

Save the Plants: Conservation of Brendel Anatomical Botany Models

ABSTRACT

For over one hundred years, the University of Florence Department of Plant Biology has owned a collection of anatomical plant models once used for teaching purposes. This collection was produced by the Brendel Company of Germany that had specialized in these models since the 1860s. The company brought together expert model makers and botanists to produce accurate plant models using basic materials: papier-mâché, wood, plaster, and gelatin. By the end of the nineteenth century, these models were renowned across Europe and the Americas for their accuracy and usefulness in the classroom.

By the start of this century, the University's models were badly neglected. Not only were the models left unprotected in a damp basement, but the collection appeared never to have been inventoried, and all the original documents had long since been mislaid.

This paper describes the project to conserve the Brendel models: an interesting, thought-provoking, and instructive study into how to treat these objects. It will consider the historical and pedagogical context of the models, as well as the complexities of their conservation, requiring the close collaboration of conservators and curators from different disciplines: botanist Graziana Fiorini, paper conservator Luana Maekawa, and objects conservator Peter Stiberc.

BACKGROUND

The late nineteenth century and first decades of the 1900s was a time when science, technology, and culture were quickly changing and developing, leading society into a new, modernized era. The World's Fairs were major attractions for participating countries and enterprises, often featuring outstanding architectural designs and introducing signifi-

cant inventions to showcase their achievements intended to accelerate development into the next century.

During this period the rational principles of illuminist and scientific methods were also being formed, and there was great intellectual fervor as the scientific disciplines gained new impulse.

Industry in general, including agriculture, needed to create a new body of highly educated, specialist workers with an understanding of how to apply these new technical advancements. Education, particularly in the technical sciences and medicine, was changing rapidly. With heightened interest in teaching botany, zoology, anatomical embryology, and mineralogy, high schools and universities required support material for adapting their teaching methods to the scale of demand. Developments in chemistry had made new substances and reagents available, new instruments were invented, and developments in optical microscopy to study live tissue and cytology opened new possibilities in the study of natural sciences and medicine.

The invention of the camera introduced scientific images and innovative techniques, such as photomicroscopy, were soon tested and explored. Images of magnified microscopic dimensions, hard or impossible to see with the naked eye or with a magnifying glass, presented a brand new world to discover and study in biology, crystallography, and physics. However, the microscope was not readily available to all (as is the case still today). There was a need to find a new way to demonstrate to large audiences of both high school and university students the microscopic detail of these new discoveries.

By the end of the nineteenth century, schools at all levels were busy modernizing and bringing teaching methods and science disciplines up to date. The demand for teaching models was substantially increased.

MODEL MAKING

During the eighteenth century wax models were used for the study of human anatomy, zoology, and botany, providing

Presented at the Book and Paper Group session, AIC 36th Annual Meeting, April 21–24, 2008, Denver, Colorado.

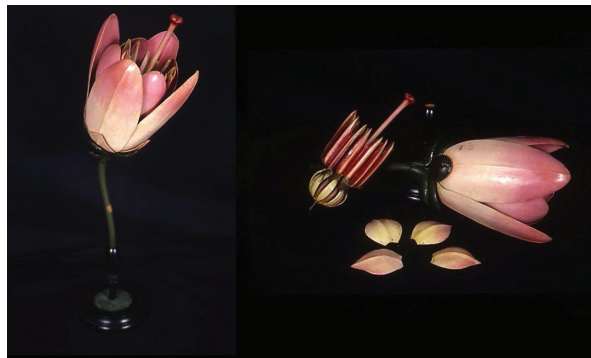
not only lifelike anatomical structures, but, with the introduction of the microscope, creating enlarged versions of the “unseen” world as well. The famous Florentine waxworks (established for the traditional manufacture of Christian



Fig. 1. University of Florence Brendel models



Fig. 2. Model enlarged 1500x. *Brachytecium acetabulum* Br. (six pieces), Bryopsida. R. Brendel, Berlin, no. 1



