



D. WILSON/MISSOURI BOTANICAL GARDEN

## GARDENS IN FULL BLOOM

In a world of declining biodiversity, botanical gardens are coming into their own — both as storehouses of rare plants and skills, and increasingly as centres of molecular research. **Emma Marris** reports.

**A**t this moment there are a couple of ladies, one in her sixties, one in her eighties, walking through a greenhouse, their silver heads surrounded by hanging orchids in oranges, scarlets and lavender-tinged whites. These ladies, orchid-fancying mother and daughter, are bound to be there, because they were there in every garden visited during the writing of this feature. They are the embodiment of the botanical garden as popularly imagined: cosy, slightly old-fashioned, detail-oriented, perhaps a touch eccentric. But these greying dryads do not tell the whole story.

Tucked behind the palmhouses of the world's larger gardens are buildings filled with industrial wheeled shelves for mounted plant specimens, scientists sitting round-shouldered over microscopes, and growth chambers housing rows and rows of seedlings.

Botanical gardens have always been repositories of knowledge as well as cuttings. For centuries they were the heart of botanical scholarship. These days, most plant scientists work in academic settings, and increasingly study plants at a molecular level not obviously suited to the setting of greenhouses and flowerbeds. The challenge for

botanical gardens is to maintain a place in the scientific world while remaining true to their hybrid heritage, a heritage that encompasses aesthetics, exploration and education as much as academic study.

The two traditional scientific specialities of botanical gardens are plant taxonomy — the discovering, naming and sorting of species — and whole-organism biology — the study not of the ecosystem of the wild tulip, or the cellular functions that the tulip shares with a bunch of other plants, but of the tulip itself. Now, several of the world's larger gardens are broadening their focus and undertaking the sort of molecular investigation more typically found in research universities. Some botanists worry that this move stretches resources that would be better focused on the gardens' traditional strengths.

But researchers within the gardens argue that a botanical garden, filled with so much knowledge of plant diversity and bristling with plant life, is the ideal place to do such work. As head of molecular systematics at the Royal Botanic Gardens in Kew, southwest London (see 'Kew Gardens'), Mark Chase pores over DNA and RNA to probe plant relationships. But he'll still pop out on a spring

morning to look at the garden's many irises. He calls it "reciprocal illumination". Looking at the plant, then at the molecules, then back at the plant, "you really see things you hadn't noticed previously," he says.

Michael Donoghue is a university plant systematist who, although firmly rooted at Yale University in New Haven, Connecticut, understands the lure of working in gardens. He argues that molecular systematics are "part of the gardens' mission to understand plants in all their glory". The New York Botanical Garden's grand foray into genomics — the \$23-million Pfizer Research Center is opening there next month — may "raise some eyebrows", Donoghue says, "but why not endeavour to do all you can?" He adds that his counterparts at gardens are able to tackle much meatier projects for longer periods: "We go from grant to grant; at the gardens, they have a longer view and really devote a lot of time and energy to one mission."

### Keeping up traditions

But Richard Olmstead, a molecular systematist at the University of Washington in Seattle, echoes the worry in the botany world that such moves could diminish the gardens' focus on taxonomy and whole-organism biology. "Insofar as any of their research is diverted towards more modern approaches away from those more traditional approaches, those traditional things are not going to get done, because no one is picking them up," he says.

No one is picking them up because there is, at the moment, no money in it. "Many people follow the money down to the molecular end," says Peter Crane, director of Kew, referring to the way that botany is often practised in academia these days. "It's a bit of a shame. We need a more integrated plant science." Edward Schneider, president of the Botanical Society of America, and a scientist at the Santa Barbara Botanic Garden agrees: "We need to preserve the understanding that a plant is more than just a bag of genes."

Membership in the American Society of Plant Taxonomists has been steady over the past ten years. Nevertheless, there does seem to be a want of expertise on plant diversity in the average university department. "The number of people does not seem adequate to deal with the challenges that



J. PEDEN/NEW YORK BOTANICAL GARDEN

Good spot: a new research centre means the New York Botanical Garden will provide a site for genomics as well as for picnics.

face the field," says Peter Raven, president of the Missouri Botanical Garden in Saint Louis (see 'Missouri Botanical Garden', overleaf). When universities want to compare species to deepen their understanding of a molecular finding, he argues, they increasingly turn to botanical gardens for help.

Some think that universities have abandoned the whole-organism approach. Dennis Stevenson, vice president for botanical science at the New York Botanical Garden, has a guess as to why: "Their faculty can't go running off into the jungle." In contrast, many botanical gardens' researchers start their projects with a vigorous mosquito-slapping tour through the remote and fecund places of Earth in search of specimens. "Most of the world's plant-diversity specialists are in the north, and most of the plant diversity is in the south," explains Crane. The most tangible fruits of these trips are large numbers of dried plants mounted on cards and bits of DNA in tubes filled with silica gel.

