Far from the Hearth
Essays in Honour of Martin K. Jones

Edited by Emma Lightfoot, Xinyi Liu & Dorian Q Fuller
Far from the Hearth
(Above) Martin Jones at West Stow, 1972 (with thanks to Ian Alister, Lucy Walker, Leonie Walker, and West Stow Environmental Archaeology Group); (Below) Martin Jones in a millet field, Inner Mongolia, 2010. (Photograph: X. Liu.)
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Acknowledgements

The initial idea of editing this volume grew out of a conversation between Xinyi Liu and Graeme Barker at St John’s College, Cambridge in June 2016. The editors subsequently discussed the provisional layout of the volume. By April of the following year, our list of agreed contributors was complete. Abstracts followed, and the chapters themselves soon after. First of all, the editors would like to pay tribute to our 36 authors, whose excellent work and timely contributions made it all possible.

For the last two-and-a-half years, the volume has been known as ‘Fantastic Beasts’ in order to keep it a secret from Martin. As we enter the final stage, we wish to extend our thanks to all who have ensured Martin remains blissfully unaware, including Lucy Walker, and we offer her our sincere thanks. We are extremely grateful to Harriet Hunt, Diane Lister, Cynthia Larbey and Tamsin O’Connell, who are kindly organizing the gatherings to mark Martin’s retirement and the publication of this volume.

With respect to the volume’s production, we would like to thank the McDonald Institute for Archaeology Research for financial support. The McDonald Monograph Series Editor James Barrett oversaw and encouraged all aspects of this project, and we offer him sincere thanks. We would also like to acknowledge the support of Cyprian Broodbank, not least for allowing us to host the workshop at the institute, but also for his encouragement throughout all phases of the volume’s implementation. Particular thanks must go to several key individuals: Anne Chippindale, Ben Plumridge, Emma Jarman, Simon Stoddart and Samantha Leggett. Finally, we are also grateful to the anonymous reviewers who recommended changes that have greatly enhanced the final version of this volume.

Xinyi Liu, Emma Lightfoot and Dorian Fuller
August 2018
The 28-year term of Martin Jones as the first George Pitt-Rivers Professor of Archaeological Science witnessed, and in part created, a transformation in the fields of environmental and biomolecular archaeology. In this volume, Martin’s colleagues and students explore the intellectual rewards of this transformation, in terms of methodological developments in archaeobotany, the efflorescence of biomolecular archaeology, the integration of biological and social perspectives, and the exploration of archaeobotanical themes on a global scale. These advances are worldwide, and Martin’s contributions can be traced through citation trails, the scholarly diaspora of the Pitt-Rivers Laboratory and (not least) the foundations laid by the Ancient Biomolecules Initiative of the Natural Environment Research Council (1989–1993), which he chaired and helped create. As outlined in Chapter 6, Martin’s subsequent role in the bioarchaeology programme of the Wellcome Trust (1996–2006) further consolidated what is now a central and increasingly rewarding component of archaeological inquiry. Subsequently, he has engaged with the European Research Council, as Principal Investigator of the Food Globalisation in Prehistory project and a Panel Chair for the Advanced Grant programme. As both practitioner and indefatigable campaigner, he has promoted the field in immeasurable ways, at critical junctures in the past and in on-going capacities as a research leader.

The accolades for Martin’s achievements are many, most recently Fellowship of the British Academy. Yet it is as a congenial, supportive—and demanding—force within the Pitt-Rivers Laboratory that the foundations of his intellectual influence were laid. Here, each Friday morning, the archaeological science community would draw sticks to decide who would deliver an impromptu research report or explore a topical theme. Martin is among the most laid-back colleagues I have worked with, yet simultaneously the most incisive in his constructive criticism. As a provider of internal peer-review he was fearless without being unkind. The themed Pitt-Rivers Christmas parties were equally impactful—one occasion Alice Cooper appeared, looking ever so slightly like our professor of archaeological science.

Martin’s roles as a research leader extended to several stints as head of the Department of Archaeology, chairing the Faculty of Archaeology and Anthropology and serving as a long-term member of the Managing Committee of the McDonald Institute for Archaeological Research. Having started his professional career as an excavation-unit archaeobotanist in Oxford, he was a long-standing proponent of the highly successful Cambridge Archaeological Unit. In the wider collegiate community, he is a Fellow (and was Vice-Master) of Darwin College and was the staff treasurer of the Student Labour Club. In all roles he fought valiantly and often successfully for the interests of his constituency. His capacity to fight for deeply held priorities while recognizing the value of diverse perspectives was of utmost importance. His nostalgic enthusiasm for the debate with archaeological science that was engendered by the post-processual critique is one signal of an underlying appreciation of plurality. His active support for the recent merger of the Divisions of Archaeology and Biological Anthropology, within our new Department of Archaeology, is another. As a scientist (Martin’s first degree, at Cambridge, was in Natural Sciences) he values the peer-reviewed journal article above all scholarly outputs, yet has authored as many highly regarded books as a scholar in the humanities. His Feast: Why humans share food has been translated into several languages and won Food Book of the Year from the Guild of Food Writers. He views academia and society as a continuum, campaigning for archaeobotanical contributions to global food security (e.g. by promoting millet as a drought-resistant crop) and working with world players such as Unilever to encourage archaeologically informed decisions regarding food products.