LEFT TO RIGHT
Fig. 3. *Fumaria officinalis* L. (four pieces), Fumariaceae. R. Brendel, Berlin, no. 89

Fig. 4. *Calluna vulgaris* Salisb. (five pieces), Ericaceae. R. Brendel, Berlin, no.103

votives in wax) of the eighteenth and nineteenth centuries created limited numbers of anatomical and botanical wax models and accepted commissions only from a select few clients: wax sculpture was a lengthy and costly process that only the most wealthy institutes could afford. Gaetano Zumbo (1656–1701), Clemente Susini (1754–1814), Paolo Mascagni (1755–1815), Francesco Lorenzuoli (1796–1829), Luigi Calamai (1800–1851), and Egisto Tortori (1829–1893) all were renowned for their high-quality anatomical wax models (Collezioni della Specola, Museo di Storia Naturale dell’Università di Firenze).

Many European countries, particularly France and Germany, established factories making models for schools and institutes. Models had to be scientifically accurate, relatively cheap to produce, and sufficiently durable to survive several generations of students. Papier-mâché was an economical and appropriate material for serial model making in large-scale production, along with other readily available materials such as plaster, wood, gelatin, textiles, and metal.

Among the more noteworthy model reproductions were Louis Auzoux’s (1797–1880) splendid papier-mâché models for human anatomy, Leopold (1822–1895) and Rudolf (1857–1939) Blaschka’s insuperable glass models of flowers and marine invertebrates, and Brendel’s models for botany: flowers, histological vegetal series, mushroom and fern cycles, inflorescences, and phytotaxy structures were highly appreciated and were sought by the best schools. Considering their scientific precision and realism, the educational value of nineteenth-century models has not diminished in the least, and indeed some schools are using them still today.

THE BRENDEL COMPANY

The Brendel company was founded in 1866 by Robert Brendel, in Breslau, now in Poland. Brendel enlisted scientific guidance from a local pharmacist, Dr. Carl Leopold Lohmeyer, and botanical advice from the Professor Ferdinand Cohn, director of the Breslau Agricultural Station. It was Professor Cohn’s suggestion to diversify away from medicinal plants and to include other species used in agronomy or

crop production, as well as a systematic approach to botany and vegetal anatomy.

The models (fig. 1) were created from molds and assembled by expert model-makers, using a wide variety of basic materials: papier-mâché, wood, plaster, gelatin, etc. The Brendel models were characterized and appreciated especially for their overtly large size (fig. 2) and by the novel feature of being able to dismantle and reassemble the pieces (figs. 3–4), adding an extra dimension to the role of the model in the classroom. Over time, production became richer and incorporated a wider range of models, close to two hundred, into their repertoire.

The models were sold via illustrated catalogs, either through correspondence or through a network of dealers, notably Giorgio Santarelli and Alberto Dall'Eco in Florence, Václav Frič in Prague (then Austro-Hungary), and, in the United States, James W. Queen and Company of Philadelphia, the largest wholesaler of such models at the time. The catalog bears detailed descriptions of some two hundred models, some with illustrations, and highlights the choice between basic models for elementary schools, and more detailed versions for colleges, universities, and agricultural academies (fig. 5). There were also scientific instruction manuals, in effect support material for teachers, edited by university botany professors.

By the time Robert Brendel died in 1898, the company was famed and respected across on both sides of the Atlantic, having diversified into zoology, anthropology, crystallography, and mineralogy. They had won gold medals at shows in Moscow in 1872, Cologne 1890, and at the World's Fair in Chicago in 1893.

