The Science of Roman History

BIOLOGY, CLIMATE, AND THE FUTURE OF THE PAST

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CONTENTS

CHAPTER TWO

Archaeobotany

THE ARCHAEOLOGY OF HUMAN-PLANT INTERACTIONS

Marijke van der Veen

Introduction

Plants are essential to human and animal life on earth: they create the oxygen we breathe and the food we consume. Additionally, plants provide the fibres for our clothes, the building materials for our shelter, the fuel that keeps us warm, the ingredients for our medicines, and the flowers that give us beauty. Importantly, plants are also the 'materials' with which we create and maintain group identity, social relations and a sense of community (food sharing) or social distinction (luxury foods), and individual identity (clothes, colour (plant dyes) and smells (perfumes, plant resins). Plants thus engage with our everyday lives in a variety of different ways, affecting our nutrition and health, our social practices, our emotions and our work. The cultivation, distribution, selection, preparation and consumption of foodstuffs and the use of plants in many other day-to-day activities, are practices deeply embedded in our cultural norms. Importantly, this routine engagement with plants, enacting the same set of actions over and over again, day after day, year after year, makes us who we are. Archaeobotany, the study of the plant remains recovered from archaeological excavations, can thus provide insights into our different modes of being, as well as trace past social and cultural behavior and continuity and change therein. While some of these activities and choices are recorded in surviving texts from the period, many are not, either because they concern individuals and social groups that did not use texts and were not written about, or because they concerned activities nobody perceived worthy of recording. Together with zooarchaeology, human bone and stable isotope analyses (see Chapters 3 and 4) archaeobotany can offer a significant contribution to our understanding of daily life in the past. While it forms part of the archaeological sciences, and uses a variety of scientific methods, its focus is firmly on human-plant interactions.

Here the contribution of archaeobotany to our understanding of life in the Greco-Roman world is reviewed. This chapter does not offer a synthesis of the current archaeobotanical evidence (regional and temporal variability across the region are both too great to allow a synthesis in one chapter); instead, this chapter aims to highlight what can be achieved through archaeobotany by focusing on one aspect: food. It is divided into five main sections, each concentrating on one of the five phases of food, as first described by Goody: food production, the realm of the farm and the landscape; food distribution and trade, the realm of the granary, the market, and long-distance transport; food preparation, the realm of the kitchen; food consumption, the realm of the meal and, in many instances also, the realm of the table; and finally food disposal, the realm of the dustbin or refuse deposit and, par excellence, the realm of archaeology.[1] Other human-plant interactions (body treatment in life and in death; ideological role of plants and trees; selection of wood for fuel, artifacts, and building materials; impact of and on local vegetation and environment, fodder crops, utilization of wild plants, etc.) are mentioned in passing, but for reasons of space cannot be treated in any detail here. The chapter will conclude with a brief reflection on how these interactions helped create many different modes of being, how daily life in antiquity varied across time and space. Finally, it is worth emphasizing here that I regard plants recovered from archaeological excavations as a form of material culture, shaped by and shaping their interactions with people, to be studied in a similar fashion to and alongside other lines of evidence, including faunal remains, human remains, isotopes, ceramics, tools, buildings, and texts. Each dataset has its own strengths and weaknesses, and only by combining all the available evidence are we likely to get nearer to the many and varied realities of the past.

Agriculture: How Was the Food Produced?

Farming was the principal occupation of many in antiquity, with most farmers engaged in small-scale agrarian technologies, rather than in capital-intensive estates.[2] The period under study here saw many changes in agricultural practice, such as greater divergences in the scale of cultivation, the development of new technologies to improve water management and soil maintenance, the rise of arboriculture, the greater mobilization of agricultural produce over long distances (e.g., supply of the Roman armies, supporting growing urbanization, the trade in spices), and the introduction of new crops, but also many elements of continuity. Archaeobotany can help identify these, and many different approaches are available.

Such studies usually start by establishing which crops were cultivated and when this changed. For example, naked wheats had been part of European agriculture from the Neolithic onwards, but their rise to prominence is a relatively late phenomenon. Across large parts of the Mediterranean and northern and central Europe, we see the hulled wheats (einkorn, emmer, and spelt) replaced by naked, or free-threshing, wheats (bread, durum, and rivet wheat) during the later first millennium BCE and the early first millennium CE.[3] This transformation is not synchronous across the region; for example, in France the shift to naked wheat started in the south and occurred progressively later in the north.[4] The hulled wheats tend to be associated with smaller-scale, subsistence production, and the naked wheats with production for a surplus and market exchange. Additionally, one of the naked wheats, bread wheat, has superior bread-making qualities. The growing reliance on naked wheats during the first millennium CE is often linked to an increase in the need for grain to support the Roman conquest, the rise of towns, and economic expansion more widely. That other factors play a significant role too is clear from the fact that in certain areas hulled wheat, in this case spelt, maintains its position, for example in parts of southwest Germany and northern Switzerland, where ecological factors (spelt's ability to tolerate high altitudes) and agronomic ones (the continued use of the three-field system due to a lack of fertilizers), combined with a strong cultural preference for spelt, clearly outweighed any economic disadvantages.[5] Bread-making quality is another factor, and in places where a decline in soil fertility affected the successful cultivation of bread wheat, as was the case in second-century CE northern France, we see a switch back to spelt wheat, a species of hulled wheat less demanding on soil type than bread wheat, but, like bread wheat, with good bread-making properties.[6] Bread is not just a source of nutrition, of course; it is also an artifact, a cultural object, and the increased usage of bread wheat, a type of wheat that can produce a leavened, white loaf, is also linked to the rise of Christianity in the Mediterranean and northwest Europe.[7]

