adapt to different soil compositions manifests itself in genetic differences. As we speak, a final batch of the *Arabidopsis arenosa* specimens used in this study are being mounted in an adjoining room. Guggisberg collected these samples of sand rock-cress in 2012 in the Czech Tatra region and the Austrian Alpine foothills. During her field trip, Guggisberg pressed the specimens she sampled between sheets of newspaper, separated by thin felt mats that absorb moisture and corrugated cardboard that allows air to circulate.

Preparing new arrivals

Her assistant Viola Frei starts by carefully unfolding the top sheet of newspaper. Using tweezers, she painstakingly removes the pressed plant, blows all the loose earth off the roots, and drapes it over a bright white ›

sheet of archive paper. She then uses thin white adhesive strips to secure the plant in position. Next, she gathers up all the little bits that are still in the newspaper – leaves, flowers, and anything that has broken off, even tiny seeds – and tips them all into a small paper bag folded into a square, something botanists refer to as a "capsule". She then glues the capsule and its contents to the archive paper alongside the plant. "Keeping these little bits of tissues is particularly useful for genetic studies," Frei says. "It means we can avoid damaging the voucher itself by destructive sampling." Next, Frei adds a label to the sheet containing precise details of the plant name, as well as information on who collected it, and where and when it was found.

The mounted specimen is now almost ready for archiving, but before it can enter the herbarium itself, it must first spend some time in quarantine, just like all the other new arrivals. That means wrapping it in plastic and keeping it in the freezer at minus 30 degrees Celsius for at least a week. "That's how we keep out pests such as insects, which could otherwise destroy the specimens," says Guggisberg. The final step is gluing a barcode next to the voucher, bringing it firmly into the digital age.

A staff member digitising some of the herbarium's holdings.

From digitisation …

This is a matter of some urgency, as recently emphasised by the Swiss Academy of Sciences in a conference on the importance of natural history collections. Swiss institutions hold over 60 million items distributed across all the Swiss cantons, yet they are barely accessible to modern researchers due to patchy cataloguing and classification and the fact that only 17 percent of the objects have been digitised. The team at the vascular plant collection has already geared up to tackle that problem, setting aside a special area containing two digitisation stations where they can take up to 3,000 photographs of specimens a week. The images are then incorporated together with basic metadata into the in-house database system called *digitalis*$^{Z+ZT}$. Guggisberg demonstrates the geo-referencing potential offered by this integrated system with an example: "Let's say I come across a voucher dated 1910 with the location information Oerlikon/Feuchtwiese. I can call up a historical map of Oerlikon and see that it most probably referred to this former swamp area," says Guggisberg, highlighting an empty space next to a few houses sketched on

Mounting plant specimens on archive paper requires a delicate touch.

the on-screen map. An online portal makes the transcribed data publicly accessible.

Digitisation projects involve more than just photographing samples and assembling the relevant data, however. The items must first be checked, catalogued and, in some cases, even renamed. The importance of this step was highlighted in a pilot project funded by the ETH Library, which tackled the digitisation of the extensive crucifer (Brassicaceae) collection, which contains some 82,000 records. This family includes the world-renowned star of modern plant genetics, an inconspicuous plantlet called *Arabidopsis thaliana*. Recent genetic studies prompted some phylogenetic changes. "And that meant we had to make a lot of adjustments in the herbarium," says Guggisberg: "We checked a total of 2,315 taxonomic names and we had to update 971 of them."

The team also digitised the types. Type specimens – in other words specimens of newly discovered plants – are the most important objects in a herbarium. The vascular plant collection at the United Herbaria contain 16,000 types, all of which can now be accessed in a digital format.

"A digital image will never be able to replace the real 3D object."

Alessia Guggisberg

...to citizen science

Besides continuing to inventorise the collection's holdings, Guggisberg's plans for the future also include tapping into other opportunities related to digitisation. For example, she recently submitted a citizen science project on Valais flora to the ETH Library. The goal is to recruit enthusiastic volunteers for the transcription of specimen labels. This task requires both an interest in botany and a healthy dose of detective skills. Indeed it takes a certain kind of person to decipher old, handwritten notes such as those in Johannes Gessner's herbarium but, once the information is in the database, it can be read and accessed by anyone.

Yet Guggisberg cautions against getting carried away by the opportunities digitisation offers: "A digital image will never be able to replace the real 3D object," she says, leading us out of the digitisation area and back to the archives. The silent presence of the more than two million specimens around us give her words added weight. ○

Zurich Herbaria:
→ www.zuerich-herbarien.ethz.ch/en