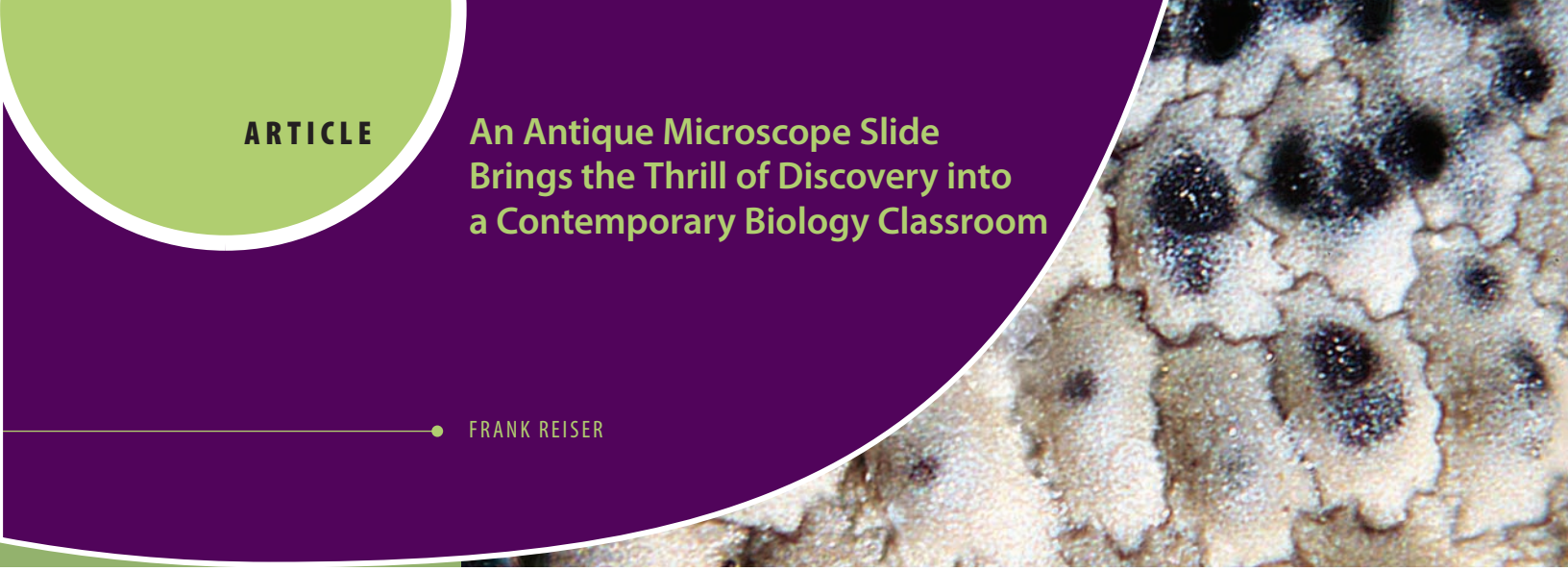
ARTICLE

An Antique Microscope Slide Brings the Thrill of Discovery into a Contemporary Biology Classroom



FRANK REISER

Abstract

The discovery of a Victorian-era microscope slide titled "Grouped Flower Seeds" began an investigation into the scientific and historical background of the antique slide to develop its usefulness as a multidisciplinary tool for PowerPoint presentations usable in contemporary biology classrooms, particularly large-enrollment sections. The resultant presentation was intended to engage students in discussing historical and contemporary biology education, as well as some of the intricacies of seed biology. Comparisons between the usefulness and scope of various seed identification resources, both online and in print, were made.

Key Words: *Grouped Flower Seeds; Watson and Sons; antique microscope slide; online seed identification resources; seed identification manuals; seed biology; large-enrollment lecture.*

Large-enrollment lecture sections are difficult teaching environments for practitioners of constructivist or inquiry-based methodologies. As class sizes grow, I find that my efforts need to be logarithmically increased to overcome the "alone in a crowd" feeling seemingly wedded to budget-saving, mass-education modes. Thankfully, the digital projector has become ubiquitously available for educators who desire to connect intellectually with the individual student awash in a sea of heads. When one couples the projection device with digital photography and a display program such as PowerPoint, a computer-savvy educator can compile and express the personal experiences of learning and discovery to large groups. For me, a fulfilling part of teaching is being able to share with a class what I am currently studying and the pathways that I've had to follow – pathways that usually intersect other disciplines, such as history, culture, art, business, and more. Every disciplinary intersection provides an opportunity for students viewing the presentation to link what they have previously learned to the biological content of the day's curricular goals.