The ecological and agronomic requirements of these different crops leads us to the identification of cultivation methods, such as sowing, tillage, maintaining soil fertility (manuring, fallowing or crop rotation), weeding, and irrigation. These practices are linked to crop yields, crop reliability, land ownership, labor costs, integration with animal husbandry, and intensity of cultivation, as well as with the location of the fields. Did ancient farming start as a form of low-intensity, shifting cultivation, and then progress to more labor-intensive continuous cropping, or are these types of husbandry regimes related to specific local circumstances? Traditionally, we have used indirect methods to infer cultivation regimes, by studying the ecology of the arable weeds associated with the crops. Their life form (annual/perennial) and ecology (preference for nutrient rich or poor, acid, or neutral and wet or dry soils) help to identify the conditions in the arable fields, from which cultivation techniques and scales of production can be inferred. For example, an autecological analysis of the cereal crops and their associated weed floras at six Iron Age sites in northeast England has revealed two distinct crop husbandry regimes, one representing intensive, small-scale subsistence agriculture, while the other was indicative of a more extensive regime, suggesting arable expansion.[8] Similarly, monitoring variations in weed species' tolerance for soil pH, as well as their ability to recover from soil disturbance through tillage and weeding, has helped identify marked differences between cultivation plots at a Neolithic Linearbandkeramik site in southwest Germany, with some characterized by high disturbance and high pH, others by lower levels of disturbance and ambiguous pH, and others intermediate between these two. Remarkably, these different plots and practices were linked to specific groups of houses within the settlement and maintained over several generations.[9] Furthermore, weed seed dormancy has been used to reveal a shift in plough technology and agrarian practice (from ard to mouldboard plough) in first millennium CE Britain.[10]

Increasingly, weed ecology is studied using FIBS (Functional Interpretation of Botanical Surveys). This method measures functional attributes of arable weeds (e.g., leaf area, canopy size, rooting depth, size and number of stomata, date of flowering onset, length of flowering) in modern nonmechanized farming practices and uses these as indicators of the potential of species to cope within a particular (manmade) environment. It moves away from formal analogies and, as such, avoids the problems associated with the previously used approaches of phytosociology and autecology.[11] By establishing the ecological significance of each attribute, FIBS enables us to identify which aspect of husbandry is indicated by the weeds, thus facilitating the recognition of cultivation practices, including ones no longer in existence. To date, this method has succeeded in recognizing present-day irrigated versus dry-farmed fields in Jordan, intensively manured and weeded plots in Greece, crop rotation regimes in Jordan, and sowing time in central Europe.[12]

Recently, a further method has become available, stable isotope analysis, which studies the chemical signatures in the crops themselves. To date, the focus has been on nitrogen and carbon. For example, manuring the cereal fields will raise the nitrogen values ($\partial^{15}N$) in the grains, while water availability and irrigation can be inferred from stable carbon values ($\Delta^{13}C$).[13] This work has, in turn, important implications for our reconstruction of human diet. Stable nitrogen isotope ratios ($\partial^{15}N$) from human bone collagen have been used to infer the relative importance of animal versus plant foods in the diet, as enrichment of $\partial^{15}N$ occurs higher up the food chain (see Chapter 4). If, as has now been demonstrated, manuring can significantly raise $\partial^{15}N$ in cereal grain and chaff, human diets containing a major component of manured cereal grain might, erroneously, be interpreted as indicating a high animal-based component in the diet.[14] This highlights the importance of studying the isotopic values of human skeletal material together with those on faunal *and* plant remains at each location, to avoid problems of equifinality and to integrate our understanding of foodways with that of crop management and food production.[15] Another application of this technique concerns the relationship between climate and agriculture.[16] (See also Chapter 1). For example, Riehl has linked a reduction in drought-susceptible crops in the Early Bronze Age Near East with an increase in aridity after 4000 BP.[17] Additionally, recent experimental work is now supporting the hypothesis that the atmospheric conditions during the last glaciation would have restricted the productivity of potential crop progenitors, meaning that the rise in atmospheric CO_2 concentration in the immediate postglacial period might have been beneficial to their domestication.[18] It goes without saying that there remain many methodological challenges to be resolved, but recent large-scale charring experiments have shown that the effects of charring on stable isotope values in cereal grain and pulse seeds are small and predictable.[19]

Alongside the cereals and pulses, fruit trees, and in particular grape vines and olive trees, were and are of significant economic and cultural importance in the Mediterranean region, and this is reflected in the wide range of studies concerning grape and olive cultivation, as well as fruits of other trees, such as the *Prunus* genus (cherries, plums).[20] These include various attempts to distinguish between the seeds of wild versus domestic fruit trees, establishing time and geographical location of domestication, and identifying the earliest evidence for wine and olive oil production. Initially, such studies relied primarily on seed dimensions, ratios and surface sculpture descriptions to differentiate shape types. While often successful, not all archaeological specimens could be allocated to species or type, partly because surface sculpturing and hilum did not always survive on older specimens, and partly because centuries of cultivation and hybridization have caused size overlap between species and varieties.[21] More recently, these methods have been supplemented with geometric morphometrics (Elliptic Fourier Transform method), which includes measurement and capturing of the overall three-dimensional shape of each seed, combined with statistical analyses to evaluate the diversity within and between populations. Achievements to date include the recognition of a relationship between seed shape and domestication, thus improving our ability to detect the start of domestication, and, tentatively, degrees of biodiversity and regional variability; see, for example, recent studies on olive, grape, cherry, and date.[22]

The analysis of ancient DNA (aDNA) is now an additional, if not yet mainstream, part of archaeobotanical research. Along with the tried and tested polymerase chain reaction (PCR) method, which has limitations due to the small amounts of fragmentary aDNA that survive in ancient seeds, the new "next generation" sequencing (NGS) method is offering many new possibilities.[23] One key issue in all these studies is the survival of biomolecules in ancient plant material. The survival of aDNA in desiccated plant material is remarkably good, and has already revealed unusual genetic features in desiccated barley grains from Egypt, which may reflect adaptation to the local, dry environment, as well as contributed to our understanding of the evolutionary processes underlying domestication in cotton.[24] There are, of course, few locations in the world where plant materials will survive in desiccated form, but where they do survive, their preservation is exceptional, and its full analysis thus all the more important; see, for example, the remains from Berenike, Qasr Ibrim, and Quseir al-Qadim—all in Egypt—and from Xinjiang, China, Gran Canaria, Spain, and from historic buildings in Central Europe and Britain.[25] aDNA also survives in many, though not all, plants preserved in waterlogged, anoxic, conditions, as demonstrated in grape seeds, plum stones, and wheat grains.[26] Survival in charred plant material is much more problematic, however, and is heavily dependent on charring regime, but the NGS method may ultimately prove successful here too.[27] This is important, as most plant material from archaeological sites is preserved by charring, and an exclusive reliance on desiccated and waterlogged remains would exclude large parts of the world.