Brendel's son Reinhold took over the business, moving production to Grünewald, just outside Berlin. Further awards flowed in, medals from the Exposition Universelle in Paris in 1900; Santiago, Chile, in 1902; the 1904 World's Fair in St. Louis; and in 1910 awards in Brussels and Buenos Aires. After Reinhold passed away in 1927, the records of the company's history become unclear. This is perhaps understandable, given the tremendous social and political upheaval that Germany went through during the next twenty years. There is, however, a German company PhyWe (in Göttingen) who continued producing models under the Brendel name, and their logo can be seen on some of the later twentieth century models seen in Florence (figs. 6–6c). Brendel models are often discovered by chance in public and private high schools throughout Florence and other Italian cities, or in antique shops. Few are in good condition; most appear to be clinging precariously to life in a moderate-to-poor state of preservation. It was quite fortunate that the University plant models were not tossed away or left to decay in the damp basement, and that their intrinsic value was recognized. Today there are perhaps as many as one thousand Brendel models still in Florence, spread between the school of agronomy, the science

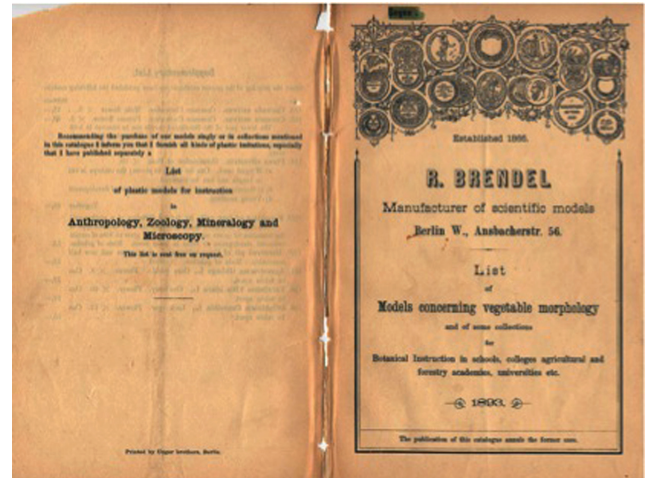
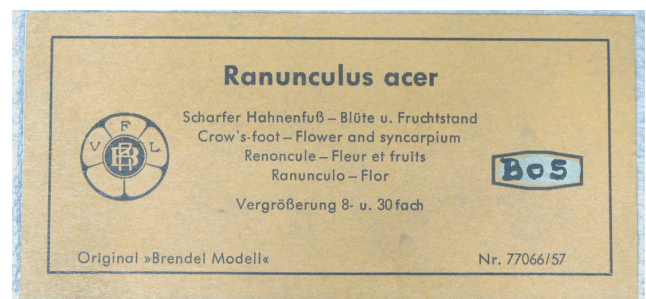


Fig. 5. R. Brendel's *List of Models*, 1893



Figs. 6–6c. PhyWe's model stand (top) with their label (middle) and "RB" logo (bottom, left), and 1963 tags (bottom, right)



Fig. 7. Different Brendel model bases

museum, and several high schools, and there are Brendel collections to be found in Europe, the United States, and Australia. Whilst the same quality and craftsmanship shows through on each model, there are minor differences in color, size, and detail that can be noted, including changing styles of the base units (fig. 7).

THE UNIVERSITY COLLECTION

The study of botany in Tuscany has a long and distinguished history. The world's first botanical garden was established in Pisa in 1543, by Italian ruler Cosimo I, so that medical students at the University of Pisa could study and gain firsthand experience of medicinal plants. Unfortunately, that was soon destroyed, and two years later he built a new one, this time in Florence. These plants, known as “*semplifici*”, gave their name to the gardens, still known today as the “*Giardino dei Semplici*”.

Over time, the study of plants grew into the creation in 1775 of the Imperial-Royal Museum of Physics and Natural History at La Specola's Botanical Garden, which in turn blossomed into the Royal Institute of Botany in 1898. It was during these years that the Institute moved and transferred to its newly restructured area and created the new Botanical Garden at the *Giardino dei Semplici*. Indeed, right next to the ancient garden is where the University of Florence Department of Plant Biology is located today.