That Martin’s achievements and influence merit celebration is clear. That his colleagues and students wish to honour him is equally so. Yet does the McDonald Conversations series publish Festschriften? This is a semantic question. As series editor I am delighted to introduce a collection of important papers regarding the past, present and future of archaeobotany, representing its methodological diversity and maturity. That this collection concurrently pays respect to a treasured colleague is a very pleasant serendipity.

Dr James H. Barrett
Chapter 3

A System for Determining Plant Macro Archaeological Remains

Victor Paz

An explanation of the methodology

In the study of plant macro archaeobotanical remains, an identification system refers to the procedure used to recognize plant remains from a sediment matrix sample. Specifically for macro remains, it comes mainly from water flotation processing of sediments, which are then sorted and identified based on general categorizations, for example seeds, parenchyma, wood, and so on. A determination system, on the other hand, is the procedure that attempts further to recognize identified materials to taxon. Determination is what we aspire to do with most of our archaeobotanical materials in order to make interesting inferences concerning the human past; the more transparent the determination system, the more informed interested parties could be. This is even more relevant when the plant remains play a central role in a wider archaeological discourse, such as on questions surrounding the complexities of people–plant and people–landscape relationships or interactions.

Just send them to a botanist?

Commonly a botanist is not readily equipped to work on charred archaeobotanical materials, which is the nature of most plant macro remains that survive in an archaeological site. They are not used to determining taxa from seeds, let alone transformed fragments of seeds and vegetative organs. Botanical identifications as organized in ‘keys’ almost always start from identifying flowers, fruits and leaves (e.g. Calumpong & Menez 1997; Clapham et al. 1987; Cullen 1997; King & Robinson 1987; Stace 1997), and seldom through a key based on seeds or vegetative organs (e.g. Rose 1981). Most of the time, from a botanist’s point of view, identification through the flowers and fruits is more than enough to determine species successfully (cf. ESF 1989, 7); plant parts that very seldom survive in pristine condition.

With this fundamental difference in approach, and not particularly keen on knowing the answers to problems set by the archaeologists, it is not hard to expect a botanist to be unenthusiastic about the task of identifying the macro remains in an archaeobotanical assemblage. Sadly, what regularly happens is the non-conversion of samples to data. In my own experience, when project directors prefer to send their archaeobotanical flot samples to a botanist, rather than to an archaeobotanist, they end up disappointed. It is very rare to come across results of such collaboration in our part of the world. Trained botanists such as Jon Hather (1992; 1994) and Douglas Yen (1977; 1988), who worked on Asian and Pacific materials, and were deeply interested in archaeological questions, are rare to find. The responsibility therefore falls on the shoulders of the archaeologist specializing in archaeobotany. The archaeobotanist fills the gaps of knowledge and know-how between archaeology and botany.

A focus on macros

Plant macro assemblages have a high level of determination success. Unfortunately, even after two decades of methodological progress, we have not been uniformly straightforward with the way we determine the plant remains, and in many parts of the world archaeobotanical studies remain an afterthought in archaeological projects. There may or may not be a correlation between the two above-mentioned woes, but we could at least try to address the latter in this chapter.

There really is a need to clarify further the methodology for the determination of macro plant remains. The intention is to achieve through practice an accepted convention that is not chiefly based on the authority of the specialists. We must clarify all the variables in the process, including the proper place of an individual’s authority in the system. The chain of reasoning which led to a determination must be explained. Anyone who bothers to read an archaeobotanical report may then judge how much value they would give to the findings, and how far they are will-
ing to take it. The determinations an archaeobotanist provides define the inferences we make as archaeologists. When plant remains are identified with precision to species, it is mostly taken at face value and the significance of its presence in the archaeology is lined up to support large-scale narratives. This is especially relevant in narratives involving plant domestication, origins and spread of agriculture, human subsistence strategies and, to a lesser extent, inferring rituals and well-being practices (see Barton & Paz 2007; Paz 2005; 2012).

**A reflection on determinations**

I believe that the aim of archaeobotanical determination is to demonstrate how the botanical remains we recover were indeed part of a specific plant. We use the botanical taxonomy as a baseline, with the binomial taxa convention indicating genus-species as a target of our determination attempts. As archaeologists, specifically as archaeobotanists, we start with the premise that, given the right samples and sufficient reference collection, we can determine identifiable plant remains to the level of species. I think this premise is where the problem starts.

Walton Green (1999, 18–21) argued in his work, and mainly through several discussions at the George Pitt-Rivers Laboratory at Cambridge, an intriguing recommendation for archaeobotanical determination. It is epistemological and forces the archaeobotanist to reflect on how one determines plant remains. In his proposal, non-prefix binomial taxon identification may only be used if:

- There are no ordinal or binary characters differing between identified and reference samples, and all quantitative characteristics are closely matched—within two standard deviations
- Specimens of all taxa in the local Floras of equivalent rank in the same taxon of immediately superior rank have been examined and eliminated, for example identification of all members of the genus that are in the local Flora
- Multiple modern reference specimens were examined from more than one population. The accession number and location of the reference material should be cited; at least one population should be from the same geographical area as the archaeological specimen; identification of the reference material should be based on full-plant identification
- Green proposed to use the prefix ‘prob.’ for all identification of which the archaeobotanist is convinced, but which do not fulfil the conditions for un-prefixed identification. This category includes identifications done with photographs and images, after which all closely related taxa of equivalent rank have been eliminated. He uses a prefix ‘cf.’ when the specimen being identified merely shows similarities to, and could be a member of, the stated taxon. A prefix ‘elim.’ is used as a discretionary prefix to show that the identification was only done through a process of elimination (as opposed to examination of morphological characteristics). In other words, when the ideal condition for determination is not met, the authority of the investigator is brought into play and prefixes are added in the taxonomic determination.

