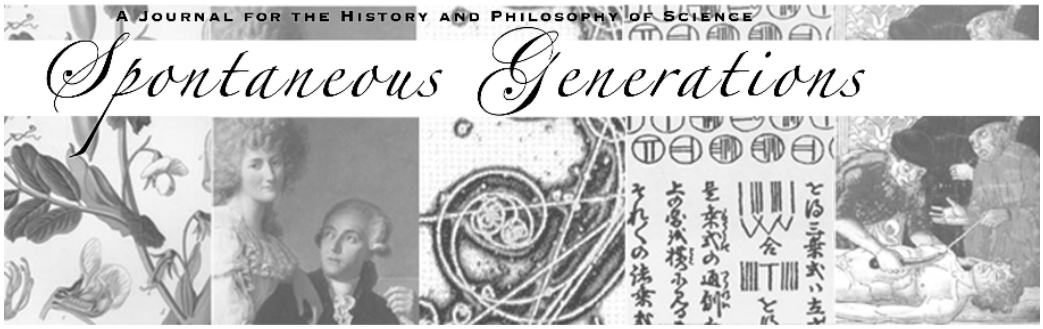

Flatter than a Pancake: Why Scanning Herbarium Sheets Shouldn't Make Them Disappear

Author(s): Maura C. Flannery

Source: *Spontaneous Generations: A Journal for the History and Philosophy of Science*, Vol. 6, No. 1 (2012) 225-232.

Published by: The University of Toronto
DOI: 10.4245/sponge.v6i1.16134

EDITORIAL OFFICES

Institute for the History and Philosophy of Science and Technology
Room 316 Victoria College, 91 Charles Street West
Toronto, Ontario, Canada M5S 1K7
hapsat.society@utoronto.ca

Published online at jps.library.utoronto.ca/index.php/SpontaneousGenerations
ISSN 1913 0465

Flatter than a Pancake:
Why Scanning Herbarium Sheets Shouldn't Make Them Disappear*,†

Maura C. Flannery‡

Herbaria are collections of preserved plant specimens, primarily composed of paper sheets with pressed plants or plant parts attached to them. Each specimen is labeled with the plant's genus and species, name of the collector, where collected, and when. The most valuable kind of sheet is the holotype specimen. This is the specific plant that was used in describing the species by the person who first identified it. Often several specimens were taken from the same plant that became the holotype, and these are called isotypes. Both the holotype and isotypes may be called a type. Because of the importance of the type, the isotypes are usually sent to several herbaria as insurance that a type will still exist even if one or more of these sheets are destroyed.

A type is the specimen that botanists must reference when reclassifying or renaming a species. This means that they must either travel to the herbarium that houses a type or borrow the sheet. Active herbaria are like lending libraries in that there is traffic in specimens being borrowed and lent. If a researcher is reevaluating an entire genus or family, this can mean visiting one or more herbaria and/or borrowing scores, if not hundreds, of sheets, a process that is labour-intensive and expensive but also essential. The plant itself, and in particular the type specimen, is the final arbiter in any taxonomic determination, the visual evidence of the plant's characteristics. It was out of the usefulness of the herbarium sheet that the type concept arose at a time when the number of new species, and of botanists, was proliferating. Often the same plant was given two different names by different taxonomists. By anchoring the name to one specimen, botanists hoped that such duplication would eventually be eradicated

* This article was written with the support of the St. John's University Faculty Writing Initiative. I would also like to thank the herbarium curators who have been so gracious with their time in our conversations.

† Received 23 February 2012.

‡ Maura C. Flannery is Professor of Biology and Director of the Center for Teaching and Learning at St. John's University, NY. She has published a number of articles on the relationship between art and biology; she is now focusing on the history of botanical collections and botanical illustration.

(Daston 2004, 153-54). That day hasn't come, but type specimens have brought much order to the field.