Like many of its peers, the Florence Institute of Botany recognized the value of the new teaching materials available and invested in a collection of Brendel models. According to the 1906 inventory register, the first models were purchased from Giorgio Santarelli (a Florentine resale company of science materials) during 1898–99. Professor Oreste Mattiolo, then Director of the Botanical Institute, purchased a collection of sixty-six specimens, principally fungi, mosses, flowers, and insectivorous plants, for the grand sum of ITL 3,777 (equivalent to around \$19,500 today, or \$300 per model.) There are 168 Brendel models in the collection today; unfortunately, it was never thoroughly inventoried and documents detailing its provenance have been lost or forgotten. Extensive

research through the University's archives, however, pieced together a fragmented history of the collection.

The 1898 collection was augmented in 1921 by a further eleven models. Thereafter there are no records of any further purchases, yet today there are ninety-two more than records suggest were purchased. Thirty-seven are labeled as belonging to the Royal Institute of Higher Studies for Women, since absorbed into the University of Florence. These are from the same period and include several duplications, for which the conservators were very grateful later on. Further eighteen models still bearing the original Brendel labels were catalogued, thirty-five unlabeled models, and two labeled differently, a French model bearing the name of Émile Deyrolle in Paris (the store still exists today on Rue du Bac), and one labeled as “*Dall'Eco*” in Florence. It was common practice for dealers to relabel goods under their own label, and there is no doubt that these are Brendel models from the same factory and period.

DESCRIPTION AND CONDITION OF THE MODELS

Each model is glued to a vertical or bowed rattan rod which easily fits into a knob mounted on wooden base, both well-turned and polished in black lacquer. There are bases with one, two, three, or four knobs, depending on the



Figs. 8a–b. Single model bases (left) and two- to four-knobbed model bases (right)



Figs. 9–10. Circular and rectangular Brendel model labels



Fig. 11. *Cuscuta trifolii* Bab.–R. Brendel, Berlin, no. 108



LEFT TO RIGHT

Fig. 12. *Aristolochia siphon* l'Herit. (insectivorous model), Aristolochiaceae. R. Brendel, Berlin, no. 102

Fig. 13. *Mentha cervina* L.–R. Brendel, Berlin, no. 62 (ex R. Ist. Sup. Femm. FI)

number of plant elements represented (figs. 8a–b); others have the models directly attached. A circular or rectangular paper label identifies the model and is glued or affixed to the base with small brass nails. Some bases also have smaller slit knobs where labels were once exhibited. The circular labels on the bases are very detailed: there is the Latin nomenclature, the generic common name in German, the series number, the magnification of the object printed in black ink on green card, and the company name, *R. Brendel Berlin* (figs. 9–10). Earlier models seem to be written only in German whereas the later model generic names are also written in English, French, and Italian.



Fig. 14. *Ficus carica* L. (two pieces), Urticaceae. R. Brendel, Berlin, no. 136 (ex R. Ist. Sup. Femm. FI)



Fig. 15. *Salvinia natans* embryo model–R. Brendel, Berlin, unlabeled, (ex R. Ist. Sup. Femm. FI, no. 87–2), Anteridio (cellular division) R. Brendel, Berlin, no. 81 (1); *Pellia epiphylla* embryo model, R. Brendel, Berlin, no. 74 (1)

Together with their respective bases the models measure on average 50 to 60 cm in height. Most of the bases' diameters measure 12 or 14 cm, the smallest 10 cm and the largest, 20 cm.

The unusual shapes and awkward sizes of some of the models result in irregular weight distribution, making them unstable if handled incorrectly. Metal hooks and hinges are used to open and close some model parts or to secure them in place. Also some of the detachable elements had become badly worn, so that they no longer fit properly in place and tended to fall.