I am fascinated by old science equipment, particularly pieces related to biology teaching.

○ The Teacher's Interest Triggers the Process

I am fascinated by old science equipment, particularly pieces related to biology teaching. When items are affordable, which is often (so I suspect that few others share my interests), I add them to my growing collection. When I found skillfully prepared Victorian-era microscope slides listed under the category "Folk Art" in an antique dealer's online catalog, it led not only to my acquiring them but also to the beginning of a journey involving Internet and library research, trips to herbaria, field collecting excursions, and, finally, to the development of a PowerPoint lecture for community college biology students. The slide that triggered the snowballing project is titled "Grouped Flower Seeds" (Figure 1).

Having spent most of my life as a biology educator, I view most of what I encounter in life from a science-oriented perspective. Finding prepared microscope slides described as "folk art" sharply conflicted with my sense of the correct order of disciplines – particularly for items that I would reverently classify as the tools of scientists. The antique dealer's case for placing antique slides under a "folk art" heading is arguably correct from an artistic perspective. The most straightforward definition confirming that comes from Oregon State University's Department of Anthropology, which defines folk art as "any art created by a self-taught individual" (http://oregonstate.edu/instruct/anth370/). This definition encompasses microscope slides of subjects such as micro-writing (example: *The Pledge of Allegiance* written on a grain of rice) within the purview of the arts and provides good fodder for student discussions as to where the line should be drawn.

○ The Who, What, Where & When of the Slide

William Watson & Sons, Company, London (1834–1957), was a large supplier of optical instruments and prepared microscope slides, selling by catalog in both England and the United States between 1834 and 1957. Why would a company produce and market a microscope slide of flower seeds glued in a symmetrical arrangement? There are no indications that "Grouped Flower Seeds" (GFS) was intended to serve a purpose in academic biological study. Simply put, the GFS slide was made to be an entertaining novelty for the thriving amateur microscopist market of the time. From 1837 to 1901, which many biologists have dubbed

The American Biology Teacher, Vol. 74, No. 5, pages 311–317. ISSN 0002-7685, electronic ISSN 1938-4211.
DOI: 10.1525/abt.2012.74.5.5

Figure 1. "Grouped Flower Seeds," a prepared microscope slide arrangement of 92 angiosperm seeds glued on an opaque background. Produced by W. Watson & Sons, High St., London, ca. 1890 (10×).

Figure 2. After 1907, "Ltd." was added to the Watson label; its absence indicates that the GFS slide was produced earlier. Notice the glass slide's finished edges and corners and the black enamel ring sealing the specimen.

the "Golden Age of Natural History," nature study was a popular pastime. Having a microscope in the home was not uncommon among families well-off enough to have leisure time. Exploring nature's microscopic world was a hobby enjoyed by many microscope owners, while others less involved might set up a microscope with slides as a conversation seed-crystal during social functions.

"Grouped Flower Seeds" is a dry mount with an opaque black background, requiring oblique, top-stage illumination for microscopic viewing. Ninety-two small seeds are glued into a geometric pattern, surrounded by a metal collar to prevent the cover slip from touching the seed arrangement. Outside the mount, gloss enamel paint seals the chamber from external humidity. There is no mounting medium filling the space between the seeds and the cover slip, so the slide is fragile. Rough handling could dislodge the seeds from their positions, ruining GFS's geometric arrangement, so allowing students unsupervised viewing of the deep-mount slide would be risky.

The slide's date of creation is estimated to be between 1890 and 1907. The approximation was inferred by comparing the labels affixed to GFS with matching label designs used by W. Watson & Sons, as illustrated in Bracegirdle's compendium of antique microscope slides (Figure 2). Additionally, a Watson & Sons advertisement listed a slide titled "Grouped Flower Seeds" in the 1893 edition of *Hardwicke's Science Gossip*, confirming the existence of a slide with the same name being offered by the company during the corresponding time range. Because Watson & Sons resold slides made by other commercial preparers under their label, the actual creator of GFS is not known; but with databases containing digitized catalogs, magazines, newspapers, and books of the period rapidly growing online, the GFS artisan may yet be uncovered.

