PLANTS & PERPETRATORS: Forensic Investigation in the Botany Classroom

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Usually silent and immobile, plants do not appear to offer the action-packed adventure looked for by today's media-saturated students. As a botany instructor, I hope to help some of those students appreciate the subtle, quiet, yet phenomenal wonders of the plant world. Finding ways to allow students to apply what they learn about plant structure and function to practical situations can bring meaning to the study of botany for those who are not inherently drawn to it.

One popular application of biology for today's students who are so well-versed in crime-based television shows is forensic science. While there have been several papers applying forensic entomology in classroom lab experiences (Carloye, 2003; Miller & Naples, 2002), forensic botany has received less attention. Allowing students to apply botanical knowledge to a forensic simulation provides an opportunity to include more inquiry-based and problem-based learning in the botany class, and to bring botany to life by solving of a pseudo-crime.

Scientific knowledge of plants has long been used to solve a variety of crimes (Coyle, 2005; Dickison, 2000; Lane et al., 1990). One of the more famous examples of this comes from the 1935 Lindbergh kidnapping case. In this crime investigation, botanical evidence, based on the wood anatomy of a ladder, helped convict Bruno Hauptmann of kidnapping the baby of famous aviator Charles A. Lindbergh and his wife Anne Morrow Lindbergh (Dickison, 2000; Lane et al., 1990). In many other investigations, botanists have interpreted the anatomy, morphology, chemistry, and systematics of plants in the service of solving crimes including poisonings, assaults, and murders (Anonymous, 1999; Blaney, 1995; Bock & Norris, 1997; Dickison, 2000; Lane et al., 1990).

I use the following laboratory experience at the end of my undergraduate botany course as a review exercise before the final exam. The experience requires students to use what they have learned during the semester about plant taxonomy, structure, ecology, and anatomy in order to determine the perpetrator in a mock murder investigation. One class period of an hour and 20 minutes is sufficient to present the problem and allow students to do the investigation; we take another 20 minutes in the following class period for groups to present results and conclusions (about five minutes per presentation).

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The Scenario as Presented to the Class

A wildlife biologist has been murdered. The body was found in a small pond about 17 miles from the biologist's office. The pond is man-made, about an acre in area; it has one small boat dock, and on two sides it is bordered by marshy areas.

Three suspects have been taken into custody. All three were work colleagues of the victim, and all had been romantically involved with the victim in recent months. The victim had been "playing the field", as they say, but none of the suspects had known until last week, when this fact came to the surface in their shared laboratory. This gives all three of them a motive for the crime. Their colleagues, Jane and Mark, witnessed the terrible fight that ensued. Both Jane and Mark have good alibis, having spent the day of the crime at a conference in Raleigh, North Carolina.

The three suspects all claim to have been working alone in the field on the day of the murder. Suspect A claims to have been working on invasive plant eradication in a woodlot. Suspect B claims to have been surveying rare carnivorous plants in a protected bog, while Suspect C claims to have been trapping small mammals in an agricultural field.

Police have collected dried mud from the workboots of all three suspects, and are calling upon your botanical team to determine the contents of the samples. They hope that through this analysis you will be able to help them corroborate—or contradict—the alibis of one or more of the suspects.

Selection of Plant Materials Used as Evidence

In selecting plant materials for each site, I choose some that are ambiguous (may be present at more than one of the sites) and some that are diagnostic (would only be found at one site). For example, in the sample from Site C, grass spikelets and possibly even cyanobacteria could be found in an agricultural field as well as a pond, whereas duckweed would not be growing in the agricultural field. Rushes and sedges may be found both in ponds and bogs, but the presence of *Sphagnum* would allow students to distinguish Sample B as originating from the bog. I try to represent as broad a taxonomic range as possible to incorporate structures from throughout the semester. There are plenty of other types of plant material that could be used as well; for example, root anatomy or pollen morphology can be very diagnostic. The plant materials selected for the investigation are necessarily limited by what is available to the instructor and therefore will vary with geographical location and access to other resources.

Preparing the Samples

I collect soil from my home garden, selecting soil that is deep enough to have little organic material already present. All samples are prepared with the same soil so that the focus will be on the differences in plant material present rather than on differences in soil type. I mix this soil with some water to create a thick mud, and then mix in the plant materials listed in Table 1. Plant materials are field-collected or obtained from our teaching greenhouse. The plant materials are torn into small pieces so as to require careful study of anatomy and morphology. The mixture of plant materials and mud is then spread into a marked petri dish and air-dried.

The Investigation

Before the day of the forensics lab, I ask students to read the Lane et al., (1990) article as an overview of how botanical knowledge has been used in other forensic investigations. When students arrive to class on the day of the lab, they discover that I have taken on the imaginary role of Chief Forensic Botanist and that they are supposed to be my assistants on a murder investigation. I present them with the crime scenario, first orally and then as a handout (as written in the previous section) to which they can refer. In addition to necessary information, the scenario includes details that are not necessary to solve the crime because one of the aspects of forensics is sorting out what information is relevant and what is not. I explain to students that the job of each lab group is to analyze the sample from one suspect. To do this, they need to examine the sample carefully and use the knowledge of plant anatomy, morphology, and ecology that they have acquired during the semester to learn as much as they can about the place where the sample originated. I encourage them to be inquisitive, to challenge themselves to discover as much as they can, and to be careful not to miss the smaller parts and details.