A wide variety of materials was used to form the different structures and appendages found on the models. These include wood, papier-mâché, cardboard, plaster, reed pith, metal, string, feathers, gelatin, glass or bone glue beads, and treated cloth. Many appendages are also formed of metallic thread, and other different fibers (horsehair, hemp, or silk threads). Some elements were made directly by plying rush twigs into the desired shape, while leaves, bracts, and flower petals or entire models were made from pressed cardboard or papier-mâché, primed and painted by hand (figs. 11–15).

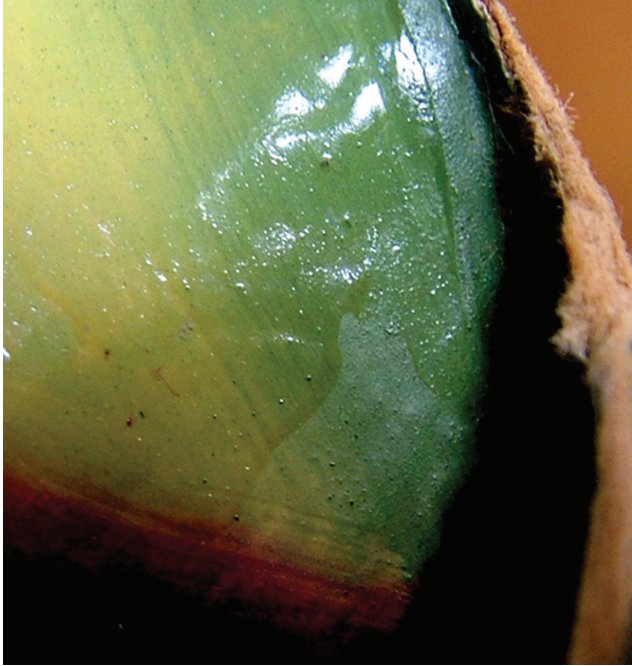


Fig. 16. Shellac over painted surface, detail *Calatide* (two pieces), R. Brendel, Berlin, no. 170b

Other shapes and models are in plaster and all details are painted by hand. The color used is pigment in a water-based medium, protected by a shellac varnish (fig. 16).

Some models are composed of a transparent, gelatin-based material (these are asterisked and noted in the Brendel catalogs (figs. 17–18). Certain parts of the plant structure, such as the spores, filaments, membranes, receptacles, and dissected organs, are also gelatin-based. These

are completely painted over and their gelatin structure was revealed only through areas where the layers of pigment had flaked away from the surface. The models in gelatin are also those in the most precarious state of preservation. Indeed, at the time of writing, appropriate solutions are still being sought for treating these models.

In general, the botanical models were poorly preserved. The factors that contributed to their degradation varied from constant handling to natural aging in time, but above all, it was the result of exposure to unstable preservation conditions in an unsuitable environment (stored in cardboard boxes in a damp basement). The more severely damaged models were those that could be dismantled or those with complex projecting structures. These were often broken into fragments, with damage to both the main structure and those attachments that were more delicate and susceptible to breakage, such as the bristles, thorns, anthers, and sepals (fig. 19). Moreover, previous inexperienced and unqualified repair attempts had been summarily performed on some of the models with Scotch tape and/or inappropriate glues, and these had partly damaged the painted surfaces (fig. 20). In addition to the dust and surface dirt accumulated on the models and their bases, there were areas with raised surfaces and losses of color, and many labels had become unstuck and were partly torn.

The general precariousness of the models was exacerbated by a more widespread form of damage—namely, cracks, fissures, complete disintegration of parts, and loss of adhesion of the whole structure; quite simply, they were just falling to pieces (fig. 21).

The support bases for the models were in reasonable condition, although many had suffered structural damage with cracks and holes where the wood had split or distorted.