Areas of research currently addressed by archaeogenetics include the identification of plant material where conventional methods fall short (e.g., in the naked wheats where chaff fragments are absent), the number of domestication events for each crop, the trajectory of the spread of agriculture, the identification of landraces and biodiversity, and the adaptive evolution of crops after domestication, especially once they move into regions outside of their natural environments (flowering behavior and day-length responsiveness, nutritional value, tolerance to drought or waterlogging). Phenotypic characterization and genome sequences may, of course, be difficult to achieve, considering the complexity of the genetic basis to many phenotypes.[28] In fact, some evolutionary questions may more easily be extracted from extant landraces, considering the relatively short evolutionary history of many of the crop plants—in the case of vegetatively propagated fruit trees and vines, this may concern just a few generations—and this has recently been done for barley.[29] In all this work, the use of specialized laboratories and a strict protocol are, of course, essential prerequisites.[30]

Monitoring changes in the scale of agricultural production partially relies on the identification of changes in the density of remains deposited in the archaeological record. Here it is important to appreciate that the archaeobotanical record, and in particular the deposition of charred remains, is created by both routine activities and occasional accidents and/or deliberate conflagrations, and that great care is needed to distinguish between the two.[31] The charring of plant material during routine, day-to-day household-based activities such as grain dehusking, cleaning, drying, and food preparation immediately prior to consumption will result in low-density deposition of remains, especially by-products such as chaff and weed seeds, rather than grain. In contrast, the accidental or deliberate burning of produce (storerooms catching fire, acts of violence) will lead to high-density deposition of plant material (grain, pulses, other foodstuffs). These latter events will occur more frequently in places where produce is handled and stored in bulk, which tends to be at large producer sites rather than in small domestic settings. Thus, an increase in the predominance of grain-rich samples is likely to be an indicator of an increase in the scale of production and consumption. This approach has been used to interpret the increase of grain-rich samples at selected Iron Age sites in Britain as evidence for the production of surpluses consumed during feasting.[32]

An increase in the visibility of large quantities and high densities of agricultural by-products used deliberately as fuel (e.g., chaff, olive pressings) is another marker of the increase in agricultural production. Pomace, the pressings of olive oil, burns at a high and constant temperature and produces little smoke, making it an ideal fuel indoors, but also for industrial production.[33] Across the Mediterranean charred remains of olive pressings have been found, but an expansion in its use is visible during the Roman period, highlighting a marked increase in olive oil production and thus the availability of large quantities of pomace as fuel for the growing urban population, in urban bakeries and in the growing pottery industry (e.g., Herculaneum and Pompeii). Olive oil production may have reached up to one billion litres each year during the height of the Roman Empire, which would translate into 1 million tons of pomace and 2–4.5 billion hours of heat.[34] Similarly, in Roman Britain we see a proliferation of samples rich in chaff at rural sites, often, though not exclusively, associated with so-called corn-driers, together with a rise in large barns, mills, and other agricultural structures, all pointing to an expansion of agriculture in response to greater demand after the Roman conquest of the region.[35] At the same time, the disappearance of agricultural by-products at certain sites, such as the disappearance of chaff and weed seeds from proto-urban settlements such as Pompeii and Silchester, has been taken to mean that these now became more fully urban in character.[36] Research addressing similar issues is currently ongoing in Rome.[37]

Here it is worth emphasizing that food was produced not just in the countryside, but in the towns as well. For example, the suburbs of Rome and many other towns were surrounded by market gardens and orchards, and many townhouses had gardens too, used for decorative purposes and food. Their abundance and importance became clear during excavations at Pompeii, Herculaneum, and nearby villas, all destroyed by 79 CE eruption of Vesuvius. Root cavities, charred seeds and fruits, pollen, planting trenches, and plant pots were found in many garden plots, both large and small; even entire orchards, vineyards, and market gardens were present within the city walls of Pompeii. Food plants recovered from these gardens include almonds, beans, citrus, figs, grapes, hazelnuts, pears, and herbs such as dill, rosemary, and thyme. The importance of garden production is reflected in the fact that an estimated 17 percent of the excavated area of Pompeii was allocated to gardens and the growing of plants.[38]

Further indications of agricultural change, other than those mentioned above, include the expansion of agriculture into (or contraction out of) regions less suited to agriculture combined with the adaptation to local climatic and edaphic conditions and the development of suitable crop management practices (drainage, irrigation, heavy plough).[39] As a final point, both palynology and charcoal analysis make a significant contribution to our understanding of vegetation change and the human impact on the local environment, including the expansion of arable land and the sometimes devastating effect of deforestation on the landscape, but these studies lie outside the scope of this chapter.[40]

Combined, the evidence reveals huge and complex variations in the type and scale of agricultural practices, meaning that the ancient agricultural texts and plant treatises (e.g., those by Cato, Columella, Pliny, Theophrastus, Varro), valuable though they are, should be read in their temporal, cultural, and regional contexts, rather than as reliable guides to agriculture across the entire Greco-Roman world. Agricultural practices develop through interactions with many different variables, including cultural (e.g., scale of land use, form of land tenure and degree of market involvement) and natural ones (e.g., climate, altitude, soils, hydrology, physical requirements of plants), and are thus historically contingent and in continuous flux.[41]

Distribution and Trade— Where Did the Food Come From?

The storage, distribution, and exchange of agricultural produce are part of every farming regime, but when these practices move away from household or domestic settings to larger communal or empire-wide requirements, significant structural and organizational changes are needed. The Roman period in particular saw increased mobilization of resources over vast areas, including the feeding of Rome with grain from North Africa, the supply of the Roman army at the frontiers of the Empire, and the trade in exotic luxuries such as spices from the Indian Ocean to satisfy the growing demand from the elite. Archaeobotany can contribute to our understanding of each of these processes.

