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Forensic Botany: An Under-Utilized Resource

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ABSTRACT: Plants have long been used as both weapons and evidence in criminal investigations. The proceedings of Socrates' trial and subsequent adjudicated suicide by means of *Conium* brew are in the botanical folklore. In this country, plants as poisoning agents have always been well known, but only since the Lindbergh kidnapping trial have other kinds of botanical evidence gained legal sanction. Botanical resources for forensic evidence remain underutilized because of the lack of botanical knowledge among most people involved in criminal investigations. However, resourceful investigators and scientists with initiative are beginning to change this. Now, evidence from plant systematics, palynology, plant anatomy, plant ecology, and related fields is acceptable. The moving forces behind increasing the uses of non-traditional scientific fields in criminal investigations continue to be innovative criminal investigators and imaginative scientists willing to contribute their talents to forensic efforts.

KEYWORDS: forensic science, forensic botany, forensic ecology, plant anatomy, clandestine graves, stomach contents, botanical criminalistics

Botany and the law are combined in the very early writings of Western Civilization. When Socrates was condemned to death for treason in 399 B.C., he was allowed, because of his high social status, to choose his own method of dying. He chose to drink a tea of poison hemlock, *Conium maculatum* L. Plato has left us a graphic account of Socrates' death in the *Phaedon* (1,2). Although he was not present at Socrates' death, he describes the death from the perspective of Phaedo, who was present. The symptoms set forth clearly reflect contemporary descriptions of hemlock poisoning symptoms: A gradual loss of muscular control and power, loss of sight, and respiratory failure (3–5). In modern times, these symptoms are known primarily from accidental poisoning of children who make whistles from the hollow stems of the plant or who mistake it for something edible because of its resemblance to celery.

From those ancient times until now, countless cases involving plant poisons have passed through the courts of the world. However, the expanded use of plant characteristics in criminal cases is a relatively modern development. The modern era of forensic botany for other than instances of poisoning was initiated by the first modern-day celebrity trial of the kidnapper of Charles Augustus Lindbergh, Jr. in January, 1935. It was in this case that plant anatomy was accepted as primary evidence in a first degree murder conviction. This was also a landmark case because it led to the formation of federal laws regarding kidnapping. It is most fitting that the evidence from this investigation be reexamined here in this overview of forensic botany.

Subsequent contributions to this journal issue describe botanical evidence and expertise obtained from several botanical specialties, including plant systematics, palynology (the study of pollen and spores), mycology (the study of fungi), plant anatomy, and plant ecology. In addition, a soil scientist and an entomologist make significant contributions from their specialties. In the remainder of this article, we will cite examples of how botanical evidence has been applied in cases other than the Ruidoso plane crash, describe our experiences with botanical evidence in forensics, discuss why botanical evidence has been under-utilized and suggest how this might be remedied in the future.

Plant systematics is defined as the study of evolutionary relationships among plants and includes taxonomy as a subdiscipline dealing with the identification and naming of plants. Plant identification has become very important in the identification of controlled substances, many of which are plants or plant products. Examples of plants that often require scientific (botanical) identification are marijuana (*Cannabis sativa:* Moraceae), opium poppy (*Papaver somniferum:* Papaveraceae), and peyote (*Lophophora williamsii:* Cactaceae). Recently, we were asked to identify plants from the garden of a suspected drug dealer: Included were opium poppies, some with slit fruits which is the common method for harvesting raw opium; peyote buttons, the name for the consumed portion of the plant; and two other species of cacti, one a known hallucinogen that, commonly, is deadly. Often in court cases dealing with marijuana, expert identification of the species is required because some state statutes consider possession of only one of the several species of *Cannabis* to be illegal.

Palynology, the study of pollen, superficially may seem an esoteric discipline but the opposite is true. Plants may be identified to the level of genus or sometimes even to species by features of the pollen grains. Oil geologists learned early that the presence of certain kinds of pollen grains were useful indicators of oil deposits because oil and coal both are remnants of once living plants. Their pollen provides a clue to the vegetation type that existed during the geologic era in which they were formed. When vegetation can be identified, then informed guesses about past environments and climates are also possible. Identification of plants using pollen was singularly important in the botanical investigation of the Ruidoso plane crash. Both the physical features and the interactions of pollen with insects at the crash site were informative.