I then divide students into lab groups and give each group a sample from one of the three subjects. I make available for their use all of the basic lab equipment that they have used during the semester: microscopes, dissecting tools, slides and cover slips, simple microtomes and embedding wax, stains, reference slides and books, field guides. I also provide soil sieves for rinsing soil from plant material. Groups are then free to investigate their samples for approximately an hour. They can consult among groups and can use books, notes, greenhouse plants, or the Internet as reference materials.

During the second class period, lab groups give five-minute presentations to the class so that the class can come to overall conclusions concerning the murder case. Groups are asked to describe clearly:

Table 1. Plant materials used to prepare specimens, including identifying characteristics of each (for instructor use).

Suspect	Actual habitat	Claimed habitat	Plant materials used	Some identifying characteristics
A	woodlot	woodlot	pine needles	sunken stomata, resin ducts, shape of cross-section
			moss capsules	operculum, peristome teeth, spores
			wood fragments	xylem cells (tracheids and/or vessel elements)
			pollen-producing pine strobili	papery sporophylls, microsporangia
			fern pinnae with sori	sorus, sporangia with annulus, spores
			grass spikelets	palea and lemma subtending each flower; plumose stigma
B	bog	bog	*Sphagnum* (moss) leaves	distinctive pattern of photosynthetic and hyaline cells
			Spirogyra (green alga)	filamentous growth, helical-shaped chloroplasts
			pine needles	sunken stomata, resin ducts, wedge-shaped cross-section
			sedge spikelets	one bract and one seed per flower, no perianth
			rush capsules	six tepals around each capsule, multiple seeds per capsule
C	pond	agricultural field	duckweed (*Lemna*)	simple thalloid structure, vascular tissue, threadlike roots
			Azolla (aquatic fern)	distinctive floating fronds
			grass spikelets	palea and lemma subtending each flower; plumose stigma
			sedge spikelets	one bract and one seed per flower, no perianth
			Nostoc (cyanobacteria)	filamentous growth form, no nucleus or organelles

1. the methods they used to examine the plant materials
2. the taxonomic groups of plants they found as well as the structures used to identify them
3. their assessment of where the evidence could have originated.

I emphasize to students that it is acceptable and appropriate to speculate as needed as long as they clearly distinguish speculations from conclusions supported by strong evidence. Students are also encouraged to present evidence visually using a microscope and FlexCam® (VideoLabs®, Minneapolis, MN) to project images of the plant structures onto a video screen.

Assessment

Assessment of student learning is based upon the oral presentation and focuses on the following aspects: thoroughness and care in investigation, application of course content to analysis and interpretation of evidence, ability to draw conclusions that logically stem from the evidence, and quality of the presentation. I have been the sole evaluator in my classes, but the presentations might provide a good opportunity to incorporate peer evaluations as well.

Conclusion

Students immediately become very engaged in this exercise and enjoy the challenge it offers them. It provides a good review activity by requiring students to recall material from the entire semester, to integrate the material, and to apply it. The investigative approach leads them to solve the problem through careful, detailed observations and application of the botanical knowledge they have acquired. In the study of morphology and anatomy, where students often spend lots of time looking at prepared and labeled materials without applying the modes of scientific inquiry to solve problems, this method provides practice in the process of scientific investigation using a botanically-based observational approach.

An hour for the investigation part of the activity is adequate, but more time would allow a more detailed study and conclusions. For example, the investigation could be extended by requiring more specific identification of plant materials through comparison with herbarium samples. Whereas within the hour students can determine that the needle fragments were from pine trees, given more time and materials for comparison they could try to determine the species of pine based on anatomical characteristics. My students also suggested that the activity could be expanded by presenting each group with a different crime scenario and set of evidence. This would allow more time for investigation including library and Internet research, and then allow for longer presentations. I encourage teachers to adapt this activity to their own time constraints and course needs.

Although their conclusions were correct in general, a few of the identifications that my students came up with were incorrect. We then took the opportunity to review certain features of plant anatomy and/or morphology that they had learned but may have missed during the investigation. We also discussed the existence of certain kinds of plant material in multiple sites, the need to examine more than one item of evidence to solve the crime, and why certain pieces of botanical evidence are more diagnostic than others. We finish up by discussing what further study could be done to glean more detailed information about the evidence, such as working on identification of species and comparison with plants on site at each location.

This laboratory activity could easily be used in an upper-level high school biology course, and could be adapted for use in lower-level courses by altering the types of materials included in the samples and the expected level of interpretation of the evidence.

In a post-course evaluation of this activity, one student wrote:

> *It was fascinating to be given the opportunity to observe the accomplishments of the class throughout the semester in terms of knowledge and skills. Often times in college classes, that strengthened knowledge is never tapped into, so it goes unaware of and then lost. It also seems rare in college classes to be given the opportunity to get a feel for the actual tasks of the professionals in the field.*

Another wrote:

> *I really liked it because we had to use everything that we had learned about in class to solve a puzzle.*

In general, it is clear that students, like myself, find forensic investigation a good way to pull together the course content and demonstrate one dimension of its applicability.

Useful Web Sites

Bryant, V. M., Jr. & Mildenhall, D. C. (2004). Forensic palynology: A new way to catch crooks. *Crime and Clues*. Available online at: http:// www.crimeandclues.com/pollen.htm. Good article on the use of pollen analysis in criminal investigations.

Van Dommelen, J. (2002). Forensic Botany. Available online at: http:// myweb.dal.ca/jvandomm/ forensicbotany/. This site has useful background information on the ways in which botany is used in forensic investigation, and includes valuable references and links.

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