LEFT TO RIGHT

Fig. 17. Gelatin-based models: *Equisetum arvense* L., Sphaenopsida. R. Brendel, Berlin, no. 5. *Utricularia vulgaris* L., Utriculariaceae. R. Brendel, Berlin, no. 135, and *Pinus silvestris* (3600x) (three pieces), R. Brendel, Berlin, no. 156

Fig. 18. Gelatin-based models: *Pteris serrulata* L. (four pieces), Pteridopsida. R. Brendel, Berlin, no. 6, and *Aspidium filix-mas* Sw., Pteridopsida. R. Brendel, Berlin, no. 8



Fig. 19. Damaged sepal in gelatin with delaminated paint. *Lycopodium clavatum* L., Lycopsidea. R. Brendel, Berlin, no. 193

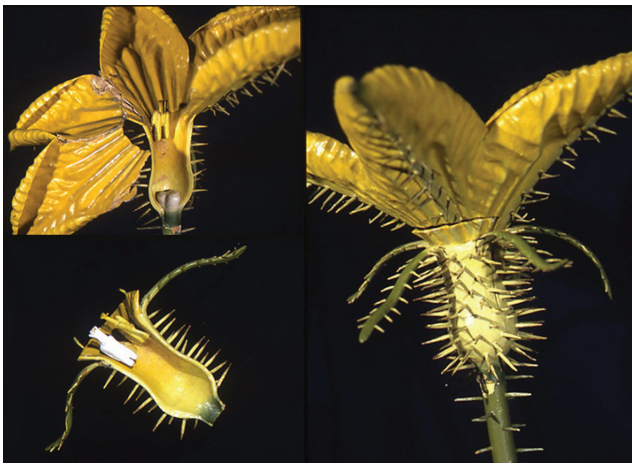


Fig. 20. Damaged paint surface and structure caused by use of inappropriate glues and handling, during treatment. *Cucumis sativus* L. (m) Cucurbitaceae. R. Brendel, Berlin, no. 152



Fig. 21. Damaged fragments

Almost all the bases evidenced woodworm holes and traces of xylophagous insects.

CONSERVATION OF THE BOTANICAL MODELS

The project to save the Brendel models from further degradation presented an interesting, thought-provoking, and instructive case study. The peculiarity of the collection and the wide range of materials used to construct the models presented a complex conservation task. Yet it was quite amusing to find the studio transformed, filled with brightly colored giant flowers, odd-looking translucent creatures, and miniature *maquette*-like sculptures, quite different and unusual from treating drawings and prints, crucifixes, and polychrome sculptures.

It was decided to divide the conservation treatment in two phases: the first to treat the support bases, and the second, the models. Tasks were also divided for handling and treating the paper elements and the other materials used between the paper and objects conservators and the scientist who was available for botanical consulting.

The fascinating synergy that was created between the three specialists is a fundamental aspect of the project that cannot be overlooked. In fact it proved to be a most pleasant and enjoyable learning and sharing experience. For example, take the *Equisetum arvense* (horsetail) models: with the aid of diagrams and live specimens, the botanist explained all phases of this non-flowering weed, in order to appreciate—with great fascination—the accuracy and precision of the Brendel models in reproducing even microscopic spore levels (fig. 22).

Whenever the conservators were faced with undecipherable fragments and there were no duplicate models on hand, the scientist's botanical expertise, supplemented as



Fig. 22. Horsetail “in bloom” at the Giardino dei Semplici (top picture); two live samples of strobili and sporangiophores (6 cm) and Brendel model (60 cm) *Equisetum arvense* L.—Sphaenopsida. R. Brendel, Berlin, no. 2. Gelatin models of the horsetail's microscopic phases; *Equisetum arvense* L. (20–100x) (four pieces), Sphaenopsida. R. Brendel, Berlin, no. 3; *Equisetum arvense* illustration in Tonzig, S., *Elementi di Botanica*

appropriate by live specimens and/or scientific drawings, was invaluable in helping to understand from a scientific perspective the fine detail required to reconstruct the broken or missing pieces (fig. 23). The botanist was equally fascinated to learn of all the different materials that had been used to create the models, as well as of the conservation techniques used to restore and preserve them.

