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RESEARCH FRONTIERS  
IN ANTHROPOLOGY

*THE ANALYSIS OF ARCHAEOLOGICAL  
PLANT REMAINS*

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(1997)*

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Prentice Hall, Upper Saddle River, New Jersey 07458  
Simon & Schuster Custom Publishing  
Needham Heights, Massachusetts 02194



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Upper Saddle River, New Jersey 07458

"The Analysis of Archaeological Plant Remains" by Naomi Miller pp.229-244  
Reprinted from Research Frontiers Volume 2: Archaeology

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Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-536-59881-9

Prentice-Hall International (UK) Limited, *London*  
Prentice-Hall of Australia Pty. Limited, *Sydney*  
Prentice-Hall Canada Inc., *Toronto*  
Prentice-Hall Hispanoamericana, S.A., *Mexico*  
Prentice-Hall of India Private Limited, *New Delhi*  
Prentice-Hall of Japan, Inc., *Tokyo*  
Simon & Schuster Asia Pte. Ltd., *Singapore*  
Editora Prentice-Hall do Brasil, Ltda., *Rio de Janeiro*

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THE ANALYSIS  
OF ARCHAEOLOGICAL  
PLANT REMAINS

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Naomi F. Miller



An otherwise sophisticated prehistorian once remarked to me, "I can see why you'd collect plant remains if your interest is in the origins of agriculture, but once you're dealing with literate, urban civilizations, why bother?" Why indeed? Agriculture was the economic base of the early civilizations. The specialization of labor and consequent social differentiation we associate with "civilization" would not have been possible without surplus-generating production. Even for literate societies, textual evidence provides only a narrow window into agriculture and the effects of land clearance, fuel gathering, irrigation, and other land-use practices. Because plants play such an important role in food, fuel, and items of trade, they reflect many dimensions of society—including cuisine, the organization of labor, and social differentiation—in all times and places. It is for these reasons that I am interested in plant remains.

Paleoethnobotany concerns itself with the relationship between people and plants in the archaeological record—including aspects of ecology, economy, society, and ideology.<sup>1</sup> To understand that relationship, it is necessary sometimes to go beyond studying plant remains from archaeological sites (*archaeobotany*). We may also need to consider the evidence of history, ethnohistory, folklore, and botany.

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## TYPES OF PLANT REMAINS

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The three most important categories of plant remains from archaeological contexts are macroremains (e.g., seeds and charcoal), pollen, and phytoliths (microscopic silica bodies found in some plant tissue). Other less common sources of information are plant impressions in clay, artistic representations of plants, lipid analysis (which identifies fat sources, animal or vegetable), and artifacts made from plants.

To recover plant remains, we have to separate them from the sediment matrix of the archaeological site. Flotation and screening for macroremains mechanically separate the plant materials from the dirt, stones, and artifacts. No special laboratory facilities are required. For pollen analysis, we mechanically remove and chemically dissolve everything that is not pollen—the organic materials, silicates, and carbonates that comprise the sediment matrix. Similarly, phytolith analysis uses mechanical and chemical means to concentrate the items of interest. Since hydrofluoric acid dissolves sand (i.e., silicates), phytoliths (which are made of silica) in a

sediment sample analyzed for pollen will be destroyed, so separate analyses are required. In contrast to macroremain analysis, pollen and phytolith analyses require special laboratory facilities.<sup>2</sup>

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## Macroremains

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Macroremains are relatively large items that generally comprise the bulk of plant remains recovered from archaeological sites. They include seeds and seed-like plant structures, fruits, wood, leaves, tubers, and so on. But remember that most of the plant parts brought to a site by people will not remain on the site. After all, plant matter used as fuel is burned, people eat the food plants, animals eat the fodder. Artifacts like wooden tools, baskets, and mats represent a small and easily lost portion of the total plant material people use over the years and are usually encountered less frequently than ancient trash.