While I have full praise for the recommendations of Green, and was inspired by his reasoning, I differ at some fundamental level. As a starting point, I think Green’s proposal, as stated in his first point, is unnecessarily strict and paralysing for the investigator. While it is correct to suggest consulting all the Flora of a region and, from this reference, seek for actual taxon matches, many regions in the world do not have a complete Flora—let alone a localized one. The amount of effort and time that will have to be allocated in order to look at all equivalent rank and immediate superior rank queries will be initially daunting. I have to say, however, that once done successfully, a taxon will then be easily determined next time around. But that is if one finds the references that will satisfy the demand for a complete documentation of a taxon.

In many places in the world, regional Floras are far from complete. There are no complete compendiums for most tropical regions, and there is a scarcity of sub-regional Floras to refer to. The scale of building a complete Flora is monumental. The British Isles is a good example for a region having a confidently comprehensive flora record. The Flora project was begun in the late nineteenth century, to be completed only in 1934 (Stace 1997). The project was completed thanks to a large population of botanists undertaking systematics, recording a temperate-based climate flora.

Looking at tropical regions, such as Southeast Asia, or even just Island Southeast Asia, what we have is a much larger land area and a broader range of tropical climates and flora. The attempt to complete a tropical Flora has shown difficulties from the outset (Mabberley 1992, 9). The regional Flora—Flora Malesiana—started only in the late 1940s (van Steenis-Kruseman 1950) and has not been completed to date, with very erratic additions through the years (Ashton 1982; Laubenfels 1988). As of its latest addition in 2013, it has published 21 volumes under Series 1 (seed plants) and four volumes of Series 2 (Pteridophytes); most of the more recent volumes contain revisions/additions of taxa already covered in earlier volumes. To think that this was done with better technology, with about a hundred international collaborators working on the project globally (see Floramalesiana.org), it may be unlikely that an
almost complete record of the flora of a tropical region can be produced in the next few decades. In addition, if the direction of botanical systematics becomes more reliant on genomics (Soltis et al. 2013; Sytsma & Pires 2001), the physical traits of the plant will likely become secondary in defining taxon; it seems less promising for the purposes of macro archaeobotany.

The central issue, I believe, is whether it is possible to construct a complete record of a region’s current and past flora. Unfortunately, this is highly improbable, especially in regions with very rich and diverse plant life, such as the tropics. It is also worth asking if we can truly gather absolute knowledge on the flora of a region, on top of totally knowing its past plant population history. It is a fundamental question to ask: are we confident that science has actually recorded every plant taxon formed in nature and living at the present? What about the countless species of plants that were selected against and are long extinct, or have reverted back from being cultivars/domesticates to a new ‘wild form’ at any given time in the past? I propose that, rather than basing our determination attempts on perceived absolute knowledge of current and past flora, we admit that we are making best-fit determinations and that we explain this with clarity. The archaeobotanist who plans to use the archaeobotanical data shall then be properly guided as to what extent the data may be of use for supporting their research problem, and gauge its useful value for generating inferences.

**Contribution of this system**

There are two intertwined elements in this system; one is for determining transformed seeds, fruits and nuts, and the other focuses on charred parenchyma tissues, with further determination of wood not fully addressed. The main focus of this system is the determination of parenchyma remains. The corpus established by Hather is the foundation of this approach and mainly applied to Southeast Asian and Pacific archaeobotanical assemblages. It confirmed beyond doubt that charred parenchyma can be identified and separated from other plant charcoal remains. It has further confirmed patterns observed by Hather—specifically on the relevance of the difference between tissues charred fresh and charred dry (Paz 2001). A third confirmation is the survival of surface and sub-surface features of vegetative organs, such as the periderm structure. Hather (1988, 146) already pointed out that its survival is significant to the exercise of identification.

My own ethnoarchaeological work with a Negrito community in the Sierra Madre of Luzon demonstrated that a common way of processing taro corms is by roasting on an open fire. It was observed that the scraping and cutting-out of charred portions of the corm leads to a concentration of charred parenchyma tissue coming from the surface and near-surface of the vegetative organ. They have a better likelihood of survival because they get charred and integrated into the ashy matrix of a hearth with minimal time lapse (see Paz 1999). Observations done on the periderm of root crops reference samples such as yam (*Dioscorea alata* L.), taro (*Colocasia esculenta* [L.] Schott), sweet potato (*Ipomoea batatas* [L.] Lam) and cassava (*Manihot utilissima* Pohl) did not reveal possible diagnostic quantitative features. Most of the fragments observed, though, had parenchyma cells attached to phellogen-associated tissues beneath the periderm. When they survive together, and can be quantifiably observed, it will allow the possibility of identification beyond saying that the material is a periderm fragment.

A clear contribution of this work to the study of charred parenchymatous tissues is the further quantification of species-specific determination. In Hather’s work, this was not necessarily done, because his concern then was more to see the general patterns, and observations that may help guide early attempts to identify charred remains in the archaeology. In our system we have created two distinct steps to add rigour to the determination process; an internal and external step. This will be further explained below.