William Watson started his business as an optician's shop in London, England, in 1837. By 1876, the company had grown from manufacturing spectacles and magnifying glasses into producing microscopes and cameras of the firm's own design. Their catalog advertised a large microscope slide inventory until World War II (1939), at which time the company was conscripted to manufacture optical instruments for military use. After the war ended, the company, now owned by the founder's grandchildren, dropped prepared slides from the company catalog. A few years later they retired, permanently closing the company's doors.

By avocation, William Watson was a horticulturalist and maintained his own greenhouse. He conducted experimental crosses between flower varieties, publishing a number of his studies in respected journals of the time. How involved Watson was in the production of the GFS slide is not known, but he unquestionably had access to a variety of plant seeds for the slide's production – an important consideration when searching for the identity of the seeds used to make the slide (Bracegirdle, 1998).

I purchased the GFS slide for several reasons, not the least of which was the opportunity to add an interesting piece to my personal collection of Victorian scientific paraphernalia. I also wanted to incorporate the slide's image into my class lectures, using it as an interdisciplinary bridge between biological, historical, and artistic arenas. Another reason for

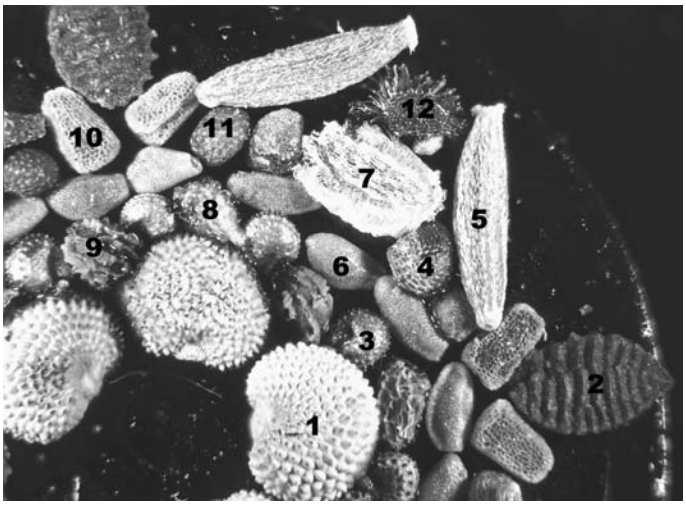


Figure 3. "Grouped Flower Seeds" identification key. (1) *Silene latifolia alba*. (2) *Oxalis stricta*. (3) *Portulaca pilosa*. (4) Cinquefoil. (5) *Senecio vulgaris*. (6) *Campanula*. (7) *Nemesia* sp. (8) *Orobanche* (?). (9) *Antirrhinum* sp. (10) *Digitalis purpurea*. (11) *Nasturtium officinale* or *Petunia* sp. (12) *Gentiana*.

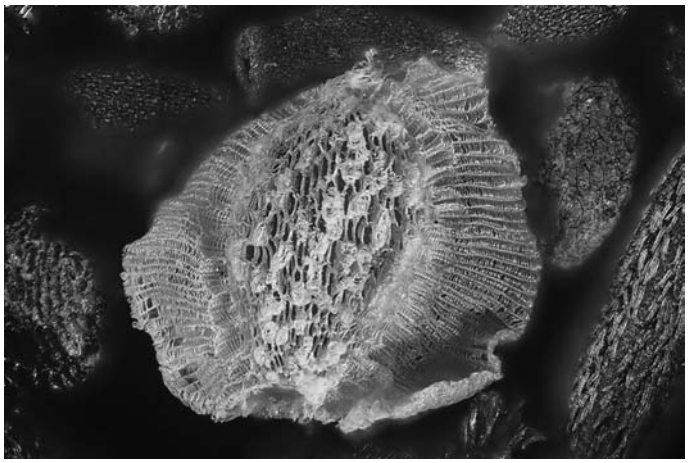


Figure 4. An aril of *Nemesia* (GFS seed 7). The lacy disseminule with a striated border is an outgrowth of where the seed attaches to the parent plant's ovary wall (funiculus). *Nemesia*'s aril aids the wind dispersal of the true seed hidden inside the delicate cage.

purchasing GFS was that owning the slide would allow me to display the item for student examination whenever I believe it would be beneficial to do so. I always fear that there is a credibility gap between projected PowerPoint images and the "real thing" in students' minds. The physical presence of GFS in the classroom helps bridge the divide between the PowerPoint images and the real thing. I allow students to view the slide by setting up a hands-off demonstration stereoscope for viewing during the lecture break. (Transparent tape holds the slide to the stage.) But to effectively use GFS in a biology course, I needed to identify the seeds in the arrangement (Figure 3).