Fungi, like flowering plants, have been associated with criminal activities throughout history. Mushroom poisoning, from universally toxic alkaloids or through promotion of allergic responses, is well known. Fungal spores are decay-resistant and sufficiently diverse to be used for identification in many instances. In the Ruidoso case, fungal spores were present in the airplane parts.

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Plant anatomical evidence is especially dependent on one aspect of the plant cell, the cellulose cell wall. Cellulose is a polymer that is indigestible to most organisms including humans. The above- and below-ground parts of plants are composed of cells whose living contents are enclosed in cellulose polyhedrons. Animal cells lack this indigestible covering and do not persist through time as do those of plants. Anthropologists, archeologists, and paleontologists have made use of the enduring quality of plant cell walls. By examining plant remains associated with mummies, bog people, and ancient mammoths frozen in Arctic ice, diets from other geological eras have been reconstructed (7,8). In the Ruidoso investigation, plant cells and their associated hairs or trichomes, were able to be identified because of the relative permanence of the cellulose walls.

In our forensic work with plant cells, we have utilized characteristic features of the wall, especially from food plants, to identify the stomach contents of homicide victims. The cellulose walls of most plant cells we consume pass through the human digestive tract and are excreted with only minor changes in structure. At death, the pyloric sphincter ceases to allow the passage of stomach contents into the small intestine. Although further action by stomach acids may continue to affect the contents of the cell, the acids have little or no effect on the cell wall, as viewed under the light or scanning electron microscope (Fig(s). 1, 2).

How we became involved in forensic botany illustrates the frequently serendipitous nature of botanical-forensic associations. Ben Galloway (M.D.), a pathologist affiliated with the University of Colorado's Medical School and the Denver Coronor's Office, phoned one of us (JB) because he noticed that she was teaching a course entitled Plant Anatomy. Dr. Galloway, during the course of an autopsy, had observed what he assumed to be pieces of vegetables in the stomach of a homicide victim. He asked if it was possible to identify the fragments. A search of the plant anatomy literature found no current publications dealing with the subject, although plant anatomy textbooks occasionally illustrate the anatomy of food plants (10,11). He supplied us with prepared slides of the gastric contents of the victim. By scanning textbooks for clues of cell configuration and preparing comparative slides, we were able to identify some of the plant remains, including beans, cabbage, and green peppers. The identifications suggested the victim had a meal with her assailant, who, therefore, was probably not a stranger to her. The information was later important in associating the assailant to the crime. Without Dr. Galloway's insight, the evidence would never have become available.

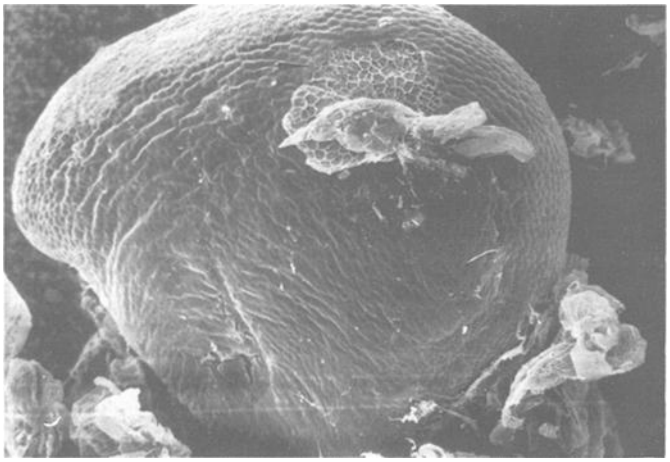

FIG. 1—*Strawberry seed. Note tooth mark on seed. 140×. Scanning electron micrograph by M. A. Lane.*