For a non-botanist, looking at a type specimen can be a disappointing experience. Take, for example, the sheet for a brightly-colored orchid species in flower—and the majority of herbarium sheets display the plant in flower because it is this reproductive structure that is usually most important in classification. On the sheet, the orchid, including the flower, is brownish in color, with little hint of the vibrant greens of its leaves and stem or of the purple or yellow of its petals. In addition, the plant is flat as a pancake. The three-dimensional plant specimen has been pressed between pieces of absorbent paper for days or longer to dry it, a necessary step in preservation. If the plant remains moist, it is almost immediately attacked by agents of decay, molds and bacteria, and becomes useless for taxonomic purposes. If well-dried and attached to a sheet of acid-free paper, a specimen can last literally for centuries. The oldest extant herbarium sheets, from the mid-sixteenth century, are those of Gherardo Cibi, a student of the Italian botanist Luca Ghini who created the first herbarium. Before the time of Carl Linnaeus, sheets were bound in volumes, but this prevented them from being rearranged as classifications were updated. Linnaeus laid his sheets flat in a cabinet organized on shelves for each of the plant families he created. This is essentially the same system used today, with sheets of a single genus collected in a file folder and the folders stacked in a metal cabinet. The folders are never stored vertically because the pull of gravity can loosen material from the specimens.

Brown and Flat

In *The Order of Things,* Michel Foucault notes that when natural history developed in the eighteenth century—the age of Linnaeus—"the need was to bring language as close as possible to the observing gaze, and the things observed as close as possible to words. Its genius was in restricting the area of its experience" (Foucault 1970, 132). By this he means that the observations considered relevant neglected taste, smell, touch, and even colour; vision was preeminent, but black-and-white illustrations were enough. Linnaeus even looked down on these, perhaps in part because he was not a very able artist (Reeds 2004, 249), but he prized his herbarium. While to a novice the orchid sheet may look disappointing because it is brown, flat, and dried, to a plant taxonomist everything is present that's necessary to classify the plant. Foucault makes the point that for the naturalist, seeing a few things systematically is enough for identification, and these are: the forms of the structural elements, their quantity, how they are distributed in space relative to each other, and their relative magnitudes. This is precisely what can be determined about a plant from an herbarium specimen. The flower is intact with all its structures, the usual main points for species determination. The other structures are also present, and

their sizes can be measured; in addition, the relationships among the structures are apparent despite the flattening. While the specimen's flatness might seem to make relations in space difficult to detect, a botanist with experience of live plants is able to determine such space relationships as whether the leaves are arranged opposite to each other on the stem, alternately along the stem, or in whorls around the stem.

Besides being used in the identification of plants and in determining their relationships with each other, herbaria serve a number of other functions. They document what plants were found where at a particular moment, so they can be used to track environmental change. For example, they can tell botanists the date the first specimen of an invasive species was collected in a particular area or when the last specimen of a disappearing species was recorded. If a plant in flower was collected in May a hundred years ago, and now the same species, collected in April, is in flower, that may be one more piece of evidence for global warming (Primack et al. 2004, 1260). A study of herbarium specimens can help pinpoint when a particular invasive beetle species first arrived in a country by noting the first dates of the preserved plant specimens in which significant amounts of the anti-beetle secondary metabolites are detectable (Zangerl and Berenbaum 2005, 15529). There are even cases where herbarium specimens have been analyzed for mineral content as a way to identify areas with high concentrations of a particular mineral in the soil and therefore possible sites to mine for that substance (Mabey 2010, 136). Needless to say, if minerals and metabolites can be extracted from herbarium specimens, so can DNA, at least in some cases (Andreasen et al. 2009, 959).