○ A Botany Educator's *Mea Culpa*

Botanists know well that, when teaching about seeds, not everything referred to as a "seed" is precisely that. To be botanically correct, the term *seed* should be limited to the reproductive unit that contains the embryo of the plant-to-be, along with its stored food and encapsulating seed coat or test. Often, seeds are embellished with additional parts, derived from the floral remnants of the parent plant that serve to aid the "true seed" in its protection and/or dispersal (Figures 3 and 4). But even the botanically cognizant casually refer to both true seeds and "seeds with accessories" simply as "seeds." Because practitioners in the sciences need precision when speaking or writing formally, the botanical term of choice for both true seeds as well as those carrying extra parts is *disseminule*, a catchall term that covers all variations of reproductive packages, botanically known by terms such as *aril*, *achene*, *capsule*, *caryopsis*, *nut*, *drupe*, and *true seed* (Figure 4). Sometimes an entire plant is considered a disseminule, as in the case of tumbleweeds. *Propagule* and *diaspore* are two other terms for botanical procreative packages. *Diaspore* was introduced in 1927 by Sernander as a term restricted to angiosperm reproductive units (Booth, 1988). *Propagule* is a term with more "wiggle room," as its definition includes both sexual and asexual methods of reproduction, even extending to a horticulturist's leaf and stem cuttings. Biology teachers often find themselves torn between using germane terminology and courting their students' understanding.

The *mea culpa* that I make while lecturing about the GFS slide to a class is a confession of my intentional use of the vernacular definition of *seed*. I first make clear what botanically is truly a seed and then explain the less precise, more commonly understood meaning for the term and why *disseminule* is a better word choice. Nevertheless, after that admission, all of the disseminules/diaspores in the arrangement (whether aril, achene, or true seed) are collectively called "seeds." The botanical terminology used in this paper is in accordance with that used in the seminal work on seed dispersal by Leendert van der Pijl (1969; a digitized version is currently available at http://onlinelibrary.wiley.com/doi/10.1002/fedr.19710810814/abstract).

○ Seed Identification Keys Are the *Rarae Aves* of Biological Manuals

Working to identify unknown seeds is a daunting task. Seed taxonomists use a complex vocabulary that can quickly dishearten the uninitiated, dashing expectations that an unknown seed's identity could be uncovered with an easy look-up. Increasing the task's tedium is the fact that most authoritative seed descriptions are scattered throughout botanical publications over a wide time span.

Searching Bowker's *Books in Print* for currently available seed identification guides returns only one: *Seed Identification Manual* (Martin & Barkley, 2000). The guide is a reprint of the 1961 edition published by the Regents of the University of California, which lists Alexander Campbell Martin as the sole author – a name familiar to anyone who collected the *Golden Guide* paperback nature series popular during the 1950s. The guide is profusely illustrated with black-and-white photographs of 600 species of seeds, but, unfortunately, the reissued version of the book has reproduced the pictures with a quality lower than that of the original edition. Also unfortunately, the book does not include a key, so identification requires a lot of page-flipping to match up the unknown seed with the images. Thanks to used-book dealers listing their stock online, the first edition is findable (with patience).

There are four other out-of-print seed identification guides that can usually be obtained with little difficulty. The *Illustrated Taxonomy Manual of Weed Seeds* (Delorit, 1970) covers 192 species with a dichotomous key to aid in searching, and *Weed Seeds of the Great Plains: A Handbook for Identification* (Davis, 1993) covers 280 species with a polychotomous key. Both books contain excellent color photographs. The U.S. Department of Agriculture's (USDA) 1963 agricultural handbook, *Identification of Crop and Weed Seeds*, covers 623 species with black-and-white photographs referenced by working through a "drill down" series of technical keys. The handbook is agriculturally oriented and resultantly provides the best Graminae (grass family) seed coverage of all the references. Once one begins seeking to identify an unknown seed, the importance of having as many references as possible is quickly realized.