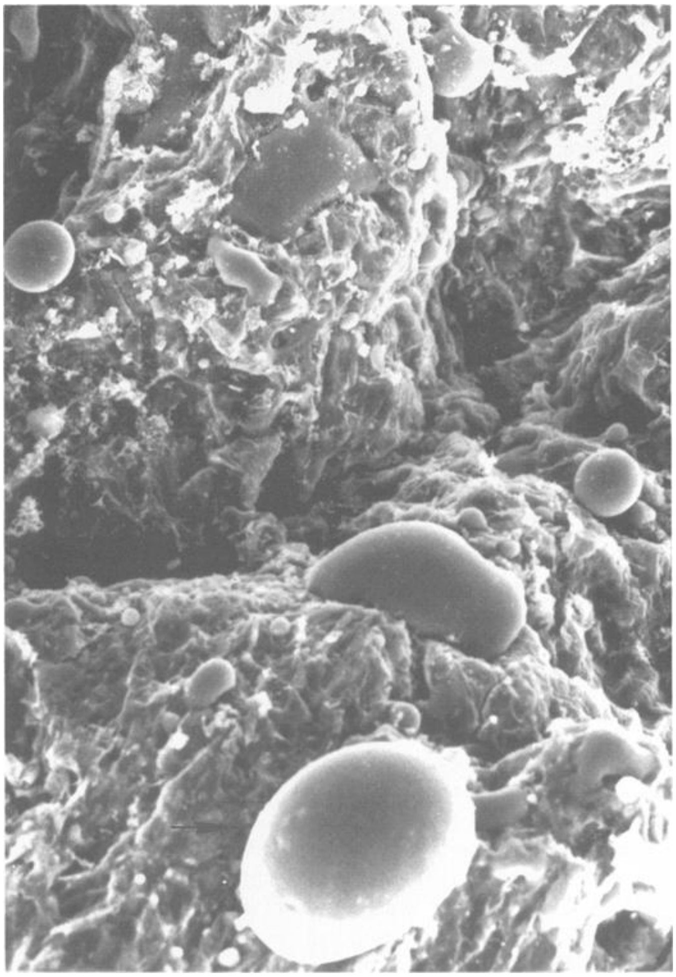

FIG. 2—*Olive—Note large oil droplets. 140×. Scanning electron micrograph by M. A. Lane.*

After this initial foray into homicide work, we became aware of several other cases involving identification of gastric contents. Because our primary professional research lay outside forensic science, in plant population biology (JB) and comparative endocrinology (DN), we wrote a guide to plant food cells for the independent use of criminal investigators and pathologists (9). Preparation was funded by the National Institute of Justice and distributed by the United States Department of Justice to forensic laboratories around the country. The publication is now out-of-print.

It is difficult to generalize about the patterns of useful evidence from plant anatomical examination of gastric contents. However, some examples illustrate the breadth of its application. In one case, two people disappeared at the same time, were killed in the same manner, but were not acquainted with one another. One victim was found frozen in a snow bank six months after the other victim was found. A study of gastric contents indicated that both had consumed foods typical of a Mexican menu. Plant cell evidence thus linked the victims by suggesting they were in the same place for their last meal. In another case (12), the garnishments to pizza proved useful clues to solution of a crime. In a recent highly publicized crime, identification of potato starch grains were important in determining the last meal of the victim of a serial killer. In some cases involving child victims, our findings have confirmed or denied claims that children were treated in certain ways prior to their deaths, e.g., were alive ten or more hours after having eaten specified foods when gastric contents suggested otherwise. In more than one case, when testimony about food consumption was proven false, a supposed care giver confessed to actions that had led to the death of a child.

These examples illustrate just a fraction of the ways plant cellular material from gastric contents has been applied in forensic investigations. We believe wider use of the information from plant remains will be made when investigators are better informed about the useful diversity and durability of plant cell walls. All of our contributions have been initiated because of the imaginative, innovative approaches to evidence taken by physicians, coroners, district attorneys, sheriffs and their officers, detectives, and uniformed police officers.