**Determination procedure**

The archaeobotanical reports and presentations of archaeobotanical results in publications often do not provide the necessary details as to how a determination was reached. In areas where there is a deep tradition of archaeobotanical work, the need to go through the justification of an identification of every plant remain may be extremely redundant and tedious. In regions like Southeast Asia there are a few exceptions where the publication of results is extensively discussed (see Castillo & Fuller 2010): examples are the terminal publications of the Khok Phanom Di project in Thailand (Thompson 1996) and the Niah Cave Project in Sarawak (Barton et al. 2016a,b). I take the position that the exception can be made the rule, wherein we shift the reliance of the system towards the scrutiny of the plant remains themselves based on access to reference resources while defining the role of the investigator’s authority. It is clear to me that the need for a more organized and transparent system is not a pedant’s exercise.

*The system for determination*

Discussing the ideal and the actual practice of identifying transformed plant remains is important. I attempt
Chapter 3

Table 3.1. Classifications of seeds based on preservation conditions (after Hubbard & al Azm 1990). Regrettably this system was adopted by only a few others. In my own work its use is limited to Preservation class 6 and Distortion classes 2–7. With the exception of waterlogged material, I consider Preservation 1 and Distortion 8 to be contamination, but they still can/must be described.

<table>
<thead>
<tr>
<th>Class</th>
<th>Preservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perfect</td>
</tr>
<tr>
<td>2</td>
<td>Epidermis virtually intact; rhachillae observable so as other external elements</td>
</tr>
<tr>
<td>3</td>
<td>Epidermis incomplete; rhachillae, hairs etc. occasionally preserved</td>
</tr>
<tr>
<td>4</td>
<td>Fragments of epidermis remaining; other features virtually unobservable</td>
</tr>
<tr>
<td>5</td>
<td>Identified by gross morphology only</td>
</tr>
<tr>
<td>6</td>
<td>‘Clinkered’ ('see-through' with the shape of the seed preserved in the outline of the mass of the bubbles, but with a clear view from one side to the other through the holes)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class</th>
<th>Distortion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No noticeable distortion</td>
</tr>
<tr>
<td>2</td>
<td>Slight puffing of seeds noticeable</td>
</tr>
<tr>
<td>3</td>
<td>Clearly distorted</td>
</tr>
<tr>
<td>4</td>
<td>Gross distortion</td>
</tr>
<tr>
<td>5</td>
<td>Seeds fused together in a solid lump, faceted when free</td>
</tr>
<tr>
<td>6</td>
<td>Carbonised tarry material exuded from distal ends of caryopses</td>
</tr>
<tr>
<td>7</td>
<td>Sides of the seed longitudinally wrinkled, partially collapsed and concave</td>
</tr>
<tr>
<td>8</td>
<td>Sprouting: as (7), but with the radical greatly elongated</td>
</tr>
</tbody>
</table>

Table 3.2. Table indicating variables relevant in establishing the level of confidence of determination: (Y) good match; (?) questionable match; (X) not present; (prob.) probably; (elim.) eliminated.

<table>
<thead>
<tr>
<th>Variable</th>
<th>No prefix</th>
<th>prob.</th>
<th>cf.</th>
<th>elim.</th>
<th>suffix</th>
<th>Form/shape description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference collection</td>
<td>Y/?</td>
<td>Y/?</td>
<td>?</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Image</td>
<td>Y</td>
<td>Y/?</td>
<td>?</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Illustration</td>
<td>Y/?</td>
<td>Y/?</td>
<td>?</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Flora</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y/?</td>
<td>X</td>
</tr>
<tr>
<td>Taxonomic details</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y/?</td>
<td>X</td>
</tr>
<tr>
<td>Geographic area</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

To reason that identifying and determining macro archaeobotanical remains follows these premises:

1) No specialist/expert knows everything, and therefore cannot simply leave identifications unexplained. A system must therefore be verifiable and allow for explanation as to how determinations were made. The practice to be followed in this work will adopt the spirit of versions of scales of confidence already applied in Asia and the Pacific by Douglas Yen (Bodner 1986; Glover 1976; 1981) and Gary Crawford (1983; 1986), but limits and situates the role of the specialist in the determination process.

2) The focus of the identification/determination system is not to pursue a theoretical absolute correspondence between the archaeobotanical material and a species of plant living in the distant past; rather it is on achieving a best-fit identification/determination, and the manner of how the investigator can convince interested individuals of the merits of the results presented.

3) A composite of methods and references must be used. When reported, images of the material and what it was compared to should be included to support the determination. In turn, work done this way contributes to an improvement of archaeobotanical referencing—improving the reference base for others to use.

4) There are certain identifications/determinations of macro remains that, while they may not pass the rigid prerequisites for the highest level of confidence (no prefix), may be stated as such based on the experience and knowledge of the archaeobotanist.

There is no need to go into detail regarding the methods applied to collect macro archaeobotanical
samples (Barton et al. 2016b; Fuller 2008; Paz 2001). We start with a sample collected by hand or through flotation. The contents of the sample are sorted into plant remains and other materials, for example animal and insect remains, non-organic artefact, and so on. The botanical remains are further divided between the identifiable and the non-identifiable pieces.

The identifiable plant remains are further sorted into pieces that can be further determined and those, especially seeds and nut fragments, that are so badly charred that no further determination can be done. This sub-set can, however, still be further classified, following the preservation/distortion nomenclature proposed by Hubbard and al Azm (1990; Table 3.1). The determinable remains that cannot be identified at the moment, due to a failure of matching, can be further described by their general shape (after transformation) using a system proposed by Martin and Barkley (1961) or a similar/modified approach. When images are shared of these remains in reports or publications, other practitioners may be able to identify/determine, or make suggestions, which may be pursued later.