Storage of grain and other foodstuffs beyond the domestic scale is visible in the archaeological record through the appearance of large storage and processing facilities, such as granaries, storage pits, corn-driers, mills, and barns, through an increased occurrence of deposits full of charred grain or other stored food crops, and through evidence for inadequate storage in the form of batches of germinated grain or crop seeds spoiled by insect damage. For example, we now have convincing evidence that inadequate storage became a serious problem in Roman Britain. Grain pests (*Coleoptera*) that thrive in poorly ventilated storage buildings and in grain that is not fully dry when put into storage, make their first appearance in Britain during this time.[42] These grain beetles have not been recorded on Iron Age or earlier sites and are not thought to be native to Britain. They appear from the very start of the Roman Conquest, probably as adventitious inclusions in grain brought into Britain by the Roman army during its early campaigns. Examples include the first century CE finds of grain weevils (*Sitophilus granarius*) at Alchester (here together with other imports, such as millet and coriander), London, and York.[43] The sudden appearance of these grain pests can be linked to the increased use of large, open grain stores containing bulk quantities of grain (in contrast to domestic-scale household storage previously), which created environments in which these grain pests could thrive. Additionally, the large-scale trade and movement of grain—both across the Channel and within Britain—facilitated their rapid spread.[44] Examples of stored grain that had sprouted due to poor storage conditions were found in Roman York and London; the latter assemblages comprised between 23% and 44% of sprouted grain.[45]

Evidence for such medium to long-distance trade can be detected through the presence of 'exotic arable weeds' within stored produce. For instance, the presence of seeds of *Orlaya platycarpa* in a shipment of wheat and in a batch of spelt chaff found adjacent to granaries, both in the Netherlands, points to imported grain. *Orlaya* is a sub-mediterranean species, not native to the region, and its presence thus suggests that the grain was brought in from Belgium or further south.[46] Similarly, fruits of *Myagrum perfoliatum*, a species of southern European and Near Eastern origin that will not grow successfully north of the Loire, found in bread wheat and spelt wheat at several Roman sites in northern France also points to grain transport to the northern parts of the Roman Empire.[47] In the same way, the presence of a few grains of einkorn, as well as seeds of lentils and bitter vetch amongst a deposit of spelt grain in first-century Roman London identified this batch of grain as originating from either the Mediterranean or the Near East.[48]

This raises questions about the supply of the Roman army when settled along the frontiers. Should we envisage centralised long-distance supply routes, local compulsory requisition, temporal and regional adaptation to local circumstances, or a combination of these at various times? What about the ability of local landscapes and agricultural populations to sustain the additional burden? Did the military presence create unsustainable local pressure, destabilizing local production, or, instead, generate stimulus and agricultural growth? The evidence of grain shipments reaching northern France and the Netherlands from further south suggests the need for medium- to long-distance supplies, but the modeling of data derived from landscape reconstruction, archaeozoology, archaeobotany, and wood analysis in the Lower Rhine Delta shows a more nuanced and complex pattern, with the region initially likely able to sustain the food and wood requirements of the army, but with increasing pressure on resources from the second century CE onwards.[49] Some local provisioning was in evidence throughout, but supplemented with extraregional resources. That the increase in demand put pressure on local farming is apparent in parts of northern France, where we see a switch from bread wheat, a crop that had been on the rise since the late Iron Age, back to spelt wheat during the second century CE, probably due to soil exhaustion—bread wheat is a more demanding crop than spelt wheat.[50]

Grain was not the only product needed at the northern frontiers—timber was another—and the application of dendrochronology combined with the identification of the wood used in river barges, in the construction of a harbor quay and in road building, again point to the movement of resources across considerable distances, as well as offering exact dates for specific construction events. For example, the oak piles used in the construction of the harbor quay at Voorburg-Arentsburg, the Netherlands, in ca. 160 CE originated from southeast Netherlands and southern Germany, while the rebuilding of the quay shortly after 205 CE used oak from the Mosel region.[51] Similar techniques established that two Roman river barges and a Roman punt from Utrecht, The Netherlands, must have been constructed in the Lower-Scheldt region and thus points to inland navigation between this region and the Rhine-based limes, while wood used in the construction of a road joining the limes in the Lower Rhine region in 124–125 CE, perhaps related to the visit of the emperor Hadrian to the region, was all derived from a single source, probably that between Xanten and Venlo, and transported some 100 kilometres over water using barges.[52]

At the opposite end of the Roman Empire, wood analysis of timbers, artifacts, and charcoal also reveal long-distance contacts, with ship timbers and ship-related artifacts made of Indian teak wood (*Tectona grandis*) at the ports of Berenike and Quseir al-Qadim, both located on the Red Sea coast of Egypt, underlining the role of these ports in the Indian Ocean spice trade. Temporal changes in the range of exotic versus native woods used for everyday artifacts and ship timbers at Quseir al-Qadim point to changes in shipping practice, with ships built according to the Mediterranean tradition as well as Indian Ocean vessels frequenting the harbors during the Roman period, in contrast to the Islamic period when Indian Ocean vessels tended to terminate their journeys at Aden, leaving Egyptian or Yemeni vessels to carry the goods up the Red Sea.[53]

Recent excavations at both Berenike and Quseir al-Qadim (Myos Hormos as it was known as in antiquity) have also provided a rich new archive of archaeobotanical evidence for the spice trade. Both sites represent key transport-hubs in the Indian Ocean trade, and the hyperarid climate at the Red Sea coast of Egypt has resulted in the spectacular preservation of botanical remains of spices and other food remains.[54] Here, temporal change in the number of imported species and their numerical frequency in the Roman and medieval Islamic deposits has helped us identify how the spice trade differed in both nature and scale between these two time periods, with black pepper the most abundant spice in both periods, but with many other spices too rare and precious to be accessible to those working in the Roman port, and, in fact, to most living elsewhere in the Empire. By the medieval Islamic period, this had changed, with a wider range of spices, including ginger and cardamom, now consumed in the port, and by a wider, if still elite, group across the Mediterranean and beyond.[55]

Work at other harbors is augmenting our understanding of the role and importance of these long-distance networks, and this increasingly also includes studies of the actual harbor environments and changes in the vegetation and landscape of their immediate surroundings, through geoarchaeological and pollen analyses.[56]

