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Paleopharmacology

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An emerging field devoted to the exploration of the archaeological record for evidence of medicinal plants.

In the future, archaeology will have a role in pharmaceutical research. In the late twentieth century, much of the world's pharmaceutical research has been based on ethnographic documentation of tribally recognized medicinal plants. Once the active chemical compounds in the plants are identified, they are either extracted or synthesized for commercial use. The American film *Medicine Man* depicts this approach. As shown in the film, such pharmacological research is threatened by declining tribal populations with loss of traditional herbal knowledge coupled with declining biodiversity. With the loss of ethnopharmacological information, the knowledge of ancient cultures can be tapped through archaeology. Every prehistoric culture had some sort of healthcare system, and a pharmacopoeia was integral in each ancient cultural system. Most medicinal compounds used were derived from plants. In theory, the archaeological record can be used to identify medicinal plants used in ancient times. In practice, new archaeological research has demonstrated the presence of anomalous plant finds that, under scrutiny, prove to have had a medicinal use. Therefore, the reserve knowledge of medicinal plants can be expanded by exploring the archaeological record for relevant botanical remains.

The paleopharmacological approach compares archaeological data with ethnographic and plant-chemistry data. Through this approach, researchers identify specific ailments treated with plant extracts and identify the physiologically active compounds in the plant. Thus, paleopharmacology employs archaeological and ethnographic investigation of the ancient use of medicinal plants in the light of what is known about plant chemistry and physiology.

The paleopharmacological record also includes textual information from ancient cultures that document medicinal plant usage. Most documentation of pharmacopoeias comes from the Old World. For example, Morris Weiss and Raoul Perrot have separately summarized aspects of Etruscan medicine and medieval medicine, respectively. In A.D. 77, Dioscorides (Greek physician and pharmacologist) wrote the *De Materia Medica,* which summarized Greco-Roman knowledge of medicinal plants. Medieval medical practitioners based their *Materia Medicalis* on this work. The Greeks and Romans were influenced by the herbal knowledge of the Egyptians. In 1989, Lise Manniche summarized the Egyptian pharmacopoeia from several Egyptian texts, including the *Papyrus Ebers,* which dates to 1550 B.C. At least three Aztec documents describe a New World pharmacopoeia that was studied by Bernard Ortiz de Montellano in 1975.

Method of Textual Study

The pharmacopoeia of the Aztecs was extensive. The Aztecs maintained botanical gardens for the main propose of supplying botanical remedies and as a source of pharmaceutical experimentation. The Spanish were impressed by Aztec medicinal knowledge and sponsored the documentation of their pharmacopoeia. Three sixteenth-century documents survived from this effort: *Primeros Memoriales, Codex Matritense,* and the larger *Florentine Codex.* Ortiz de Montellano's analysis of these documents stands as a model for text-based paleopharmacology. The analysis had three goals: identification of the described plants, analysis of the plants for physiologically active compounds, and determination of their therapeutic effectiveness for native-defined illnesses. Ortiz de Montellano identified the precise species for twenty-five plants that had a wide variety of native uses, including anthelminthics, sedatives, expectorants, digestive remedies, purgatives, and diuretics. The active chemicals in each plant were identified in twenty-one species and then were evaluated with respect to their effectiveness in native use. Of twenty-five plants, sixteen are effective in their native uses, four are possibly effective, and five are not effective. Two of the plants that are not effective for the native-described use are effective in other ways. This study demonstrates how textual paleopharmacological information can lead to the discovery of traditional plant remedies and the chemical evaluation of their effectiveness. The fact that 80 percent of these plants are effective and 85 percent have physiologically active compounds also demonstrates the accuracy of ancient peoples in identifying medicinal properties in plants.

Method of Nontextual Study

Unfortunately, for most ancient New World cultures, no written record exists of the plants utilized for medicinal purposes. However, ethnographies show that New World cultures had a rich plant pharmacopoeia. Daniel Moerman (1986) has summarized nearly 2,400 plant species that have been documented ethnographically as having medicinal value among Native Americans (Moerman 1986). Native American medicinal plants provided significant additions to the European remedies. For example, quinine, which was a South American malaria cure, is obtained from the bark of the cinchona tree (*Cinchona officinalis*). This remedy was introduced into Europe in the seventeenth century and, by 1681, became the universally recognized antimalarial drug. Quinine was eventually synthesized in 1944. Another South American plant, coca (*Erythroxylum coca*), is the source of medicinal cocaine. Cocaine has never been synthesized. Considering that Native Americans were ravaged by epidemics and war for 300 years before the ethnographic record was compiled, it is very likely that many more medicinal plants were part of the precolumbian Native American pharmacopoeia and wait to be found in the archaeological record.