Specific to the assemblage of seeds, fruits and nuts that were identified, I proposed the following determination arranged by descending scale of confidence.

Non-prefixed: A binomial taxon determination may be made without any prefixes whenever it fits all determination variables (see Table 3.2); it fits taxonomic diagnostics, geographical distribution, and the species citation in a Flora. These are firm prerequisites for a non-prefix determination. It must also fit clear photographic/image reference(s) of the plant parts, for example seed, nut, etc., and/or line illustration reference(s), or both. The use of a reference collection is still important, but not essential.

Prefixed ‘prob.’: Matches Flora citations, geographical area and fits taxonomic details; the existence of image, illustration or reference collection, but not all. It differs from the ‘non-prefixed’ determination in that only one out of three—image, illustration and reference collection—matches or is a good fit, with the other two variables weak or questionably matching.

Prefixed ‘cf.’: All the determination variables may or may not exist (see Table 3.2). The archaeological material resembles an image/illustration/reference sample or a previous identification by an archaeobotanist/authority, but there is no exact morphological fit. Three out of the five other categories match the archaeological material, but the investigator has doubts about the exact fit of these categories with the material.

Prefixed ‘elim.’: A low confidence determination. It indicates that the material may perhaps be the taxon proposed, but the determination was derived without any images, illustrations or reference collection sample. The specialist/archaeobotanist makes an authority/experience call.

Suffix ‘type’: This is applied when the level of confidence is very low or lacks most determination variables. It means that the shape of the specimen fits a previously well determined plant familiar to the investigator. The candidate plant comes from the same geographical area, and has some of the morphological characteristics of this plant’s seed, nut or fruit. It must only be used to determine remains, at most, up to genus level.

Form shape description: None of the six determination variables exist, but the archaeological specimen is distinctly a seed, a nut fragment or any other plant part. The material may then be described by its preservation/distortion condition and general shape, for example Spheroid, Angular, Triangular, and so on. A number is attached to the shape description based on a chronological sequence with other specimens from the same site that were only given shape descriptions, for example ‘Angular 3’, ‘Spheroid 2’ and so on. Sometimes under this categorization a very tentative identification may be added, mostly at the family level (with prefix ‘cf’). This is to facilitate future researchers, who may have a better stock of references and experience, to verify the hunch (see Fig. 3.1).

Charred parenchymatous tissue identification and determination

A parenchymatous tissue fragment is a specific kind of charred plant remain. Archaeobotanically it is almost always in the form of plant charcoal that looks amorphous to the naked eye; devoid of clear structures, such as the remains of wood rays. Further analysis may determine if indeed the charred material is parenchyma. Untransformed parenchyma cells are more or less shaped as isodiametric polyhedrals with thin non-lignified cellulose walls. The tissues formed by parenchyma are usually ground tissues in which other tissues are embedded. Parenchyma cells are concerned with photosynthesis, storage of various materials, wound healing, secondary thickenings and the origin of adventitious structures (see Esau 1965, 8; Tootill 1984). There are specific plant organs that are mostly composed of parenchyma tissues. These are the
Figure 3.1. General schema showing the process of identification and determination of plant macro remains.
vegetative organs which humans have made a habit of exploiting, such as tubers, corms and rhizomes.

The identification system for charred parenchyma tissues was developed only in the last two decades of the twentieth century. However, the identification of remains of root/stem tubers in archaeology has a longer history. Early identification of arrowroot (Canna edulis Ker Gawl.) and cassava was possible in South American sites in the late 1950s because they were recovered almost whole and desiccated (see Hather 1988; Towle 1961). In charred form, pioneering archaeological identification of remains of root/stem tubers were on whole or large fragments of vegetative organs, for example potato, sweet potato and cassava (see Hather 1988; Rosendahl & Yen 1971). Until the 1970s it was only possible to identify remains of vegetative organs when they survived in large pieces, with their external morphology mostly intact. The challenge was to develop a method of identification that would allow analysis of smaller fragments, up to pieces that are not larger than 10 mm, which is the common condition of preservation in an archaeological context.

The Hather methodology

The challenge of developing the methodology for identifying seemingly nondescript charred vegetative organs was taken up by J.G. Hather (1988) in the mid 1980s, and since then has become the key approach followed (see Holden et al. 1995; Oliveira 2008; Paz 1997; Pearsall 2000; Perry 1999; Ussher 2015). Hather’s training was in botany before he developed his interest in archaeology. He worked on a fundamental archaeological problem, which was how to identify root crops in charcoal form (Hather 1988; 1991). He was the first to characterize clearly the difference between charred vegetative and charred non-vegetative parenchyma tissues. Hather also pioneered developing a vegetative organ reference collection comprised of thin-sectioned tissues and charred whole vegetative organs from various taxa mainly for archeobotanical purposes. In the process he demonstrated that ‘charred plant tissues may be recognized as having characteristics of the anatomy of organs of a family or related groups within a family’ (Hather 1988, 341). Hather was also the first to recognize the significance of taphonomic processes in any attempt at studying charred vegetative plant remains, which led him to develop a system of identification based on a combination of morphological features, anatomical features and artefactual characteristics of charred tissues—concluding that all identification of charred organs, even with the remains of tissue components identifiable, has to be wholly artificial in nature (Hather 1988, 346).