As well as being an insurance policy in the event of rare plants going extinct, the DNA samples feed into molecular

## Kew Gardens

**Founded:** Kew Gardens became a botanic garden in the modern sense in 1759.

**Research budget:** £8 million (US\$14 million).

**Famous for:** The Palm House (pictured right), designed by Decimus Burton and Richard Turner in the 1840s; the ten-storey pagoda, built in 1762, which is open to visitors this spring and summer; and its winter orchid show.

Peter Crane (pictured right), director of Kew Gardens, is very neat and tidy — just a small, decorative ink stain on his cuff. He is walking the 129 hectares these days with a bit of preemptory nostalgia, as he leaves for the natural history Field Museum in

Chicago in the autumn. "I don't think once you've been here, you ever really get rid of the infection," he says. "We've planted literally millions of bulbs in my time here."

In the lake outside the Palm House, moorhens and huge white-headed geese float about. In the spring, carpets of bluebells, daffodils and crocuses are around every turn. In the corner of the garden are the research labs, a recent paper from which reported that two species of palm tree had diverged despite sharing



Peter Crane, head of Kew, cherishes botanists' traditional skills in whole-organism biology.

the same habitat (V. Savolainen *et al. Nature* doi:10.1038/nature04566; 2006).

E.M.



KEW

KEW

work. The mounted plants end up in herbaria — libraries of many millions of plants that are consulted by scientists. Although many university departments still have herbaria, they are increasingly becoming concentrated in botanical gardens. “Botanical gardens are becoming depositories of herbaria, because universities are moving in a more molecular direction,” says Schneider.

Jim Solomon runs the Missouri herbarium. He says that when he feels anxious or stressed he likes to sit down and sort a box of uncatalogued specimens. The plants last a surprisingly long time, attached to paper backing with linen strips or Elmer’s glue, and, although often rather brown, can retain a few lively characteristics. A maple specimen — *Acer macrophyllum* — collected in 1892 by Emma Shumway in Seattle, Washington, looked as if it had been caught falling from the tree just seconds ago. “As habitats are modified, as plants go extinct, these collections will become increasingly important as a record of what these things looked like,” says Solomon.

### Plant protectors

Although preserving the vanished is important, preserving the all-but-vanished is even more so. Botanical gardens support conservation in two ways. They study plant diversity and establish what is rare where. And they grow rare plants and keep their seeds. *Cosmos atrosanguineus*, the chocolate cosmos plant, can now be smelt and seen only in gardens such as Kew, because it is extinct in its native Mexico. Unfortunately, all the chocolate cosmos plants alive today seem to be cuttings of a single plant — so they are ‘self-incompatible’ and won’t reproduce. Preserving genetic diversity is a large part of the gardens’ agenda. “There is an increased focus on not just having one individual with a label on it, but creating *ex situ* populations of threatened plants,” says Pete Hollingsworth, director of genetics and conservation at the Royal Botanic Garden Edinburgh.

The London-based Botanic Gardens Conservation International (BCGI) keeps some 600 member gardens in touch with each other on conservation matters. “I would say that the vast majority of our members have some sort of research programme,” says Suzanne Sharrock, director of



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public awareness and understanding at BCGI. “In some cases it would be a very small programme, but the fact that they are botanical gardens rather than just public parks indicates that they are trying to be something more than a nice place to have a picnic.” Botanical gardens in Australia, South Africa, Brazil, and, increasingly, China, are praised by botanists from Europe and North America for their garden science and conservation activities. Sharrock thinks that if they all spoke with one voice, that voice might be pretty loud. “There are botanical gardens in every country in the world, and in every major city,” says Sharrock. “They have the potential to be a very powerful force.”

At the Second World Botanic Gardens Congress in 2004, the delegates adopted 20 goals for 2010 in support of the Convention on Biological Diversity’s Global Strategy for Plant Conservation. Among these goals is doubling the number of “trained botanical-garden staff working in conservation, research and education”. Another is compiling “a working list of known plant species”.

Various bits and pieces of such a possible database already exist. The International Plant Name Index strives for comprehensiveness in cataloguing the seed plants of the New World and Australia, but it only lists names. Raven thinks that his garden’s database of vascular plants (pretty much everything except mosses and liverworts), TROPICOS, might be “an important part of a final strategy”, pointing users to published work on the species, and in some cases to maps of ranges.

Plans for the ultimate database inevitably lead to talk of DNA barcoding. If species-specific differences in defined DNA sequences were matched with a species name in some kind of database, an untrained person could use a sequencer or a DNA-chip to read the barcode in a botanical sample, send it to the database, and get back a name and all other necessary taxonomic data.

Apart from its undoubted geeky appeal, such a technology would in principle save a lot of time and drudgery. Carrying out identifications for colleagues at home and round the world is time consuming and uncompensated. The use of

## Missouri Botanical Garden

**Founded:** 1859. Still operated under the terms of founder Henry Shaw’s will.

**Research budget:** US\$9.4 million.

**Famous for:** The Climatorn geodesic dome and free concerts on Wednesdays in the summer.

Peter Raven is the president of the Missouri Botanical Garden, a 32-hectare spread in Saint Louis. With an egg-shaped head and an engaging smile, he has lived in a corner of the garden — like a vicar in his vicarage — since 1971. However his status as, among other things, the lead author of the bestselling plant-science text for undergraduates gives him an influence far beyond the bounds of his parish.