The preservation environment determines which plant parts left after people abandon a site will actually persist in the soil. For organic materials to be preserved, biological, chemical, and mechanical degradation must stop. In temperate, open-air conditions like those prevalent on the east coast of North America, we expect to find charred remains only.<sup>3</sup> Plant remains may also be preserved in dry caves, deserts, pyramids, or in waterlogged deposits.<sup>4</sup>

Typically, macroremains are recovered manually, as seen during excavation and screening, or they are recovered through flotation. Only fairly large botanical items will be recovered through screening, as archaeologists commonly use quarter-inch or centimeter mesh in the field. Chunks of wood charcoal and large seeds like olive pits or nuts are readily removed. However, individual seeds and other charred bits are usually fairly meaningless without their archaeological context. Therefore, the unit of paleoethnobotanical analysis is ordinarily not the individual seed or piece of charcoal, but rather a sampling of the material available within a particular volume of sediment from a clearly defined location on the site. As long as the remains do not explode upon contact with water, flotation is the most efficient way to concentrate small seeds and plant parts scattered in the soil matrix.<sup>5</sup>

As a rule, one ought to be able to develop a flotation system and sampling design for any project and budget, no matter how

small. The simplest flotation systems consist basically of a bucket, a sieve, and some water. Dirt may be poured into the bucket and stirred, and floating material is then poured off onto a cloth or sieve. Alternatively, the soil sample may be poured into a large sieve that is swirled in a barrel of water; floating material is scooped up with a small strainer and emptied onto a cloth to dry. More elaborate flotation systems take advantage of running water piped into a modified barrel. The soil sample is poured into the screen-lined barrel and sinks; an upward flow of water helps lift the plant remains, which are caught in a cloth or screen after they float over the lip of the barrel.

After the flotation sample has dried, analysis begins. The assemblage of macroremains is identified and quantified. Archaeobotanists use morphological criteria (size, shape, and surface features of seeds, and ring patterns of wood). Some seeds and plant parts are only identifiable at the very gross level of plant family (e.g., grass), and others may be identified even to variety (e.g., six-row barley). Unfortunately, many specific and varietal distinctions are based on flower morphology, and flowers are almost never preserved. Therefore, one must frequently be satisfied with identifications just to the genus level. Many botanists and archaeobotanists are working on refining the taxonomy of early domesticates (e.g., goosefoot in North America, wheat in the Old World, and plant tissues).<sup>6</sup>

How one chooses to measure and assess the different types and quantities of plant remains reflects the assumptions and inferences one makes about deposition, preservation, and recovery processes. For example, American Indians ate both hickory and acorns, but hard, dense hickory shell is much more readily preserved than acorn shell. Burned remains of hickory are better able to survive flotation, as well. Because a simple comparison of nutshell weight would severely underestimate the quantity of acorn, experimentally derived estimates of nutmeat based on the weight of modern burnt nutshell permit more accurate estimates of the importance of hickory and acorn in the ancient diet.<sup>7</sup> Cultural interpretations are based not only on the relative quantities of plant remains, but also on their spatial distribution and archaeological contexts. For example, four hundred wheat grains from a storage context (i.e., food remains) cannot be interpreted the same way as four hundred wheat grains distributed unevenly over forty hearth or trash deposits (i.e., remnants of dung fuel or crop-processing debris).

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## Pollen

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Pollen is the male germ cell of seed-bearing plants. It may be dispersed by wind, insects, other animals, water, and so on. Under anaerobic, undisturbed conditions, such as those found on lake bottoms, the pollen exoskeleton persists indefinitely, which allows the palynologist to identify the plants that produced the pollen. As is true of macroremains, however, some pollen types are more distinctive than others. For example, members of the daisy family are generally not distinguishable from one another—all have spiny pollen, and the only distinction is between high spine and low spine pollen. But many members of the pine family, with two air sacs, can be distinguished from other conifers.<sup>8</sup>

The identification of pollen types allows one to reconstruct ancient vegetation and, by inference, climate. Changes in the relative amounts of different pollen types provide evidence of vegetation and climate history in a region. However, plants contribute widely differing quantities of pollen to the pollen record. Palynologists therefore study the modern "pollen rain" in order to see which plants may be over- or underrepresented. Most pollen analyses are done on lake and bog sediments and focus on reconstructing local and regional vegetation patterns.

Archaeological pollen cores, or profiles, are usually not directly comparable to lake cores; the air currents and other "natural" means of pollen transport and deposition associated with lakes are not relevant to settlements, where people have erected roofed structures or brought in wild or cultivated crops. In temperate conditions, like those prevailing in eastern North America, mechanical abrasion, exposure to oxygen in disturbed soils, and earthworms (which eat high-protein pollen) reduce pollen preservability, so most archaeological sediments are unsuited to pollen preservation.