In the absence of native textual documentation, ethnographic analysis of extant or historical Native Americans has provided the bulk of our knowledge of New World pharmacopoeia to date (i.e., 1998). However, evidence of medicinal and psychotropic plants is growing in the archaeological record. The data come from several sources: corporeal remains, coprolites, and standard plant finds. The study of prehistoric psychotropic plants has the longest history. In 1977, Gary Fry identified dogwood (*Cornus stolonifera*) bark, which produces an opiumlike, narcotic effect, in a coprolite from Utah. The use of this plant among Archaic hunter-gatherers in Utah signals either its medicinal or ceremonial use. In the lower Pecos region of Texas and adjoining northeastern Mexico, a long tradition of psychotropic plant use dating from 10,500 to 1,000 years ago has been documented (Adovasio and Fry 1976). This tradition included three psychotropic plants that were used in succession. Texas buckeye (*Ungnadia speciosa*) was used with mescal bean (*Sophora secundiflora*) in the earliest part of this time period. Later, the use of buckeye declined as mescal bean became the preferred psychotropic. Finally, by ca. A.D. 1000, peyote (*Lophophora williamsi*) began to occur. The earliest find of peyote consists of a necklace on which peyote buttons were strung. One main trend indicated by this analysis is the sequential abandonment of more-lethal, in favor of less-lethal, plants. Buckeye is the most poisonous of the three, followed by mescal bean, and then peyote.

Many early finds went unnoticed for their pharmaceutical value. For example, Paul Martin and John Rinaldo noted the find of jimsonweed (*Datura* spp.) seeds from a pueblo in New Mexico. Jimsonweed is a strong, but dangerous, psychotropic plant. The seeds were cached with ceremonial objects in a kiva (men's ceremonial structure). The association of seeds with the objects in the kiva suggests that the Mogollon people of New Mexico used this hallucinogen in ceremonial rites. The connection between the seeds, their psychotropic potential, and the ceremonial association was not made in the original report. This suggests that surveys of previous archaeological studies hold the promise of recovering more information regarding medicinal plants.

Evidence of medicinal plants appears in some of the more than 1,000 coprolites analyzed from the Southwestern and southeastern United States. Coprolite analysis provides a means to view plants or plant parts directly consumed by humans, including evidence of medicinal plants. Macrofossils present evidence of medicinal plant use. Perhaps the longest-acknowledged pharmaceutical plant from the archaeological record is *Chenopodium* spp. as an anthelminthic (Riley 1993). Decades of research demonstrate *Chenopodium* as an important part of several Native American pharmacopoeias. Five North American tribes, the Cherokee, Rappahannock, Houma, Koasait, and Natchez, used various species of *Chenopodium* to treat parasitic-worm infection. In the study of Aztec medicinal plants summarized above, Ortiz de Montellano discovered that the Aztecs also used *Chenopodium* species as a treatment. Coprolite studies in North America also indicate prehistoric use of the plant. The 1991 study by Karl Reinhard and colleagues presents a case that certain species of *Chenopodium* were used in the Southwest as anthelminthics. This study also suggests the inadvertent use of *Chenopodium* as a prophylaxis when it was a dietary staple among Archaic hunter-gatherers. Among agriculturalists, there is limited coprolite evidence that suggests that certain species, *C. graveolens* and *C. botrys,* were recognized and specifically used as anthelminthics. It has been pointed out that a weakness in this study is that pinworm was the parasite under research, whereas *Chenopodium* is a recognized remedy for hookworm genera and the giant intestinal roundworm, *Ascaris lumbricoides* (Riley 1993). Secondly, data from the sites of Salts and Mammoth caves in Kentucky provide evidence of both hookworm and *A. lumbricoides* infection. There is evidence for the use of certain *Chenopodium* species in ancient southeastern pharmacopeias.