Hather also recognized the patterns connected to the condition of a tissue upon charring (fresh or dry). He observed patterns in the nature of vesicle disintegration and tension fracturing, which allows inference of the size of the organ, and the orientation of the fragment analysed in relation to the larger organ to which it belonged. The work of Hather, at the minimum, highlighted a better sorting method for charred remains in an archaeological sample. Practitioners in the past mostly identified everything as wood charcoal. After Hather’s study, we could now further sort the charred materials to possible fruit tissues and vegetative organ tissues from the actual wood charcoal remains.

The system that we have been using for determining parenchymatous charcoal directly follows Hather’s work (1988; 2000). It also follows the determination system that we presented for seeds and nuts. Determination is done through reference collections of contemporary plant parts. Comparisons are made on the morphology of a specimen against the reference collections for charred plant tissues. At best this is dictated by the extent of transformation of tissues after burning; especially in the formation of charring features, such as where cavities form, the collapse/fusing of cell walls and the preservation of elements within the remains of vascular bundles. Together with the artefactual features, the transformed anatomical features may be measurably compared, that is cell size, cell shape, cell-wall characters, cell contents, presence of arencyma and idioblastic cells (see Paz 2001).

Procedure for identification

The process of identifying charred vegetative parenchymatous tissues is as follows.

Sample sorted with the naked eye or low-power microscopy; wood-like charcoal from other plant remains, and other artefactual materials. The sorted wood-like charcoal examined for parenchymatous remains is often rounded, cells are spherical, or more or less isodiametric, tissues are made up of cells without a distinct organization; charred parenchymatous tissues often contain regular/irregular patterns of cavities; sometimes there are dense reflective regions surrounded by larger dull textured regions. All the vegetative tissue parenchyma scrutinized under a microscope, with a minimum of 10× magnification. The exposed surface must be scrutinized for other diagnostic features. When possible, further fracturing of the sample should be done to expose un-weathered or less distorted surfaces.

The best samples undergo Scanning Electron Microscopy (SEM). This involves grabbing images
of the best surfaces containing the most diagnostic features, that is cell shape, cell size, cell-wall thickness and patterning, vascular organs, vesicles and tension fractions, idioblastic cells, crystals and remains of starch grains.

The images are further analysed using an image-processing programme capable of measuring diagnostic features. All observable cells should be measured by their ‘long’ and ‘short’ axis, circumference, as well as the thickness of the cell walls. Vascular organs must be measured by the general area, ‘short’ and ‘long’ axis, and the localized cell-wall thickening pattern of xylem remains documented. If there are remains of starch grains, they should also be measured in the same manner as the other quantifiable features (see Fig. 3.1).

Comparison with reference collections and other resources

The exponential growth of comparative resources in cyberspace has become incredibly useful. Plant lists, Flora, images and other relevant research work that may strengthen variables we indicated useful for determination are now more accessible. This was not the case until at least the 1990s. Still, at the heart of our determination system is an actual reference collection of plant parts; our matching approach between past and present plant forms, and the uniqueness of the transformed archaeological remains dictates this.

There are now several dedicated achaeobotanical reference collections maintained in various research centres across the globe. One such collection is being maintained and developed at the University of the Philippines, Archaeological Studies Program (UP-ASP) in Diliman. At the core of the reference collection are plants known to be utilized by people. Specific to vegetative organs, the collection started with the most ethnographically important root crops and some samples of known famine food tubers (informed through ethnography). The premise was that these same root crops and famine tubers were significantly exploited in the region in the past. Moreover, they may serve as proxy evidence for biogeographic inferences, and past human population-movement arguments. With our approach in mind, a relatively small-sized reference collection can still be effective in arguing for a high confidence level of determination. If we are transparent, a discerning reader may make better informed decisions as to how much to accept and use the information we provide. A weak reference collection may be augmented by other collections/references and resources through the internet, and the skill/experience of other specialists—provided that specialist and reports present/share at least an image of the pertinent material.

At the core of the reference collection at the UP-ASP is the parenchyma collection; currently with eight species from four of the most important genera humans exploit for their vegetative organs, namely, *Dioscorea*, *Manihot*, *Colocasia* and *Ipomoea*, with more samples actively being added. Within the species represented in the collection are several individuals coming from several population stands—relevant, we realized, in providing a better range of measurements of diagnostic features. There is also a basic fruit pericarp collection which includes bananas (*Musa* spp.) and jack fruit (*Artocarpus* spp.) samples. In addition to the charred reference collection of parenchymatous material, a wood reference collection was developed, which now holds 100 species from 38 families. Added to these are 78 species of woody vines from 28 families.

Our running count of plant seeds and nuts in the collection is 381 species from 62 families.

While the reference collection will never be a complete representation of the current tropical flora in our region, and there are many more species that must be included in the future, I am confident that the species currently represented are sufficient to make effective archaeological macro remains determinations.