Questions concerning the logistics of supplying food, timber, and fuel are not restricted to the Roman army of course; the provisioning of the growing urban population as well as specialist workforces operating at mines and quarries needs further study. An example of the latter comes from two Roman quarry settlements, Mons Claudianus and Mons Porphyrites. Both are marble quarries that were subject to imperial monopoly with the stone used for imperial projects, such as the Pantheon in Rome (grey granodiorite columns in the portico) and for statuary made of purple porphyry. The distance from civilization—the quarries are located in a remote part of the Eastern Desert of Egypt, some seven days travel from the Nile valley—was clearly no obstacle to a rich and varied diet, as the archaeobotanical assemblages produced not just staples such as cereals, pulses, dates, and onions, but also luxuries including black pepper, artichoke, pomegranate, persea, various nuts, as well as many herbs and condiments. Moreover, seeds of plants normally eaten as "greens," such as leaf or spinach beet, lettuce, endive/chicory, cabbage, mint, basil, and rue, suggest that the soldiers or quarry workers were able to supplement these foods with fresh greens grown in small vegetable plots in the desert.[57] Additional pollen analysis and charcoal identifications brought to light that the working animals were fed barley grain, chaff, and straw, all brought in from the Nile valley, and that fuel consisted of chaff and straw as well as desert shrubs and trees, with charcoal of two acacia species brought in to be used in the smithies. Furthermore, the ceramic evidence points to the ample supply of wine and olive oil from across the Empire.[58] When we compare the botanical evidence for foods with those listed in the ostraca, there is good agreement between the two for cereals, pulses, and vegetables.[59] The texts also mention processed foods (e.g., bread, cakes, malt, wine, olive oil, vinegar), but, remarkably, are almost silent on the many herbs, fruits, and nuts that feature so prominently in the botanical assemblage, which demonstrates why it is so critically important to always use all lines of evidence when reconstructing food and agriculture. Combined, the evidence highlights that these quarry sites were not malnourished or undersupplied desert-stations, but settlements which had access to most foods that were available in the Nile valley. The importance of the stone as symbols of imperial prestige meant that these quarries were embedded in a complex logistical network linking the Eastern Desert with Rome, the eastern and western Mediterranean, India, the Red Sea coast, and with the Nile valley.

Long-distance trade in foodstuffs is, of course, not a Roman phenomenon, though current evidence suggests that this period in particular saw a major growth in the translocation of foodstuffs. For example, some 50 new food plants were brought to Britain and other parts of northwest Europe as part of the Roman conquest of this region, initially as supplies for the Roman armies, but subsequently to meet demand of soldiers and civilians more widely. Some of these foods were widely imported from the start (e.g., fig), others became more abundant in the middle Roman period (e.g., coriander), while others still only gradually increased in popularity (e.g., plum). In this context, it is important to note that many of these plants became part of local agriculture, thus switching status from imported foods to introduced crops (e.g., apple, pear, plum, cherry, walnut, cabbage, leaf beet), which had a significant impact on local agricultural practices (see above under "agriculture"), and also resulted in a major widening of dietary breadth and nutrient availability for large sections of the population (see below under "consumption").[60]

This long-distance exchange of foodstuffs in northwest Europe started when the cultural contact between this region and the Mediterranean increased. This is visible through the presence of wine amphorae, as well as the remains of olive, celery, coriander, and dill, in mid to late Iron Age sites across the region. Current evidence suggests that these foods go primarily if not exclusively to elite locations, such as the *oppida*, as part of the wider phenomenon of Roman-style products being desired and acquired by local elites.[61] This changes in the early Roman period when both the range and scale of such imports increased and such foods became available to more sections of society (see above).

The analysis of plant DNA is offering crucial additional data to our understanding of such translocations of crops. For example, many of the newly introduced food plants concern species that are exotic to northwest Europe, such as pear, plum, walnut, coriander, leek, onion, cucumber, and lettuce, but others are natives, that is, wild forms do grow in the region, such as celery and apple. For this latter group it raises the question whether the Romans brought actual cultivars of these crops with them, or, instead, introduced the concept of their cultivation and encouraged the cultivation of local species. Here DNA analysis is proving invaluable. For example, the DNA of modern apple cultivars (*Malus domestica*) indicates that the wild progenitor of our domestic apple is *Malus sieversii*, a native of the mountain region of Kyrgyzstan and northwest

China, rather than the European crab apple, *Malus sylvestris*.[62] This reveals that in the case of apple the Romans brought the cultivated apple to northwest Europe, and did not use the local wild variety, although some subsequent hybridization between the two is likely. The introduction of cultivated fruit trees into northwest Europe would thus have required the import of budded stems (scions), which could be grafted on to local rootstock (wild crab apple, sloe, etc.) that was specially developed for the purpose, or by also bringing in the rootstock, that is, the live plant. Evidence for the transportation of live plants is available in the form of *ollae perforatae*, purpose-made pots used to plant and transport trees, vines, and shrubs, which are found across the Roman Empire, including Britain, and are dated to the late first century BCE to the mid second century CE.[63] That these fruits soon became widely available is clear from the hundreds of apple pips found at several British sites, including second-century Doncaster, London, and Late Roman Silchester.[64]

The strength of DNA analyses is also evident in a recent study of historical landraces of barley. This study identified the presence of three separate groups of barley in Europe, revealing that barley was introduced into Europe more than once, each originating from a different part of southwest Asia. The strain of barley that can cope with long growing seasons and wet summers, originally domesticated in Iran, was introduced later than the others and is found predominantly in northwest Europe.[65]

Finally, and just briefly, the cargoes of shipwrecks provide further and very direct evidence of these often long-distance food transports. Finds include shipments of wheat in a sunken river barge in The Netherlands, of pomegranates in a shipwreck off the Turkish coast, an amphora full of olives found in the Thames estuary, as well as cotton seeds, coffee beans, and spices in a shipwreck in the Red Sea.[66]

Preparation—How Was the Food Prepared and Consumed?