Accessibility

These examples indicate the importance to botany and environmental science of herbaria, but despite this value they are often under attack from their home organizations, whether these be educational institutions, museums, or government agencies. All those storage cabinets take up room, and it's costly to protect that space from the three worst threats to herbaria: fire, flood, and insect damage. In addition, pressing, labeling, filing, and lending specimens are labour-intensive tasks. Even if space and money are allotted to support these collections, there are still problems of accessibility, which brings up a major social justice issue. Many plants collected in underdeveloped nations have ended up in the collections of developed nations. Particularly in the past when many types were determined, most of the collecting was done by individuals from wealthy nations, often colonial powers; these explorers then returned to their homelands with the specimens. For example, in the family Rubiaceae, there are thirteen thousand species in 611 genera. Europe only has fourteen genera while Angola has 108, yet ninety-six percent of the type specimens are in Europe (Figueiredo and Smith 2010).

It was to alleviate this inequity that the JSTOR Plant Science project was undertaken by the Andrew W. Mellon Foundation with the goal of digitally imaging two million herbarium sheets, many of them type specimens, as well as the botanical literature needed to support research on these species. The project began as an effort to make African plant specimens available to African researchers. After that project, the focus shifted to South American species, and now specimens of Asian plants are being scanned. While the availability of high-quality 600 dpi images of sheets on the Web is useful, the project assumes that researchers in Third-World countries have the technology to access these images. Despite problems with this assumption, having images available electronically is definitely a step in the right direction toward righting inequities. In addition, the institutions that received Mellon funding now have digitizing equipment so they can continue to scan more of their collections, and there are several other large-scale projects funding such activities. In the United States, there have been a number of NSF grants given for digitization, both of the information on herbarium sheets, as well as the sheets themselves.

Benefits and Disadvantages

Digitization efforts have had a number of benefits. They obviously make research easier because botanists can often get the information they need from viewing the scanned images without having to borrow sheets or travel to see them. Since many smaller collections in schools and museums have been "orphaned"—that is, have lost their homes and been absorbed by larger institutions such as the Field Museum in Chicago and the New York Botanical Garden—it often takes longer to travel to see a particular specimen than it once did; digitization eases this problem. It also makes collections accessible to a larger audience. A gardener might be too intimidated to visit an herbarium for help in identifying a plant, but now he or she can look at specimens online. Most K-12 institutions long ago lost their specimen collections—if they had them in the first place—but with virtual herbaria, their students can work out plant identifications just as researchers do: all of Foucault's basic elements exist in the electronic image.

Because of the usefulness of virtual herbaria, some have suggested that most herbarium specimens, apart from types, could be eliminated after they are scanned, thus saving institutions considerable space and money. One article (Clifford et al. 1990, 602) on this brought a barrage of letters to the editor rebutting its contentious thesis (Stevens, 1990, 222-23). Though administrators may now be loath to put such thoughts in print, that hasn't stopped them from taking actions to effectuate the same result. One university herbarium curator I spoke with said he was not jumping on the scanning bandwagon beyond types because he was worried about the consequences to the physical collection. Even if physical specimens are not destroyed, neglect can lead to the same

outcome either through loss of specimens when lack of care results in attacks by dampness, mold, and insects, or because lack of use would justify elimination. The latter is obviously what herbarium curators fear most.

Another problem with virtual collections is that it's difficult to measure their use and thus justify keeping professional taxonomists on staff to support the collections. While curators maintain detailed records on how many times their physical collections are consulted by botanists, it is more difficult to keep comparable digital records. Yes, they can tally how many times their virtual herbarium pages are accessed, but these numbers don't prove that the viewers are serious plant scientists who as a result of their access are publishing papers using this specific collection. If measuring digital access to specimens can be accurately achieved, then ironically, more digital use may help in maintaining the physical collections, especially if curators can document that digital use leads to requests to see the sheets themselves.