Measuring

Measurements of parenchyma tissue diagnostic elements are made by opening digitally stored SEM micrographs on image-analysis software. The cells, vascular organs, crystals and starch grain remains must all be measured by their long axis, short axis and area. It is appropriate to label the measurements ‘long axis’ and ‘short axis’ to avoid unnecessary difficulty in orienting exposed tissue surfaces—knowing that parenchyma cells in tissues are not consistently oriented. Added to this, the charring process transforms the features of the tissue and often skews the shape and true orientation of the cells. The cells must be measured from the inner surface of cell walls. When cell walls are composite (two cell walls fused after charring), they must be measured whole and the measurement divided into two. All measurements may be encoded and analysed on spreadsheet software, and the cluster of measurements compared with the values from known species in a reference collection—the more overlap there is in the range of measurements between the archaeological and a known species, the higher the level of match per variable.

Determination scale

As already mentioned, we determine by using categories arranged in a scale of confidence. At the highest level of confidence, the parenchyma tissue may be
Figure 3.2. Diagram of determination process, which shows the two-step process (internal and external steps).

determined to species. Any further precision is not acceptable in our methodology. At the lowest level of confidence, the material may be identified simply as parenchyma tissue (see Fig. 3.2). Applying the two-step approach in determination, we start from an internal determination step, which means that the sample was studied purely on the presence of diagnostic elements internal to the charred remains. If there are few observable diagnostic elements, then the determination is weak. At best it will have a prefixed taxon determination to genus level. At worst, we can say that we looked at the sample and could only define that it is definitely charred parenchyma tissue.

The internal variables we seek in samples are the biological structures and taphonomic artefactual features found on the actual archaeological charred tissue. Depending on the number of diagnostic elements—which dictates the determination—the external determination elements, composed of archaeological context, ethnoarchaeological data, ethnobotanical data and temporal data, may or may not be used to improve on the internally derived determination. External context must not go beyond the limits defined by the internal determination step.

If the determination is strong (that is, diagnostic features beyond cell size/shape and wall thickness were observed, the collective measurements of the features fits a reference collection taxon, celliwall thickening patterns of xylem were observed, there were druse formation or idioblastic cells observed), it
can be further improved by considering external determination variables, such as archaeological, ecological or taxonomic context and the experience-derived insights of the investigator. It may also be possible that, after considering external determination variables, an initially strong confidence determination may be weakened by contradictions beyond the physical context of the sample. This may happen especially when the internal determination conclusion is strong, but did not have enough diagnostic variables and there is inconsistency in fit when compared with samples of taxon from the reference collection, the known details of distribution of such a plant, or the time depth of the archaeological context. Without details of the cell shape and wall thickness or remains of vascular organs, high-confidence taxon determination is not possible. The use of the prefixes, suffixes and ‘type’ described for the seed determination is adopted for the final determination (see Table 3.2). With no clear diagnostic feature match with reference samples, the charred tissue can still be identified morphologically and artefactually as a root or stem tuber (see Fig. 3.2).

**Determined to taxon**

When the archaeological material fits all or most of the diagnostic features of a reference species, that is cell shape, cell-wall thickness, cell-content remains, vascular organ characteristics, idioblastic cells, crystals and starch grains, then the material may be identified to species. Having the cell size alone is not sufficient to have a non-prefixed determination of a charred tissue. Cell size is a complicated determination variable. One clear reason is that they undergo cell polyploidal development that is especially common in root crops (Ayensu 1972), resulting in cells becoming larger at average within the same species (Galitski et al. 1999; Nagl 1978); with a likelihood of even growing further through continuous domestication or cultivation selection processes. This complicates determination, if solely based on cell sizes, between an archaeological sample and an incomplete modern vegetative organ reference collection. Nevertheless, the archaeological cell samples may be plotted against the range of reference species measurements, and this may provide some grounds for further identification. The use of scatter graph representation to compare clusters of measurements on both the sample and a reference collection taxon is an effective way of comparing values.

**Determined as root or stem tuber**

The internal analysis led to a weak determination. While the basic diagnostic attributes of a parenchyma tissue were established, it lacks the other prerequisites for a taxon determination. The sample only has observable variables associated with parenchyma cells. When compared with the reference samples they did not fit the ranges associated with the species represented. The sample may be further determined as root or stem tuber, if parts of the pit structure survive, or the parenchyma cells look roughly oriented towards a central point.

**Determined as storage organ parenchyma**

Determination falls under this label when the basic diagnostic features for parenchyma are met, but the material does not fit, even in the slightest, any of the reference species—the cell shapes, size and arrangement are totally different, and measurements do not/hardly overlap with any of the ranges of reference species in the collection. The archaeological material is substantial enough to show that it was part of a large organ, but no other diagnostic features apart from those directly associated with cells were noted.

**Determined as fruit parenchyma**

An archaeological tissue falls in this category when there are no signs of vascular organs on the charred remains, and is comprised only of parenchyma cells; the general shape of the original organ can be discerned; or there are clear remains of the periderm and underlying phellogenic structures. The cells have thicker walls compared with the cell walls of parenchyma from vegetative organs.

**Determined as parenchyma**

At this level, it is clear that the tissue being determined is not a piece of lignified charcoal. It was clearly demonstrated that it fits the characteristics of parenchyma cells and tissue as already described earlier.

**Determined as unknown**

A general label given to archaeological charred plant tissues, initially categorised as parenchymatous, but after analysis could not be placed with a comfortable certainty under the category of parenchyma or woody tissue, or any other type of charred plant remains. This is usually due to extensive taphonomic transformation.