One of the significant aspects of these *Chenopodium* studies is the depiction of the development of pharmaceuticals in prehistory. Species of *Chenopodium* were used by ancient hunter-gatherers and agriculturalists primarily as a food source. As knowledge of various species of *Chenopodium* progressed, there came the recognition that certain species had a pharmacological value. These were *C. graveolens, C. botrys,* and *C. ambrosioides* (also called *C. anthelminticus*). The physiologically active compound in these species is ascaridole, which induces paralysis in at least some roundworm species. By the protohistoric and historic periods, there was complete recognition of the medicinal value of these plants with their incorporation into the Native American pharmacopoeia. Eventually, this Native American knowledge was transferred to Europeans.

Pollen provides evidence of medicinal plant teas. The analysis of coprolites for their pollen content by Reinhard and colleagues revealed the presence of pollen from several plant species not particularly known for their dietary value. *Ephedra* (mormon tea) pollen was found in Mojave Desert, Chihuahua Desert, and Colorado Plateau hunter-gatherer coprolites. The pollen occurred in large quantities, often exceeding one million pollen grains per gram of coprolite. These large quantities demonstrate intentional consumption of the plant. Traditional uses of *Ephedra* species include antirheumatic, antidiarrheal, diuretic, burn-dressing, and cold-remedy uses. One active compound in at least Asian and Spanish *Ephedra* species is ephedrine which constricts blood vessels, raises blood pressure, dilates pupils, and relaxes the intestinal and bronchial muscles (Moerman 1986). Contemporary uses of ephedrine include reduction of nasal congestion due to colds or allergies. Ephedrine is not present in North American *Ephedra* species, at least not in economically significant amounts. Consequently, identification of other physiologically active compounds in North American species awaits further research.

Larrea (creosote) was consumed in the Rustler Hills of west Texas. As with the *Ephedra* finds, there are large numbers of creosote pollen grains in coprolites from this part of the world. This indicates intentional consumption. Since creosote is not a dietary plant, its potential as an antidiarrheal medicine was evaluated. As a hot tea, decoctions of creosote have been used as a treatment for diarrhea. In addition, it is also a Mexican folk remedy for bladder ailments and for removing calcium deposits from kidneys. Creosote contains many physiologically active compounds, but specific antidiarrheal compounds have not been identified as yet.

Salix species (willow) were used by Native Americans in ancient and historical times. The bark or foliage of the tree is used to make medicinal tea. Willow contains salicin, an analgesic. Its analgesic use has been documented ethnographically among many New World indigenous cultures by Moerman in 1986. Willow pollen was found in coprolites from three prehistoric cave sites, two in the Rustler Hills of west Texas (A.D. 200-1400), and one in the Mojave Desert of Arizona (A.D. 600-900). The presence of the pollen in great quantities suggest strongly the use of willow as a medicine. All of these finds come from hunter-gatherer sites and demonstrate that hunter-gatherers identified medicinally important plants. The plants provide evidence of the treatment of minor health problems, such as aches, colds, diarrhea, and urinary problems.

In addition, medicinal plant remains have been found in the intestinal contents of burials. The analysis of these remains provides a unique opportunity to examine the medicinal treatment of seriously ill individuals. For example, coprolites were found in the abdominal cavity of a Mimbres burial from the NAN Ranch Ruin in New Mexico (ca. A.D. 1000) and analyzed by Reinhard and colleagues. These coprolites showed that the dying man was fed very finely ground corn, probably in a soup form. The pollen analysis revealed willow and unknown mustard-family pollen. The willow was administered as an analgesic. Because pollen from the mustard family has not yet been identified as to genus or species, the specific use of this plant is unknown. Several mustard species are used to maintain movement of material through the intestinal tracts of bedridden people. This may have been the use of mustard; however, unless the plant can be definitively identified, its use and its active compounds cannot be assessed. A second series of coprolites was found with an Anasazi child mummy from Glen Canyon in Utah. The analysis of these coprolites showed that the individual was fed wild grasses before death. *Ephedra* pollen was also found in the coprolites, which suggests that this was administered to the dying individual.

Other Methodological and Theoretical Considerations

Because medicinal plants are much less often used than dietary plants, they are especially cryptic in the archaeological record. Therefore, archaeologists must be carefully attuned to searching for evidence of medicinal plants. Attention should be focused on places where medicinal plants are likely to be present. Because certain plants have ceremonial significance, evidence should be sought in ceremonial contexts. The jimsonweed noted above is an example of such a find. Mummies and burials should provide a particularly rich source of medicinal data. These individuals may have been ill at the time of death and, therefore, may have been under medicinal treatment. The Mimbres and Anasazi burials noted above illustrate the potential of recovering medicinal plant data.