Despite these drawbacks, the special conditions provided by archaeological context have some advantages for palynological studies. For example, James Hill and Richard Hevly were able to recognize three types of rooms in a prehistoric pueblo in Arizona. Habitation areas where food was prepared and eaten had low but consistent quantities of the pollen of maize and other crops; food storage areas had high densities of maize and squash pollen; and ceremonial areas had pollen from plants that, based on the ethnohistoric record, would have been ritually important.<sup>9</sup>



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## Phytoliths

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Phytoliths are formed when plants absorb soluble silica from the water they take in through their roots. A silica body forms, which may take on the shape of the cell in which it is deposited. Because the silica is differentially deposited in plant cells, frequently in distinctive shapes, different plant types are recognizable. In addition, phytoliths are virtually indestructible under many conditions, the exception being soils where the pH is above 8.5. Stem tissue of some plants, especially grasses, is particularly rich in phytoliths. This is of great interest to archaeologists because the grasses include the economically important cereals that are difficult to identify by pollen analysis alone. As a relatively new technique applied to archaeological problems, advances in the principles of phytolith interpretation are made with each new analysis. Taxonomic studies are particularly important because phytolith analysis is such a new field.<sup>10</sup>

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## *SAMPLING SEDIMENTS FOR PLANT REMAINS*

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From the previous discussion it should be clear that the three types of archaeobotanical analysis discussed are complementary, not mutually exclusive. Soils that preserve macroremains may be poor in pollen or phytoliths. Similarly, soils rich in pollen or phytoliths may lack macroremains. For example, Deborah Pearsall found early evidence for maize cultivation in Ecuador through phytolith analysis, despite the poor preservation of charcoal and other organic remains in tropical soils.<sup>11</sup> In addition, different plant structures and plant products may document the variety of ways people use plants—for example, cherry wood might come from furniture and cherry pits from food use; a room full of wheat grains may provide evidence for food storage, while a high density of wheat phytoliths from straw may show a fodder storage area.

The cultural meaning of archaeological plant remains is not self-evident. Interpretation of a particular archaeobotanical assemblage must take a variety of factors into account—how the material was deposited, preserved, recovered, and analyzed. Some of these factors can be accounted for, but not controlled, by the archaeobotanist (e.g.,

how and when the botanical material arrived on the site, and how it came to be preserved). Recovery procedures, including sampling design and recovery techniques (flotation, screening) should be under the control of the archaeobotanist, although in practice it is the archaeologist in the field who makes many of the recovery decisions. The archaeobotanist has most control over analysis—choosing which samples to identify, how to quantify the remains, and how to relate the plant assemblage to the people that produced it.

All sampling for plant remains aims at representativeness. Because of differences in the nature of deposition and preservation, specific sampling strategies for macroremains, pollen, and phytoliths will vary. A good sampling design will satisfy several requirements. First, it will provide an overview of deposits with or without plant remains. Second, it will yield representative samples of those plant remains. Because macroremains are frequently visible as flecks of charcoal or concentrations of seeds, archaeologists who would otherwise not sample for botanical remains will frequently take samples of opportunistically discovered caches. Although this type of “grab” sampling is better than no sampling at all, I prefer to analyze material from sites where there has been a systematic attempt at recovering all types of remains, immediately visible or not. Pollen and phytoliths, invisible to the unaided eye, must be sampled for on faith.

To find out which deposits yield plant remains, one takes soil from a variety of archaeological contexts. Many “sterile” samples so obtained will serve as control samples for the ones rich in plant remains. Achieving a representative assemblage should be an automatic result of such a sampling strategy. Depending on the archaeological (i.e., cultural) context and the preservation environment, however, some deposits are particularly likely to yield plant remains—whether macroremains, pollen, or phytoliths—and special attention should therefore be paid to them.