To proceed in a systematic and orderly manner, all of the models were numbered, photographed, and filed individually,



Fig. 23. Phases during treatment. *Peronospora viticola*—Eumycetophyta, Oomycetales. R. Brendel, Berlin, no. 5



Fig. 24. Treatment of base

and then divided in groups according to dimension, materials, and types of damage that required treatment.

Treatment of the bases

The models were removed from their bases and each placed vertically in a temporary container. All bases were preventively treated with a Permethrin-based insecticide solution (Permetar) in turpentine. Excess amounts of hardened glue used in the earlier “do-it yourself” fix-it attempts were removed from the base surface before proceeding with consolidation. Where necessary the damaged areas were reconstructed and the woodworm holes stuccoed with a two-component epoxy putty (Araldite HV427), and then in-painted with black pigment. Some of the smaller holes were sealed with wax-based stucco tinted with black pigment. Lastly all the bases were treated with a protective layer of microcrystalline wax in turpentine (fig. 24).

The paper labels whose edges and corners were loosened or torn were adhered to the base with an acrylic emulsion (Plextol B500), while the holes and gaps were filled with pre-tinted paper pulp or paper inserts. The labels in the most precarious condition, with brittle paper and with numerous tears, were removed from their base and treated apart. Once the labels were consolidated with Japanese paper and methylcellulose adhesive, they were re-glued to the bases. The surface of the labels was then treated with a protective layer of Klucel G, 20% solution in ethanol.

Treatment of the models

For secure, effective, and controllable surface cleaning, a system using small cotton swabs dipped in 2% solution of oxgall was selected. This surfactant allowed for cleaning the polychrome surface. The areas with flaking color (fig. 25)



Fig. 25. Flaking color



LEFT TO RIGHT

Fig. 26. Before and after treatment: *Zea mays* L. (two pieces), Gramineae. R. Brendel, Berlin, no. 28

Fig. 27. Before and during treatment: *Clematis integrifolia* L.—R. Brendel, Berlin, no. 63 (ex R. Ist. Sup. Femm. FI)

were treated and refixed to the surface with Acril 33, a pure acrylic resin in aqueous dispersion.

Consolidation of the model's structure consisted of three different aspects:

- Readhesion of detached single elements
- Complex readhesion of multiple elements
- Readhesion and reintegration/reconstruction of missing parts

In all three cases, vinyl and epoxy rapid-setting adhesives were used with plastic or wooden clamps, depending on the weight and structural stability of the element under treatment (figs. 26–27).

Whenever possible, materials similar to the originals were used to reconstruct the missing parts. For example, wooden toothpicks were used for the fine bristles (fig. 28), cotton threads for the filaments, silk gauze for the sepals, and new metallic hooks replaced damaged or missing hooks on models with movable or detachable parts.

Reconstruction of missing elements was undertaken only where necessary for coherence or for restoring structural stability. A few model parts could be reconstructed looking at the duplicate models from other collections mentioned earlier. The missing parts were reconstructed using either paper or papier-mâché, cast on polyvinyl silicone molds (as used in dentistry), created from corresponding original parts (figs. 29–31). The more compact shapes were reconstructed with araldite, primed with a plaster and glue preparation, and then painted (figs. 32–34).

The surfaces with color loss were restored with pigmented, wax-based stucco. All of the restored polychrome elements with small or large gaps were inpainted with pigment and Mowilith 20 (vinyl acetate) in ethanol.