The preparation of food includes a wide variety of processes, all designed to improve absorption and digestion of the plant nutrients, remove toxins, increase palatability, change the physical form of a food, or convert raw ingredients into storable foodstuffs. Such processes include pounding, milling, boiling, roasting, steaming, parboiling, baking, and fermenting.[67] Thus, cereal grains can be converted to porridge, bread, bulgur, and beer, grapes to raisins or wine and olives to olive oil. Studies to determine these processes from archaeological remains of food are a growing area of research in archaeobotany. Several approaches are used, often in combination. Apart from establishing which parts of the plants are preserved, breakage patterns are studied, using charring experiments and Scanning Electron Microscopy (SEM), and combined with ethnographic observations.[68] For example, Valamoti demonstrates that the charring of fragmented grain causes the endosperm to ooze out, generating a characteristic bulging appearance, while the breakage of grain *after* charring shows surfaces that are porous and irregular in appearance.[69] Shiny glassy surface textures are more typical of grain that had been soaked in boiling water, broken, and then charred. This experimental work led her to conclude that grain fragments from Bronze Age sites in Greece represented bulgur (i.e., boiled and then ground cereal grain). Such preprocessing of grain for later consumption is important, as it converts seasonally available produce into nutritious and storable foodstuffs for consumption at a later date.

Similar techniques were used by Samuel to study preserved fragments of bread and residues of beer from ancient Egypt.[70] Using SEM, she was able to identify yeast cells, bacteria, and starch granules, the latter heavily pitted, indicating that enzymes had started to break down the starch, as part of the malting process. Together with experimental work, the archaeological evidence for ovens, milling tools, ceramic vats, as well as the rich artistic record from Egypt and documentary evidence, the many processes and ingredients involved in the baking and brewing traditions of ancient Egypt could be reconstructed. High magnification tissue analysis has also helped determine the type of cereal represented in the so-called amorphous charred objects, now generally assumed to represent cereal-based products, found at many archaeological sites. Likewise, a remarkably well-preserved charred flat bread (galette) from a first-century Roman cemetery in France was identified as prepared from finely ground flour of barley mixed with some einkorn or emmer, and without leavening.[71]

Beer was produced throughout prehistory but on a household scale, using ordinary vessels and ovens, and thus not easily detectable in the archaeological record, though when large deposits of germinated grain are discovered, malting and beer brewing may be in evidence.[72] In some regions and periods, we see the appearance of specialized structures, indicative of cereal processing and beer brewing on an “industrial” scale. In Roman Britain, for example, beer may have represented a cash crop, where a surplus of grain could be turned into a product that had added value and thus could be sold at a profit.[73] Here, germinated grain and detached sprouts or coleoptiles (part of the malting process) are regularly found associated with so-called corn-driers. The archaeobotanical evidence suggests they were multifunctional structures, with the more intensely heated ovens thought to have been used to dry spelt grain and the more moderately heated ones to germinate grain and produce malt.[74] Archaeobotanical evidence for beer flavorings such as sweet gale (*Myrica gale*) and hop (*Humulus lupulus*) becomes prominent from ca. 500 CE in northwest Europe.[75]

The processes involved in the extraction of olive oil or the production of wine have seen comparable studies combining archaeobotany, ethnography, scanning electron microscopy, and experimentation. Residues of these processes, including fragmented olive stones and pressed fruit flesh of grapes and olives, can and have been identified in the archaeological record, though distinguishing between whole grapes and raisins remains problematic.[76] Fats and liquids such as oil, wine, and beer may also be studied through chemical analysis of organic residues, and include the identification of an early wine through the presence of tartaric acid in a pottery jar from a prehistoric site in Iran, and the differentiation between installations for oil and wine production.[77]

Other food types have seen less work to date, but methods are now being developed to determine which part of a plant was consumed or whether the fruit was consumed fresh or dried. For example, a study of the breakage pattern of seeds of watermelon from Roman and Islamic period sites in Egypt revealed that the consumption of the seeds, rather than the just the fruit flesh, on current evidence appears to be an Islamic-period introduction.[78] The preparation of pulses by soaking these prior to boiling speeds up the cooking process, and, importantly, in certain pulses also removes harmful toxins (e.g., grass pea and bitter vetch).[79]

Consumption—Who Ate What?

Daily food intake and adequate nutrition levels are day-to-day concerns for most people, with the lack of sufficient food a concern for many, and ample availability a pleasure for some. Apart from the need to meet basic nutritional requirements, food is used in the construction and maintenance of social relations, power relations, and many other cultural, ethnic, and religious identities. Being able to determine what was eaten, how the diet changed over time or differed between social groups is thus an important aspect of archaeobotanical research. At a basic level archaeobotany can establish which plant foods were available to the inhabitants of a site and region, but in several parts of the Greco-Roman world the database is now substantial enough to allow identification of different consumer groups and temporal changes in these.

A survey of sites with excellent preservation of botanical remains across the region suggests that by the Roman period the range of food plants available to many of its inhabitants is considerable, and far beyond mere subsistence. For example, the number of food plants recovered at two Roman quarry sites in the Eastern Desert of Egypt was 50+ (desiccated remains), at the Roman port of Myos Hormos 50+ (desiccated remains), at Roman Carthage 20+ (charred and waterlogged remains), at Pompeii 40+ (mineralized and charred remains), at Herculaneum 30+ (mineralized and charred remains), at Roman London 40+ (waterlogged, mineralized, and charred remains), at the civilian settlement Oedenburg (France) 50+ (waterlogged remains), at the minor rural settlement Wavendon Gate (England) 12+ (waterlogged and charred), and the village of Nantwich (England) 10+ (waterlogged).[80] While many of these sites have an elite presence (military or civilian), which might partially explain this rich array of foods, this is not the case at Herculaneum, Wavendon Gate, and Nantwich. At Herculaneum a sewer servicing a number of shops as well as domestic, non-elite, accommodation, produced a wide variety of foodstuffs, while Nantwich is a village and Wavendon Gate a small rural settlement, indicating that this diversity of plant foods was not restricted to elite sections of the population. What is more, this diversity of food plants does not just include local plants, but exotics and/or newly introduced foods as well, such as black pepper and date at Herculaneum, coriander, leek, fig, dill, and celery at Nantwich, and coriander, plum, cherry, celery, and summer savory at Wavendon Gate. To explore this differential social access to food plants further, the analysis of plant assemblages from non-elite sites with good preservation might usefully form a future research priority.

The diet of specific individuals is usually beyond the reach of archaeobotany, except where mummies, bog bodies, or coprolites are preserved. Here stable isotope analysis can offer great insights (see below, Chapter 4), and where possible, archaeobotanical results should thus be combined with those from zooarchaeology and stable isotope analysis.[81] While the advantage of stable isotope analysis is that it can study individuals, its disadvantage is that it can only identify very broad dietary variation (terrestrial versus marine foods, C_3 versus C_4 crops),[82] and then only on sites where human remains are preserved. The strength of archaeobotany lies in the fact that it can identify individual plant species and that plant remains are recovered from all settlement sites (in contrast to predominantly mortuary contexts for human remains), thus offering the potential for large-scale regional and chronological surveys.