As our circle of acquaintances among investigators has increased, we have been called upon to use botanical knowledge in new ways. We were asked to test whether straw found on the clothing of a victim was identical to straw in a specific chicken house. In this case we were able to say that the straw samples could be the same; we did not attempt to determine if the straws were identical because such verification would have required months of comparison of cell types accompanied by extensive statistical analyses. However, the straw samples were also compared for similarity of uric acid content which was expected from the site. In another case, sunflowers had been thrown over the remains of a person found along a rural road in mid-summer in Colorado. Here, in a greenhouse, we stimulated the natural climatic conditions in order to estimate the length of time required by the sunflowers to reach the wilted state in which they were found. Our results indicated the person had been discovered shortly after being covered, a conclusion in agreement with the independent findings of a forensic entomologist.

The last botanical approach to be discussed is the utilization of plant ecology in forensic investigations, particularly as applied to the search for hidden or clandestine graves. The use of vegetation to identify places on the landscape where burials have taken place depends on a knowledge of what ecologists term plant succession. Whenever soil is exposed, it does not stay bare for long. Propagules of plant species soon move onto the bare area, and a set of pioneer species colonizes the disturbed site. Through time, the species composition changes as succession occurs, until a stable or climax community is established. The patterns of succession in vegetation are the subject of considerable study and can be predicted to a certain extent for different geographical locations. In the early days of plant ecology, from the early 1900's to the 1940s, much was made of this predictability. Since then, ecologists, especially those in the western United States, have learned that the patterns are not as predictable as were originally supposed. Nevertheless, disturbances in vegetation can be identified even two or more decades after the event, and in fresh graves, sites are covered by bare or nearly bare soil until the first post burial growing season has begun.

The need for scientific expertise in the finding of clandestine graves includes use of ecologists who can recognize localized, unusual areas of plant succession. In Colorado, a non-profit organization has been formed for this purpose. Necrosearch International, Ltd. is composed of academic scientists, experts from federal, state, county, and local governments, medical technologists, medical doctors, and professional engineers and geologists (14). Since its inception in 1991, we have located over a dozen clandestine graves both in and outside the United States. No fees are charged, but expenses of the search are requested. Meetings are held once a month, at which time cases are presented and the members decide whether to initiate a search. If a case is deemed appropriate, a scout team of two or three people with the most relevant skills meet with those people having the most knowledge of the search up to that time. One recent scout team was composed of search dogs and their handler, plus an expert in ground-penetrating radar; another consisted of two anthropologists and a botanist. We have also called upon a psychiatrist, an invertebrate zoologist, and on aerial photographers for low level and infra-red photos. The scouts report findings to Necrosearch and discuss with the group whether other experts are needed to further the search.

Necrosearch activities are independent of the regular employment of the members. For this reason, we prefer to work in a concentrated manner, usually devoting weekends to a case. In a recent visit to a Necrosearch meeting, a federal law enforcement official commented that every state should have a group like ours, but doubted many would work only for expenses. One member commented that the work was more enjoyable and interesting than his regular, paying job. The most important rewards come from the relatives and friends of those whose remains are found. Although our success means the end of hope of finding someone alive, we are told that for those who remain, "not knowing" is a worst fate.

One example of a successful Necrosearch for a clandestine grave involved forensic anthropology, search dogs, and the botanical evidence of conifer needles. A clump of human hair, tangled with conifer needles, was found by hikers who brought it to Investigator Kathy Young of the Gunnison County, Colorado County Sheriff's Office. Using DNA techniques, she matched the hair to some from a long-stored hairbrush belonging to a young woman who had disappeared 17 years earlier. Searching the area where the hikers found the hair and guided by the presence of the appropriate species of conifer, the skeleton and some possessions of the woman were located. Subsequently, the man responsible for her death was convicted of the crime. Her family was finally able to close the long search.

Forensic botany is a young, developing science. The examples provided here by no means define the scope of its uses. The recent successes of forensic botany have been largely a product of imaginative investigative teams and skilled botanists, together with some serendipity. Lack of recognition of its value reflects to some degree the absence of botanical training in contemporary medical and allied health curricula. Practioners thus fail to appreciate the usefulness of diverse structural, ecological, and physiological plant characteristics. This has not always been the case. Medical botany was a common requirement in allied health studies until fairly recently. It should once again be considered a useful component in the special education of pathologists and their technicians. Forensic botany is a valuable tool that deserves wider use.

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