“Botanical gardens have always been scholarly enterprises,” Raven says, but the Missouri garden is an

aesthetic one, too, managing neatly to be attractive even in the harsh winters of the US Midwest. The Japanese garden, for example, looks best in the snow, its distinctive lines highlighted with white.

On the paths, school kids in khakis are punching each other. Under the osage orange trees are nets to keep the large green fruit from “bonking people on the head”, according to Lisa Brandon, the public-relations manager. In this garden, like others, everything is emblazoned with the name of some donor or other. Some science research in gardens is funded by a similarly direct route, which means no peer-reviewed proposals and very little red tape. Just a thank-you note.

E.M.



Visitors flock to the Missouri Botanical Garden to see the Climatorn dome.

barcoding would free up people to do their own research.

But Raven is cautious about such a scheme. He thinks that many lifetimes could be consumed setting the system up — time that would be spent making lists rather than learning anything about the organisms. “There are many millions of nematode species,” he says, choosing an animal example. “If I had a slide of every nematode in the world, what would I do with it?” Similarly, what would one do with barcodes for the 13,000 or so moss species?

### Gardener's tips

There is, after all, so much else to look at, especially when one has the intellectual freedom that a large botanical garden can provide. Their widespread sources of funding and, in some ways, more forgiving range of stakeholders to please, mean that gardens can consider long projects and quirky studies that universities would be hard pushed to take on. In Missouri for example, 42% of the funds allocated to research comes from tickets, memberships and sales, and 58% comes from government grants, private donors and foundations. You can be “more creative,” says Ken Cameron, an orchid specialist and head of molecular systematics at the New York Botanical Garden. “At a university, you don't really have a choice. You have to toe the line and study one of these model organisms.” He prefers to study “weirdo little orchids that nobody cares about.”

At the gardens, researchers also enjoy a great deal of public support. Amateur gardeners want to know how to keep their plants alive and blooming, and look to the professionals for help, as well as for inspiration. They are also often curious about the microscopic details and ecosystem-level stories behind plants. This makes botanical gardens ideal forums for fostering the public understanding of science. The Royal Botanic Garden Edinburgh is raising funds for a building designed specifically to mediate interactions between scientists and the public. This will open “with a bit of luck” in 2009, says Stephen Blackmore, regius keeper of the garden. “A lot of people want to hear about the research,” says Blackmore, adding that scientists in botanical gardens seem to be regarded as “a good source of reliable, factual information” on everything from climate change to genetically modified organisms.

The exchange of information is not all one way. Amateur gardeners can have valuable information to impart. “For many gardeners, the information is in their heads. The tricks they use to propagate plants — how to grow a pineapple in Cornwall — don't always get written down,” says Crane. The value of this knowledge has only just been realized. Crane says he sometimes looks at the churchyard of Saint Anne's, opposite Kew's main offices, and thinks of the lost skills buried with generations of gardeners there.

Raven feels that amateur gardeners could do more to keep rare and endangered plants alive. “There is probably more scope for scientists to get involved with gardening. I could see a lot of room for home gardeners maintaining genetic diversity in a world that's becoming more homogenous.” And why not have them do research too? Some botanical gardens, including the one in Edinburgh, are already trying to track the subtleties of climate change by comparing various plant milestones year on year. Bringing home gardens into such networks would greatly increase the geographical reach of Edinburgh's researchers. Raven even imagines gardeners being issued with genetically identical indicator plants to make the data set really tidy.



Leafy retreat: Peter Raven, head of the Missouri Botanical Garden, thinks gardeners could be key players in efforts to protect biodiversity.

**“Botanical gardens are really the only places that have the skills to adapt the landscape to changing conditions.”**  
— Stephen Blackmore



Gardens may thus have a functional role in the struggle to understand environmental change. But as important or more so, say Crane and Blackmore, is their inspirational role: the model they provide of how to relate to the flora of the Earth. Metaphorical thinking about the plant world has swung like a pendulum over the past decades. A hundred years ago, humans saw plants as resources to be deployed in ways that best served man — whether in amber fields of grain or in formal strolling gardens. With the rise of environmentalism, the view that humans should let nature run its course and the wild run wild has gained strength.

But the wild, these days, is rather piebald. Roads and wires and concrete interrupt it almost everywhere. Some of the major constituents in various ecosystems are all but gone. So to keep what's there, it may be necessary to actively care for what is left, rather than to leave it be. “Most ecosystems are not what they were, and they have to be managed,” says Crane. And care is the hallmark of the gardener.

Blackmore says that only “long-term thoughtful intervention” will protect plant diversity. And in the future, with climate change increasingly apparent and familiar cycles out of whack, only a competent, calm cadre of scientific gardeners may be able to tell the world how to keep the plants we rely on going, he says. “Botanical gardens are really the only places at the moment that have the skills to adapt the landscape to those changing conditions. Maintaining biodiversity in the face of climate change is going to be a very active process.”

Emma Marris is a Washington correspondent for *Nature*.