A significant increase in availability of nutrients and flavorings has been demonstrated for the Roman period in northwest Europe. In this region the plant-based diet of the entire population throughout prehistory consisted of cereals and pulses, a limited range of wild fruits, nuts, and berries, and several wild plants used as greens, flavorings, and in medicinal recipes. Any social differentiation in diet was expressed primarily in the quantities of these foods consumed, including that of meat and better cuts of meats. This changed very rapidly with the incorporation of the region into the Roman Empire; though this process started during the later Iron Age (see "Distribution" section). A large range of fruits, nuts, vegetables, herbs, spices, and oil-rich seeds was introduced into northwest Europe at this time, initially forming part of army supplies, but soon accessible to a wider range of people.[83] In Britain for example, some 50 new plant foods were introduced. Most remained very rare, but fig, for example, is found at 40% of sites in the Early Roman period, dropping to 25% by the Late Roman period, while coriander starts at 28% and increases to just over 40% by the Mid-Roman period. While many of these foods disappear again with the withdrawal of the Roman army (e.g., olive), others stay, having become—or starting to be—integrated into British agriculture (e.g., apple, plum, cherry, walnut, cabbage, leaf beet, dill) and thus available to a wider section of society.

Where the database is substantial enough, it is possible to identify the development of different consumer groups. For example, in Roman Britain the major towns, especially London, the military sites and the rural sites form separate consumer groups, with London sites having access to the largest range of imports, fruits, and nuts, the military sites showing a larger-than-average emphasis on herbs, while rural sites show a greater reliance on vegetables and wild foods. Marked regional differences are visible too. Remarkably, the villas (elite rural sites) do not stand out as a separate group; some show similarities with the military sites (many imported foods), but others look no different from non-elite rural sites. In fact, some minor rural sites (hamlets) have a range of foodstuffs similar to that of certain villas and military sites. Thus, here the plant remains highlight the presence of considerable within-group variation, which appears linked to economic opportunity (proximity to major road and river transport, markets, presence of a shrine, economic prosperity of the region) as well as social aspirations.[84]

The interaction between food, identity and geopolitics is also in evidence at the opposite end of the Roman Empire, at Quseir al-Qadim, located on the Red Sea coast of Egypt. During the Roman period the diet of those working and living in the port reflects a strong connection with the Roman world. By the Islamic period, the residents of the port had adopted foodways more characteristic of parts of the Middle East; the port had become part of the Islamic world. These changes in diet are part of the geopolitical realignment of the Red Sea and its ports at that time, and they are an integral part of making those transformations and identities real. In other words, geopolitics does not concern only high-level political transformations, it also changes the way people live their day-to-day lives; it is through the daily routines of food procurement and consumption that these transformations become real.[85] Findings like this make archaeobotany such a rewarding discipline.

The selection of foods used in offerings and burials offers further insights into social and cultural choices and mortuary practices. In the past the basic concerns of everyday life—food availability and the continuity of the agricultural cycle—were often ritualized through the provision of offerings (agricultural produce, foodstuffs), and archaeological evidence for these has been found at many public and domestic altars, temple sites, and sacrificial pits, as well as in a range of funerary contexts.[86] The types of food recovered from such sites include charred bread and cake or pastries, cereal grains and pulses, a variety of fruits, nuts, and wild plants. Some of these may have been chosen because of their association with a particular deity, others for their scent or ornamentation or as kindling material. For example, at the classical necropolis at Thasos, northern Greece, foods such as pomegranates, garlic, grapes, and bread were found to have religious significance, while at the third-century BCE sanctuary at Messene in the Peloponnese the selection concerned cones and seeds of stone pine, olives, grapes, almonds, and chestnuts.[87] The state of the foods when placed on the fires—offerings of complete fruits or breads, as against leftovers from funerary meals—can be determined using similar techniques to those described in the section on food preparation above (scanning electron microscopy, charring experiments, fragmentation studies). Additionally, the application of combined gas chromatography–mass spectrometry has identified plant exudates (gums, resins) in late Roman burials in Britain, including resins from European pine trees and mastic/terebinth from Mediterranean *Pistacia* trees, as well as, remarkably, frankincense from Southern Arabia or eastern Africa, the latter at both Dorchester and York, Britain.[88]

Detecting patterning in these datasets is hampered by the fact that the sampling of botanical remains at burial sites, temples, and altars was often unsystematic during early excavations and, consequently, by the lack of adequate numbers of case studies from across the region. Nevertheless, the range of plants found in burials and at shrines or temples is usually very similar to that on domestic sites in the same region and period, in line with the notion that these offerings are reflections of everyday concerns surrounding food. Thus, the link between status, degree of Roman influence, and availability of newly introduced foods is seen not just at settlement sites, but in funerary contexts too.[89] Associating certain foodstuffs with particular deities is, to date, largely done through reliance on classical sources and the surviving artistic record, with the association between pine cones and the Isis cult the one most commonly referred to.[90] A recent review of the Roman period evidence for dates (*Phoenix dactylifera*) in northwest Europe suggests that this imported fruit was primarily associated with ceremonial contexts; it rarely occurs in settlement sites. It is thought to be linked to particular cults, making it more a symbolic object than a food.[91]

A special case is that of the "Lady of the Sarcophagus," the burial of a young woman discovered in an undisturbed sarcophagus in Milan, dated to the third century CE.[92] Not only could food and drink offerings be identified in the deposits associated with the sarcophagus, but microexcavation and laboratory analyses of the sarcophagus' interior also proved very informative. These identified her dress, and the possessions, gifts, or offerings placed inside the burial, including a bunch of grapes, garlands of flowers, nuts, and fruits, the latter suggesting an autumn burial. Additionally, pollen, botanical, and chemical analyses highlighted the use of resins, aromatic herbs, and unguents, such as terebinth and mastic.