**A final note**

In the methodology of comparing archaeological plant remains against contemporary plant references we are under no illusion that what we conclude was derived from absolute knowledge of what is, and what was. We are at best giving good approximations that are well informed—the best that anyone can say or do—with charred macro remains. Anyone who engages the reasoning behind our determination may follow the
steps taken without difficulty. The system underscores the importance of how determination is delimited at first by observations and information directly relevant to the plant remains under study (internal determination). All other variables that may help in improving the level of precision in the determination, including the skill and experience of the investigator (external determination), must be clearly limited by the extent of what can be said from the actual archaeological material, or from the limits of the internal step of the process.

It is fortunate for the discipline of Archaeology that methodologies and techniques coming from archaeobotany continue to progress. There are advances not only with the macro remains methods, but also with the smaller scales of plant remains. The micro remains of plants, represented by pollen, phytoliths and starch, are studied with the same amount of interest. Equally so are the advances in the analysis of plant isotopes and lipids, traces of which are ingeniously extracted from the archaeology. It is almost a truism that all the methods have strengths and real weaknesses. I, however, maintain that plant macro analyses have a unique advantage. It is only at the macro level that we see plant remains still with anatomical or biological features in their original physical associations with each other. We may recover charred seeds with the embryo placement in direct association with the rest of the seed components. A tissue of charred parenchyma, even when drastically transformed, may show the direct association with each other of cells, vascular bundles and other biological features embedded in tissue. With micro and molecular remains, we are dealing with relevant components and traces of plants that existed—all are totally detached from their original/natural context—churned within an archaeological sediment matrix. They are denied the advantage of being found as a compound tissue where several elements, undeniably associated features, can be brought to play in the determination. And so the philosophical cautionary question applies more heavily at the micro and molecular scale: have we eliminated all possible candidates for determination to taxon? Have we seen everything?

As always, the best way to deal with weaknesses in our methods is to bring together all possible lines of proxy evidence to support and improve determinations derived from the techniques applied. In a limited way we have been applying this approach in Island Southeast Asia in the study of people–plant relationships, where the determination of macro remains (conservative by the nature of the determination system) is improved by complementary results from parallel determinations of micro remains (see Barton & Paz 2007; Mijares 2007). With more collaborative work, there is indeed good reason to be optimistic about the prospects of archaeobotanical methods.

I have attempted to explain better a determination system for plant macro remains that is being used and referred to at least in Island Southeast Asia and the Pacific. Perhaps it may even turn into a proper protocol, one day, across scales of plant remains. But this is not my concern. By submitting this piece for this volume, I try to honour Martin Jones and revisit, for me, a major academic root. Our generation of archaeologists came out of the Cambridge environment very confident that we could do more and continue practising and improving our craft. Many of us are still researchers and academics. There are many wonderful individuals who actively helped me in my personal growth and contributed to my grand experience. Martin Jones was definitely one of them.

A tribute

It has been over two decades since Professor Martin Jones became my mentor. The transformational experience rewarded me with at least two major lessons: first, academic mentoring should be towards bringing out the best potential of an individual, without blatantly imposing one’s own ideas or interests. Second, it is important to create the appropriate conditions to allow like-minded individuals to interact intellectually and be academically productive. Martin Jones facilitated this learning process by simply granting ample freedom for diverse thinking and intellectual space. The central venue he provided was the George Pitt-Rivers Laboratory at Cambridge. Most of us brought into the ‘Pitt’ our own hobby-horses, rather than being topical cogs in a larger research design dictated by the big professor. There were enough of us in the same space with various perspectives to generate fascinating discussions on archaeology, archaeobotany and life in general. I came back to my home university with these lessons internalized and applied them in my effort to help develop the Archaeological Studies Program at the University of the Philippines.

When I started my graduate work, I was determined to learn a method that I could apply and teach. I scouted around and decided to learn archaeobotany generally, which was at that time still underdeveloped in Southeast Asia. The key reason for my decision was the enthusiasm I saw in the people at the Pitt-Rivers laboratory. This included the ever-present lively intellectual discourse and banter (inside the lab and in the pubs). Added to this was my outward excitement when informed that there was a way to identify tubers, and
the developer, Jon Hather, was a good friend of several members of the Pitt. At that time he was based in London at the Institute of Archaeology, University College London. It would have been logistically difficult for me effectively to learn the method, had I regularly to commute to London. As soon as Martin learned of my research interest, he immediately called Jon Hather and set up a system for him to come over and mentor me at the Pitt. The ensuing regularity of visits by Jon was effective, and also made him a welcome addition to the dynamic intellectual and social scene.

I regret that my resulting dissertation has not yet been published in full (Paz 2001). I got as far as preparing the prerequisite work, but the project got quickly buried by complications related to my university career. Before I knew it, time had rapidly marched on. Central to my dissertation was the system of determining remains I have just presented. The system that was developed is deeply rooted in Jon Hather’s pioneering work (Hather 1988; 1991; 1993; 2000). The approach has since been applied in the archaeology of Southeast Asia and the Pacific; for example in southern Indonesia (Oliveira 2008); in the Philippines at northern Palawan (Carlos 2010), and at northern Luzon (Paz & Carlos 2007); in northern Vietnam (Ceron 2013), and in the Pacific kingdom of Tonga (Ussher 2015). Those who adopted the system unfortunately laboured in reading my dissertation and I think it is about time that a useful part of that work is re-written and published—and so here we are.

I owe friends and colleagues at the Pitt-Rivers Laboratory for the intellectual discourse, and friendship, which nourished my ideas and research. This would not be at all possible if Professor Jones were a different kind of academic, and mentor.

References