○ Online Seed Identification Databases

The two most extensive seed-identification guides available online are the USDA's *Family Guide to Fruits and Seeds* (FGFS; available at http://nt.ars-grin.gov/sbmlweb/OnlineResources/frsdfam/) and Colorado State University's SeedImages.com (CSU-SI; available at http://www.seedimages.com/). At the time of this writing, a $30-per-semester subscription is required to access the CSU-SI database.

Both the FGFS (3216 images) and CSU-SI (1700 images) websites provide tutorials for using their databases, and both have search programs that provide a clickable list of "legal" seed descriptors used in each of the databases – a helpful feature in a field fraught with synonyms.

Searching the CSU-SI database will return a list of seed pictures with descriptors that match the searched-for term, as well as all other descriptors linked to that picture. This is a very different process than working through a printed dichotomous key, where the researcher cannot continue if the information needed to respond to a morphological question set is unknown. Skipping ahead in a taxonomically based dichotomous key obliterates the tool's purpose and value, even though jumping ahead and working a key in reverse can be instructive. By contrast, computer searches of online seed databases are nonlinear and remain workable with just a few descriptors. When using the CSU-SI database, each seed picture displays the entire list of "legal" descriptors for the seed. Comparing the picture with its associated terms serves as a vocabulary-building process, enabling the researcher to refine the next search attempt (Figure 5).

In the FGFS database, the seed's descriptors are linked to the taxonomic plant families, so the search returns a list of all the seeds in that plant family in the online database. Sifting through such a large number of pictures to identify a seed is time-consuming but is in keeping with the key's stated objective of being a "Guide to Plant Families."

The gold standard for seed taxonomists is the physical matching of the unknown seed with known specimens in a seed herbarium collection. The FGFS has been created by photographing examples held by the U.S. National Seed Herbarium (BARC) at the U.S. National Arboretum, Washington, D.C., which, at 120,000 seed taxa, is one of the largest in the world. Researchers can make arrangements with the BARC to have specimens drawn from the collection for close-up examination.

○ Folk Art Set the Stage but Biology Education Stole the Show

Would contemporary reproductions of the GFS slide, this time accompanied by an identification key and guidebook, provide biology educators with a useful teaching tool? I doubt that many would find it to be so. The original slide is a historical artifact that brings with it an aura of reality connecting viewers in the 21st-century classroom with their counterparts during the Golden Age of Natural History. Real things carry with them a hard-to-describe, but nevertheless engaging, quality that is meaningful to many – as seen by museum attendance outperforming that of movie theaters (Katz, 2010).

Although the GFS slide was produced and distributed for 20 years, it is rarely found for sale today. Luckily, antique microscope slides covering a wide range of topics are gaining in collectible status. Many now get at least one listing cycle on online auction sites where they stand a chance of rescue before being discarded. The applicability of an antique slide's contents to contemporary biology curricula is a call only the educator can make. In my case, when I first saw the slide, something inside me whispered, "Come, Watson, come! The game is afoot."

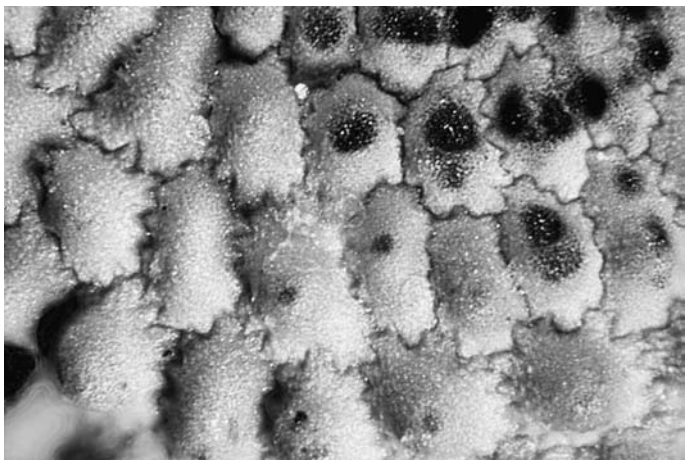


Figure 5. *Silene* (GFS seed 1). The jigsaw pattern of interlocking cell walls making up the seed coat is an identifying characteristic of the pink family. Digital databases allow "skipping ahead" in the identification process with a single characteristic such as this.