The packaging phase of the restored models was just as important and as indispensable for safely transporting the models back to the University's Department of Botany. It was fascinating to learn that in 1826, French model maker Louis Marc Antoine Robillard d'Argenteille, returned to Paris aboard the *William Wallace* from Mauritius, where



Fig. 28. *Papaver rhoeas* L. (two pieces), Papaveraceae. R. Brendel, Berlin, no. 87

he had spent twenty-four years creating 112 wax tropical fruits and plants: the *Carporama* exhibited there today, at the Musée Nationale d'Histoire Naturel. In less than a day, he had them packed ready for shipment in wooden crates reinforced with metal; despite what must have been a rough passage by modern transportation standards, each and every one survived intact! In the case of the Brendel Collection, funds were not available for the construction of bespoke (custom-made) cases for each model. The alternative was to devise secure and economical packaging for the journey across town. Firstly, each model was wrapped in lightweight paper and then with bubble wrap. Three to four models were then carefully placed and securely fitted into large cardboard boxes so that they could not nudge against each other or tip over during transportation by van to their final destination.

CONCLUSION

Model makers worked side by side and in close collaboration with scientists, along the fine line where the artist becomes scientist and the scientist an artist. Both artisan and



LEFT TO RIGHT

Fig. 29. Integration and reconstruction with paper and papier-mâché. *Brassica napus* L. (two pieces), Cruciferae. R. Brendel, Berlin, no. 19

Fig. 30. *Taraxacum vulgare* Schrank (three pieces), Compositae. R. Brendel, Berlin, no. 119 (or no. 238)

Fig. 31. *Viola tricolor* L. (two pieces), Violaceae. R. Brendel, Berlin, no. 90

scientist worked to create replicas of nature, devising ways and choosing materials that could best represent or imitate the specimen. Though these were modular, standardized creations—the products of modernized factory work—the series of models were all painted, assembled, varnished, and lacquered by hand, conferring a unique quality to each model. Are these stylized, curvilinear designs incorporating floral and other plant motifs, or are they scientific, oversized imitations of life? Does one see smoothed, polished surfaces and abstraction in the service of pure design, or factual interpretations in the service of scientific learning?

For the Brendel collection, it was the close collaboration of expert curators in different disciplines that determined and delivered the appropriate treatments, techniques and methodology required to overcome the challenges and to preserve the models. In such disciplines, the opportunities for collaboration are rare and greatly appreciated. Above all, however, each is honored to have had the opportunity to appreciate at close quarters both the technical skills and the scientific accuracy of the master model makers of Brendel. It is hoped that these collaborative efforts will have helped to prolong the shelf life of these living plants so that for years to come, others will share the sense of wonder and delight that these botanical beauties generate. It is also hoped that schools, Scientific Institutes and Museums will become more aware of their forgotten or hidden historic model collections and perhaps stumble across “new” Brendel models to add to the list of “plants to be saved” around the world.

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Figs. 32. Reconstruction with araldite and gesso, then inpainted. *Pinus sylvestris* L. (f) (two pieces), Pinophyta, Pinaceae. R. Brendel, Berlin, no. 41



Fig. 33. *Taxus baccata* L. (f) (three pieces), Pinophyta, Taxaceae. R. Brendel, Berlin, no. 40



Fig. 34. Detail of figure 33

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(ALL ACCESSED 2008)

Louis Auzoux (1797–1880). Le Musée de l'Ecorché d'Anatomie du Neubourg: <http://www.abdn.ac.uk/zoologymuseum/treasures/auzoux.php>.

Leopold and Rudolf Blaschka: <http://bbs.keyhole.com/ubb/showflat.php?Number=748642>.

Chase Studio, Inc. Cedar Creek, Missouri: Natural History Exhibit Designers and Builders: <http://www.chasestudio.com>.

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GRAZIANA FIORINI

Botanist and Curator

University of Florence

Department of Plant Biology

Florence, Italy

graziana.fiorini@unifi.it

LUANA MAEKAWA

Paper Conservator in Private Practice

Florence, Italy

maekawlu@yahoo.it

PETER STIBERC

Objects Conservator

Opificio delle Pietre Dure

Florence, Italy

p.stiberc@virgilio.it