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## *ISSUES ADDRESSED*

### *BY PALEOETHNOBOTANISTS*

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Although archaeologists have been saving plant remains from archaeological sites since the mid-nineteenth century, the systematic sampling of archaeological sediments is a relatively recent develop-

ment. The research topic that inspired modern archaeobotanical studies was agricultural origins in the Near East. Beginning in the late 1940s and early 1950s, Robert Braidwood of the University of Chicago recognized the significance of plant remains, and he arranged for Hans Helbaek, a Danish botanist, to study macroremains from the early village site of Jarmo, in Iraq.<sup>12</sup> Around the same time, Americanists were investigating the beginnings of agriculture in the midwestern United States. Since the 1960s, archaeobotanical studies have increasingly become a standard component of archaeological projects around the world, and archaeobotanists continue to address many new topics.<sup>13</sup>

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### Agricultural Economies of Complex Societies

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In both the Old World and the New, complex societies depended on agriculture for their survival and expansion. For example, evidence from plant remains has helped document the economic and political influence of the Inka in Peru. Prior to Inka expansion, there appears to have been more maize, a prized food, in the homes of local elites. The Inka promoted some social leveling at the expense of local elites, however, for even commoner households in later, imperial times had high frequencies of maize.<sup>14</sup>

As previously mentioned, archaeobotanical data is not always valued for the historical periods of the Near East, where textual evidence for plant use consists of lists of rations, sowing and yield rates, untranslatable plant names, and similar esoterica. Yet even here, texts refer to the activities of the temple or palace, and many archaeological sites have few or no relevant texts. Thus, trash deposits and human waste deposits may be the only way to document which crops were grown, how animals were foddered and, by inference, environmental and social constraints on production (see the following discussion).<sup>15</sup>

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### Formation of the Archaeobotanical Record and Its Interpretation

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Much current research in archaeobotany either focuses on or acknowledges how important it is to understand how plant remains arrive on a site and how they are preserved; that is, how

cultural practices and natural conditions "filter" the materials that are recovered. Some studies compare modern vegetation with archaeobotanical assemblages; others use ethnographic models to interpret the remains.<sup>16</sup> Archaeobotanists, more than most archaeologists, recognize that the minute items they concern themselves with do not speak for themselves, and that one's analytical tools must correct for these potential distortions.<sup>17</sup>

To give just one example of the importance of context and preservation for accurate interpretation, we can consider a seeming inconsistency in the composition of the archaeobotanical assemblage at the third millennium B.C. city of Malyan, Iran. In the present day, where both wheat and barley can be grown, wheat tends to be preferred for food because the grain is easier to process. At ancient Malyan, however, most of the charred grain is barley; the ratio of charred barley to charred wheat is about thirteen to one. In contrast, mineralized grains from a human waste deposit had a barley to wheat ratio of about one to two. This discrepancy was explained by applying an ethnographic model of plant use, which suggests that many seeds from ancient sites in the Near East were inclusions in dung that was burned as fuel. That is, the charred grains from trash had passed through animals, and those in the human waste deposit had passed through people!<sup>18</sup>

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### Environment, Economy, and Land Use

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No matter what the time period or geographical area, plant remains can provide important primary data about the natural environment and land use practices. My own research focuses on long-term human impact on the environment. In central Turkey, at the site of Gordion (and presumed home of King Midas at around 700 B.C.), shifts in the proportions of wood charcoal between about 2000 B.C. and A.D. 1000 suggested that nearby juniper woodland was reduced, oak became more prominent in the landscape, and overall dominant forest woods (juniper, oak, and pine) were replaced with secondary types. Coincident with the decline in woodland, seed evidence suggested pasture quality lessened as well; high-quality fodder legumes declined in the assemblage, and there was a small increase in spiny and alkaloid-rich plants avoided by animals.

Like all archaeologists, archaeobotanists study the variation in time and space in many aspects of ancient life. For example, in trac-

ing the influence of the environment on foddering practices and crop choice, I have examined several fourth and third millennium B.C. sites along the Euphrates river in southeastern Turkey and northwestern Syria. Rainfall increases as you go north, and the natural vegetation changes from steppe to open oak woodland. Shifts in the proportions of charred seeds of wild and cultivated plants that originated in dung fuel—direct evidence of fodder choice—follow geography. On the steppe, where rainfall agriculture is riskier, sheep and goats would be put out to graze, but as you go north, it becomes more economical to grow fodder, and cereals make a correspondingly greater contribution to the animal diet. Archaeobotanically, this is reflected in a decline in the wild seed to cereal ratio from south to north. In this example, change through time is not pronounced.<sup>19</sup>

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### Introduction and Spread of New Crops and Ecological Change