○ Field-Gathered Information about Three Seeds from the GFS PowerPoint Presentation

White Campion *Silene latifolia* (= *Silene alba*)

White campion, seed number 1 in the GFS arrangement, is a dioecious, short-lived, perennial herb native to Eurasia, and now an invasive weed found over most of North America (Figure 6). As with many invasive plants, white campion quickly colonizes disturbed soils, which occasionally might be a newly dug grave. For this reason, along with its habit of nocturnal blooming, in England the plant has been dubbed "the grave flower." White campion's seeds are held within capsules formed by the ovary wall (Figure 7). When mature, the seed capsule splits open at its apical end (partial dehiscence), with tooth-like cusps curving outward as it dries. The urn-like vessel, now surrounded by 10 teeth, two for each of the flower's carpels, will sprinkle out its reproductive contents only when the stem is vigorously moved about by the wind or a passing animal – a dispersal process called "the saltshaker method," or anemoballism. White campion was classified as *Lychnis alba* until the 1960s, but

Figure 6. *Silene latifolia*'s five filamentous stigmas extend above the flower's corolla, identifying the sex of the entire plant as female. The mature seed-filled capsule has split open at its apical end.

Figure 7. *Silene latifolia*'s maturing capsule cut longitudinally to reveal developing seeds attached to a central placenta. Two mature seeds have detached and can be seen on the lower right.

because other members of the *Lychnis* genus split their seed capsules to form five teeth and white campion makes 10, it was moved into the toothier genus *Silene*. Recent genetic barcoding data strongly suggest that species within the pink family have been taxonomically "oversplit," and a "reclumping" may lie in the plant family's future (Mayol & Rosselló, 1999).

Woodland Groundsel *Senecio sylvaticus*

Woodland groundsel, seed number 5 in the GFS arrangement, is an annual plant of wastelands and poor soils, unlike the almost identical common groundsel (*S. vulgaris*), which is a nuisance species of richer, cultivated lands (Figure 8). Groundsels are self-fertilizing plants that produce parachute-adorned achenes that carry seeds considerable distances by wind. Botanically, this is termed *anemocherous* seed dispersal. Should the hairy crown become wet at the time of its opening, the hydroscopic pappus cannot spread apart the thistle-filaments needed to increase the disseminule's aerodynamic profile. Damp seeds will not travel far from home (Figure 9). A pappus's attachment to its achene is weak, a feature allowing for easy separation between the two units. As any parachutist knows, being dragged about on the ground by a wind-driven chute makes getting a foothold difficult. It is for this reason that seedless

Figure 8. *Senecio sylvaticus* is also known as "old man of the woods" because of the gray-haired appearance created by hundreds of fluffy pappi attached to the seeds (Latin *pappus* = "old man").

Figure 9. An achene of *Senecio sylvaticus* with its thistle-like pappus attached.

Figure 10. *Oxalis stricta* blossom and a developing seed pod surrounded by five calyces.

pappi blowing about in the wind are often seen. After the achene loses its pappus, a circular collar remains on the disseminule's apical end, an important identifying feature visible on the seeds used in the GFS arrangement.

Yellow Woodsorrel *Oxalis stricta*

Yellow woodsorrel, seed number 2 in the GFS arrangement, is a herbaceous plant bearing small yellow flowers and clover-like compound leaves (Figure 10). The prolific little plant can plague greenhouse owners and landscapers because it thrives in cramped spaces such as flowerpots, gaps between bricks, and cracks in sidewalks. Yellow woodsorrel is easily grown in classrooms year-round, either near windows or under artificial lights, producing seedpods irrespective of the season (Keefe, 1965). This allows pods to be readily available for demonstrating the plant's ballistic seed-dispersal method to students whenever needed (Figure 11). When growing plants on my office windowsill, I was surprised to find the tiny (0.9 mm) seeds sticking to the window's smooth glass, as well as to the ceiling more than 6 feet away. While manipulating the plants, I have been shot in the eye with a seed more than once. Students working with