This is sometimes the case because the image is not a perfect replacement for the physical sheet. Chemicals such as DNA cannot be extracted from it, and small pieces cannot be removed for microscopic examination of anatomic structures or for other analyses. Besides lack of access to real plant material, the digitized specimen also lacks the texture of the physical sheet. The specimen may be flat as a pancake, but pancakes do have some depth, and also, they aren't paper-smooth. Both these qualities are even truer of plant material. The actual sheet can be lifted and looked at from a variety of angles, useful because lighting a sheet from the side can reveal more texture. This can be particularly important with leaves and other structures that have trichomes or hairs. These are usually visible in a good digitized image, but their number and positioning are more easily seen on the specimen itself. In other words, examining a sheet and an image of a sheet are different phenomenological experiences. As C.F.S. Pantin (1954, 596) noted many years ago, a great deal of taxonomic knowledge is of the tacit kind, since it is phenomenological and therefore difficult, if not impossible, to put into words. Digital images do not provide the same phenomenological experiences as do actual specimens. The argument could be made that some of the textural information has already been erased by pressing the specimen, and this is definitely true. However, digitization compounds the problem.

A New Interest in Herbaria

As with any technological advance and its implementation, there are obviously pluses and minuses to scanning herbarium specimens. As I have attempted to suggest here, the advantages outweigh the disadvantages, especially in terms of access. What I want to end with is what I see as the excitement that virtual herbaria have brought to the world of plant science. For years, botanists have bemoaned the lack of interest in their science and in plants in general. They have even come up with a name for this malady: plant

blindness, the public's unawareness of the importance of plants to its wellbeing and to life itself (Wandersee and Schussler 1998, 82). This invisibility is a serious problem for curators and one of the reasons for the vulnerability of herbaria to administrative attacks. The problem is that collections of dried plants don't sound very appealing to the general public. Meanwhile, though botanists value herbaria, many simply take them for granted. In the best-known botany text, the word "herbarium" is not even found in its very extensive index (Raven et al. 2005, I1-I62). This invisibility is also evident in natural history museums housing both zoological and botanical collections. I would venture that at least ninety-five percent of the displays in these institutions focus on animals, and when plants do appear, they are often in the backdrops of dioramas with large animals in the foreground. Rarely is more than a smattering of herbarium sheets displayed.

Obviously a flat, dried plant isn't as cute as a beaver or a penguin, and even deadly nightshade doesn't come across as fearsome like a lion. However, when a deadly nightshade (*Solanum interius*) herbarium sheet is coupled with information about the plant's properties, and when several images of sheets are available, as they are in the JSTOR Plant Science database, with tools to measures the plants' parts, then students can participate in a real botanical investigation and access related references as well. Such an experience can indeed be exciting, as Oakes Ames describes his own experience with type specimens: "One of the thrills of my career came in Paris when I turned with breathless interest to the Richard and Goleatti types and drawings to see at last just what was meant by hopelessly obscure words," and he found it difficult to express his "sense of happiness" (Ames 1979, 79). Perhaps students may not be so enraptured; however, if live plants can be examined at the same time as the digital image then the value of the digital record is enhanced. Then students can observe the similarities and differences between the two.

It is not only students who could benefit from such exposure. There are several indications that the availability of digital herbarium collections is allowing them to be more broadly appreciated. This is not just because the collections themselves are more easily available on the web, but because of social media as well. There are numerous examples of gardeners, artists, historians, and environmentalists including scans of herbarium specimens in their blog posts. This suggests that many specimens have cultural value outside of science. For example, specimens collected by Lewis and Clark have great historical significance, as do those of Charles Darwin and those of Linnaeus himself. Such literary figures as Johann Wolfgang Goethe, Jean Jacques Rousseau, and Emily Dickinson all kept herbaria. All these collections are freely available online. JSTOR Plant Science sponsors a blog with posts that often deal with the historical or cultural significance of sheets in its virtual collection. More and more museum and university herbaria are updating their virtual herbaria to attract similar attention. As these resources become better known, the

invisibility of herbaria may begin to fade.