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The spread and exchange of crop plants began almost as soon as people began farming in both the Old and New Worlds. Globally, however, the pace of change quickened with the European invasion of the Americas, which resulted in major change to the existing Native American land use systems.<sup>20</sup> The most obvious effect was two-way exchange of crops. For example, Old World plants like peach and watermelon were rapidly accepted by the Native Americans.<sup>21</sup> The Europeans brought many of their own crops (grains, fruits, nuts, ornamentals, etc.) to grow. The settlers also began to grow Indian cultigens, like maize, beans, and squash, and they introduced these crops to the Old World. The goal of crop studies is not to develop a laundry list of historically documented introductions. Rather, tracing the spread of introduced plants helps one trace the spread of European influence and enables one to see that the foreigners kept many of their old food and farming habits, but also learned how to grow and use the new crops.

Of course, useful crops were not the only plants that were exchanged. Weedy "camp followers" like crabgrass radically changed the vegetation, not only around the new settlements, but in the interior as well, for plants do not recognize the same cultural boundaries that people do.<sup>22</sup> Thus, even the weeds help document the effects of European expansion.

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## Trade

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Exchange of crop plants represents one type of trade but, if a group successfully adopts a new crop, the initial trading relationship can cease. In some cases, however, an important exotic plant could not be grown easily, or at all. For example, Mediterranean plants like the olive do fine in California, but not on the east coast of North America. Nonetheless, olive pits were found in a dry crawl-space below an orangery at the home of the prominent family of Charles Calvert, colonial governor of Maryland.<sup>23</sup> If the pits were deposited when the space was actively used for growing warmth-loving plants, we might suspect olive was grown as a high-status plant, for it requires special growing conditions. This hypothesis would be tremendously strengthened by the discovery of olive pollen, or even wood, as evidence of the tree itself growing. Rodent-gnawed olive pits found in a trash deposit post-dating the crawl-space could be the remains of an imported (but still relatively high-status) food. Thus, depending on the archaeological context and the total archaeobotanical assemblage, occurrence of an exotic plant may show important facets of historic economy.

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## Spatial Organization—Especially of Urban Areas, Farmsteads, and Gardens

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A city is more than just a collection of buildings. Open space, tended or not, is part of the urban scene, and even the most desolate tract will soon sprout hardy weeds. As Wilhelmina Jashemski has shown for Pompeii, urban areas may have gardens, both private and commercial.<sup>24</sup> Plant remains found on an ancient garden or field surface may reveal fertilizing practices or what was growing on the plot itself. For example, charred remains mixed with small eroded pot sherds indicated that household debris was worked into the soil as fertilizer at Herod the Great's palace in Jericho. Maize and squash pollen has been found in ancient fields in northern Arizona, but it was absent from adjacent areas, clear evidence that the field once supported those crops.<sup>25</sup>

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## CONCLUSION

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All peoples have some direct relationship with the botanical world, and the material evidence they leave behind can be recovered and interpreted. Paleoethnobotany is one of the most important tools we have for developing a picture of ancient life and landscape.

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## NOTES

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## SUGGESTED READINGS

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Hastorf, Christine A., and Virginia S. Popper. *Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains*. Chicago: University of Chicago Press, 1988. The papers in

this collection—directed toward students of archaeobotany—discuss the many ways archaeobotanists extract cultural meaning from the bits of charred seeds and wood recovered from archaeological sites.

Miller, Naomi F. "The Near East." In W. van Zeist, K-E. Behre, and K. Wasylikowa, eds. *Progress in Old World Paleoethnobotany*. Rotterdam: A.A. Balkema, 1991, pp. 133–160. An overview of archaeobotanical discoveries in the Near East.

Pearsall, Deborah M. *Paleoethnobotany: A Handbook of Procedures*. San Diego: Academic Press, 1988. An essential resource for all archaeologists, filled with practical information about archaeobotanical sampling and recovery procedures in the field. For the professional as well as the student, it details how to set up an archaeobotanical laboratory and begin the analysis of plant remains. The analysis of macroremains, pollen, and phytoliths are all covered.

Watson, Patty Jo, and C. Wesley Cowan, eds. *The Origins of Agriculture: An International Perspective*. Washington D.C.: Smithsonian Institution Press, 1992. Chapters directed toward college students and other interested people focus on the archaeobotanical evidence for cultivation in east Asia, the Near East, Africa, Europe, eastern North America, the southwestern United States, Mesoamerica and Central America, and South America.