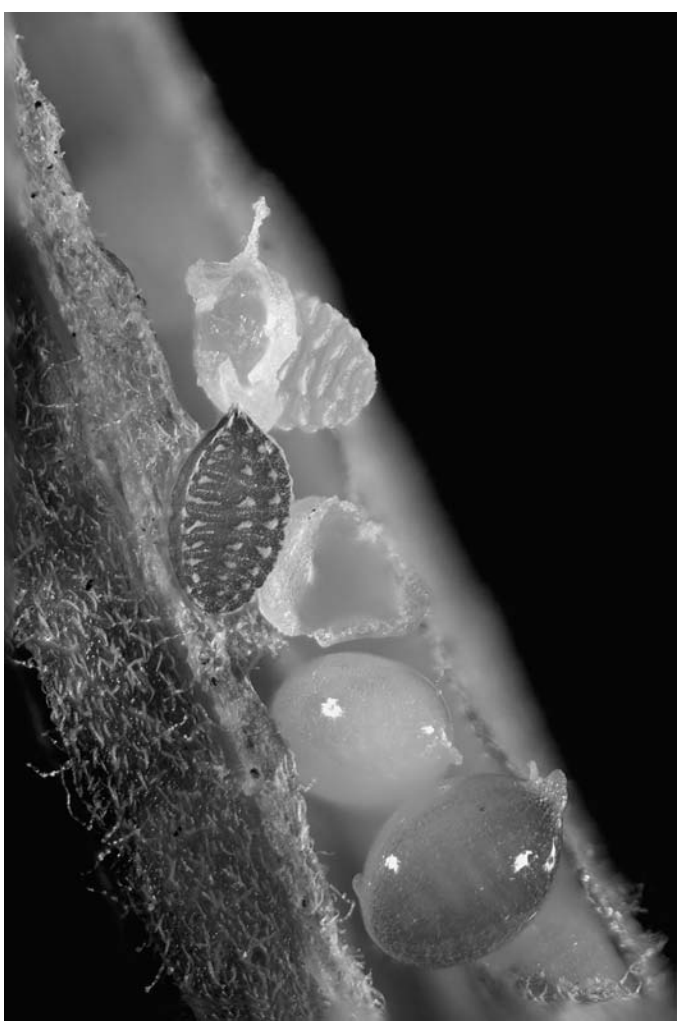


Figure 11. A misfired *Oxalis* seed hooked on hair adorning the parent plant's pod. The vertically split (dehiscence) pod still holds the spent, crumpled, white aril between its lips.

the plants are advised to use eyewear to protect them from this usually harmless but annoying property.

Acknowledgments

I would like to thank Thomas F. Wieboldt, Curator, Massey Herbarium, Dept. of Biological Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA, for his assistance with several seed identifications; and Lisa Maria Martin, Omaha, NE, for her editorial guidance. The GFS slide is in the personal collection of the author, and all photographs are by the author.

References

Booth, D.T. (1988). Winterfat diaspore morphology. *Journal of Range Management*, *41*, 351–353.

Bracegirdle, B. (1998). *Microscopical Mounts and Mounters.* Oxford, U.K.: Seacort Press.

Davis, L.W. (1993). *Weed Seeds of the Great Plains: A Handbook for Identification.* Lawrence, KS: University Press of Kansas.

Delorit, R.J. (1970). *Illustrated Taxonomy Manual of Weed Seeds*. River Falls, WI: Agronomy Publications.

Gleason, H.A. & Cronquist, A. (1991). *Manual of Vascular Plants of Northeastern United States and Adjacent Canada*. New York, NY: New York Botanical Garden.

Katz, P.M. (2010). Service despite stress: museum attendance and funding in a year of recession. Washington, D.C.: American Association of Museums. Available online at http://www.aam-us.org/upload/Service-Despite-Stress.pdf.

Keefe, A.M. (1965). Plants for a window garden. *American Biology Teacher*, *27*, 118–123.

Martin, A.C. & Barkley, W.D. (2000). *Seed Identification Manual.* [Copy of 1961 ed.] Caldwell, NJ: Blackburn Press.

Mayol, M. & Rosselló, J.A. (1999). A synopsis of *Silene* subgenus *Petrocoptis* (Caryophyllaceae). *Taxon*, *48*, 471–482.

Musil, A. (1963). *Identification of Crop and Weed Seeds: Agriculture Handbook 219.* Washington, D.C.: U.S. Department of Agriculture.

van der Pijl, L. (1969). *Principles of Dispersal in Higher Plants*. Dusseldorf, Germany: Springer-Verlag.

FRANK REISER (freiser.ncc@gmail.com) is Professor of Biology at Nassau Community College and has served as president of The Empire State Association of Two Year College Biologists, an NABT affiliate organization.