It's also becoming more common for artists to explore herbarium collections and even aid in digitization. Joanne B. Karr, a British artist, has collaborated with a small Scottish museum in scanning the herbarium of Robert Dick (1811-66), a Scottish baker and botanist. The sheets were digitized and then the backgrounds digitally "cleaned" to remove brown spots and signs of age on the paper. This is sometimes done in digitization projects, though usually not in standard scans of herbarium sheets. Whether or not such cleansing has a positive effect is a matter of debate. The processed sheet looks clean and neat, but in some cases the dry, brown specimen seems incongruous against the pristine white background: the two just don't go together. For a book on John Muir, digitization of some specimens went even further: the labels themselves were electronically erased, moving the plants from works of science to works of art (Gisel 2008, 23 and 30-31).

Other artists besides Karr have drawn inspiration from herbarium collections. Rob Kesseler, a ceramicist, has been an artist-in-residence at the herbarium of the Royal Botanic Gardens, Kew (Cressey 2011, 177), and the painter Victoria Crowe held a similar position at the Cambridge University Herbarium. The more we allow artists and other non-scientists to observe the living world in all its manifestations, the more deeply they will not only know but relate to that world. Herbaria are wonderful visual resources, and digitization is a technology for making these resources more available and more obvious to the world beyond the botanical community. This is definitely a major contribution to the fight against plant blindness.

Maura C. Flannery
St. John's University
8000 Utopia Parkway
Jamaica, NY 11565
USA
flannerm@stjohns.edu

References

Ames, Oakes. 1979. *Jottings of a Harvard Botanist*. Cambridge, MA: Botanical Museum of Harvard University.

Andreasen, Katarina, Mariette Manktelow, and Sylvain G. Razafimandimbison. 2009. Successful DNA Amplification of a More than 200-year-old Herbarium Specimen: Recovering Genetic Material from the Linnaean Era. *Taxon* 58(3): 959-62.

Clifford, H. T., R. W. Rogers, and M. E. Dettmann. 1990. Where Now for Taxonomy? *Nature* 346(6285): 602.

Cressey, Daniel. 2011. Botanical ceramicist. *Nature* 479(7372): 177.

Daston, Lorraine. 2004. Type Specimens and Scientific Memory. *Critical Inquiry* 31(1): 153-82.

Figueiredo, Estrela, and Gideon F. Smith. 2010. The Colonial Legacy in African Plant Taxonomy. *South African Journal of Science* 106(3/4): Article 161.

Foucault, Michel. 1970. *The Order of Things: An Archaeology of the Human Sciences*. New York: Random House.

Gisel, Bonnie J. 2008. *Nature's Beloved Son: Rediscovering John Muir's Botanical Legacy*. Berkeley, CA: Heyday.

Mabey, Richard. 2010. *Weeds: In Defense of Nature's Most Unloved Plants*. New York: HarperCollins.

Pantin, C. F. A. 1954. The Recognition of Species. *Science Progress* 42 (October): 587-98.

Primack, Daniel, Carolyn Imbres, Richard B. Primack, Abraham J. Miller-Rushing, and Peter Del Tredici. 2004. Herbarium Specimens Demonstrate Earlier Flowering Times in Response to Warming in Boston. *American Journal of Botany* 91(8): 1260-64.

Raven, Peter, Ray Evert, and Susan Eichhorn. 2005. *Biology of Plants*. 7th ed. New York: W.H. Freeman.

Reeds, Karen. 2004. When the Botanist Can't Draw: The Case of Linnaeus. *Interdisciplinary Science Reviews* 29(3): 248-58.

Stevens, P. F. 1990. In Defense of Taxonomy. *Nature* 347(6290) (September 20): 222-23.

Wandersee, James, and Elizabeth Schussler. 1998. Preventing Plant Blindness. *American Biology Teacher* 61(2): 82-86.

Zangerl, Arthur, and May Berenbaum. 2005. Increase in Toxicity of an Invasive Weed After Reassociation with Its Coevolved Herbivore. *Proceedings of the National Academy of Sciences* 102(43): 15529-32.