It is important to ask whether a specific population is at risk for specific diseases treated with medicinal plants. For example, prehistoric inhabitants of the Rustler Hills were environmentally predisposed to diarrhea. The Rustler Hills of Texas are composed of dolomite and lie in the center of the Great Gypsum Plain; the water contains very high levels of magnesium and sulfur and acts as a laxative. The most direct evidence that diarrhea was a common prehistoric malady is a high percentage of the diarrheal coprolites recovered from the caves. In light of these observations, the inhabitants of Rustler Hills were in need of antidiarrheal compounds, such as *Larrea* and perhaps *Ephedra*. From South America, autopsies of Peruvian and Chilean mummies indicate that pulmonary disease had a very high prehistoric prevalence. During the analysis of materials from Jane E. Buikstra's recent excavations in Peru, aromatic fruits were discovered in coprolites that produced a menthol smell. The fruits may represent medicinal use of plants for pulmonary disorders. Currently, these fruits are still under investigation by Buikstra and Reinhard to determine the genus and species of the plant that produced them and the physiologically active compounds that they contain. Dental disease was a problem for horticultural people due to high carbohydrate diet and among desert hunter-gatherers due to the highly abrasive nature of their diets. The early use of willow among hunter-gatherers and later horticulturalists may have been stimulated by toothaches. Thus, medicinal plant use in prehistory can be incorporated into the overall picture of disease ecology to arrive at an understanding of ancient health problems.

Theoretically, it is unwise to assume that plants were used to treat the same illnesses in the past as those existing today. It is also unwise to project contemporary uses of medicinal plants into the past. Ortiz de Montellano, analyzed the effectiveness of Aztec plants in treating the diseases defined by the Aztecs. This is the proper approach to paleopharmacology. In the absence of written records, defining the disease ecology allows one to infer what symptoms were most common among ancient peoples and then guess the application of medicinal plants to these symptoms.

It is possible that the medicinal plant species were used for food or beverages rather than as medicines. However, this does not negate the medicinal value of the plants. Among modern tribal peoples, up to 50 percent of the plants in the diet can have a tribally recognized medicinal role as well (Etkin and Robs 1992). This is especially true of spices that often have physiologically active compounds. The difference in a plant's value as a spice as opposed to a medicine is often determined by the quantity that is consumed. Therefore, when large amounts of plant foods are found that normally appear in small or trace amounts, medicinal use is possibly signaled.

The origin of medicinal plants has been a topic of recent discussion as reviewed by Reinhard and colleagues in 1991. In 1989, Moerman statistically identified "high use" and "low use" categories for thirty-nine plant families. He then inferred mechanisms by which people originally identified high-use plants as medicinal. Many medicinal components are secondary compounds produced in the plants to reduce browsing by animals. Plants signal the presence of these compounds by visual or olfactory signals. Moerman and Michael Logan have suggested that humans used these signals as clues to identify plants of potential pharmaceutical value. This discussion is related to the question of whether or not some medicinal plants originated as dietary foodstuffs. The suggestion has been made that goosefoot was used first as a dietary plant before the medicinal property of a limited number of its species was recognized. However, at least *C. graveolens,* an anthelminthic species, produces an intense odor and color change in the autumn. Cattle recognize these signals and avoid the plant. Perhaps prehistoric humans recognized two varieties of goosefoot, dietary and pharmaceutical, defined by smell and color. In 1988, Logan contributed another perspective to the discussion of the origin of medicinal plants—proposing a scenario in which the introduction of agriculture resulted in land disturbance with consequent growth of pioneer species, thus increasing the spectrum of plants available to human populations (cited in Reinhard et al. 1991). After experimentation, agriculturalists discovered that some of these weeds had medicinal value. Therefore, agriculture could have resulted in substantial expansion of the medicinal knowledge.

Paleopharmacology provides important time depth to the study of the origin of medicinal plants. It adds significantly to the understanding of human manipulation of plants for medicinal purposes. The understanding of the history of medicine and medical discovery is expanded by the field. Finally, paleopharmacology has the potential to add new knowledge of heretofore unrecognized medicinal plant species.

See also Archaeoparasitology, Coprolite Analysis, Paleoethno-Botany

Further Readings

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