Plants and plant substances were, of course, also consumed for their medicinal, aromatic, psychoactive, and decorative properties. These comprise both cultivated and wild plant species. It can be difficult to determine whether certain wild plants were used for any of these purposes, as they are often part of the local vegetation or weed flora, meaning that there are several possible mechanisms by which they arrived on site. Where such plants are found in pure and dense concentrations, as is the case for terebinth, poppy, and *Lallemantia* at several prehistoric sites in northern Greece—in quantities of 50 seeds or more—the evidence that they were used for specific purposes is convincing, even if we cannot be certain what that purpose was.[93] As with all archaeobotanical evidence, density of the remains combined with contextual information is crucial here.

Disposal—What Is Left for Us to Find?

Of all stages, this is the one most critical for archaeologists. After all, food is eaten and thus disappears. As a result, archaeobotanists have to reconstruct what was consumed, who ate what, how it was produced, distributed, or prepared through the leftovers and the waste discarded at each settlement. This means that with rare exceptions (mummies, bog bodies, time capsules such as Pompeii), we are dealing with a partial and fragmentary dataset, and one that is reduced further by the fact that dead plant tissues on or in the ground normally decay after a number of years, meaning that plants survive in the archaeological record only in certain specific circumstances. Consequently, a whole host of methodological procedures needs to be adhered to, to ensure that the data are collected and interpreted correctly. Fortunately, research has shown that archaeobotanical data are structured in a very consistent way, thus facilitating cross-cultural and temporal comparisons.[94]

The four most common modes of preservation encountered are charring or carbonization, waterlogging, desiccation, and mineralization (mineral replacement). The actual mode of preservation matters greatly, because each type of preservation preserves a slightly different range of plant types. For example, cereals and pulses are typically found in charred form, while remains of fruits, vegetables, herbs, and spices are more commonly recovered in waterlogged or mineralized form. Nuts, oil-rich seeds, and fiber plants such as flax, take an intermediate position; they are commonly found in both carbonized and waterlogged state.[95] Desiccated plant material can include all categories of crops, including vegetative parts of these crops, often in a remarkable state of preservation, but they are rare. Thus, the reconstruction of agricultural practices and consumption of staple foods (cereals and pulses) is best carried out using charred remains, which, fortunately, are found on virtually all settlement sites. In contrast, questions concerning food consumption patterns of other types of food (esp. fruits, nuts, herbs, and spices) may be better addressed using assemblages of waterlogged, desiccated, or mineralized material, the latter primarily found in sewers, latrines, or cess pits.

The strengths and weaknesses of these different modes of preservation have been highlighted by some regional assessments. For instance, a comparison between charred and waterlogged remains of wild food plants from central European Neolithic sites has indicated that charred assemblages possess on aggregate about 35% of the range of edible wild plants documented in waterlogged samples.[96] Similarly, at Roman North African sites with charred and desiccated preservation, the charred component of assemblages comprises just

20% of the total number of identifications, while the desiccated material comprises, on average, twice as many food and other economic plant taxa than the charred component. Finally, a sewer at Roman Herculaneum, containing primarily mineralized plant remains, produced very few cereals, even though these would have been a significant component of the diet.[97] This leads to two important observations. Firstly, in instances where excellent preservation is expected (sites with a high potential for waterlogged, desiccated, or mineralized preservation) sites should be sampled in great detail, to provide full evidence for activities that are not or only partially traceable at other sites. Secondly, the fact that charred remains are found at virtually all settlement sites and many ceremonial sites, combined with the fact that these assemblages show remarkable consistency in the range of plant materials they comprise (grain, pulses, cereal chaff, arable weeds and occasional nut shells and fruit stones) makes these very suited to reconstructions of agricultural practices and regional and chronological comparisons of these.

The remains of food and other plants are generally not visible with the naked eye and thus not routinely recovered during excavation; a carefully designed sampling strategy should, therefore, be part of each excavation project, aiming to collect material from the full range of activities that occurred on site. As total sampling (i.e., collecting samples from all excavated deposits) is not always practical on large-scale excavations, a sampling strategy that combines random and judgment sampling is likely to be the most successful.[98] Sample size should be adjusted to ensure retrieval of at least 100+, but preferably 300+, identifications per sample.[99] In many cases this will mean a sample size of 60 litres from deposits with charred remains and up to 10 litres where waterlogged, desiccated, or mineralized remains are present.[100] Sieving should be appropriate to the type of deposit and mode of preservation, with water flotation or wet sieving over an 0.5mm mesh practiced as standard today, though with an 0.3mm mesh used where waterlogged deposits are encountered. It goes without saying that partial sampling, small sample sizes, the use of too wide a mesh, or not sieving at all, will produce assemblages not representative of the target population and thus of little value.

Establishing the formation processes of each sample and the route of entry into the archaeological deposit for each species and plant component is a critical aspect of the interpretation of each sample. Understanding these processes has relied heavily on ethnographic studies of traditional farming and the sequence of crop processing activities taking place after the harvest, as well as on charring and digestion experiments, to establish the direction of loss.[101] Such studies rely on calculating ratios for the main crop components, densities of remains per liter of sieved deposit, frequency of each species in the samples, diversity indexes, and identification of spatial patterning of remains across sites and regions, as well as correspondence analysis and other multivariate analyses to identify correlations and associations between samples, taxa, occupation phases, and types of site. To ensure that such calculations are reliable, samples should have a sufficient number of identified remains. Ideally each sample contains at least 300 identifications, though those with 100+ can be used for less demanding analyses. As in all quantitative analyses, it is critical to think carefully about what data go into each analysis, to determine the formation process of each sample before deciding to include samples in any analysis, to ensure that each compares like with like.[102] The acronym GIGO (Garbage In, Garbage Out) is a helpful mnemonic here.

Critically important too is the dating evidence for all samples, and direct dating of individual plant specimens is advisable where archaeological dating is imprecise, where residuality in a deposit is suspected, where the result seems to be unusual for the time or region concerned, or where the introduction of new crops is monitored.[103]

It goes without saying that the archaeobotanical data need to be compared and integrated with the results of other bodies of evidence from the same sites, regions, and periods. Here the formulation of research questions is beneficial. While each project will have research questions that are specific to each line of evidence, it will be advantageous to create a number of shared research questions, where each dataset addresses the same set of questions, to identify whether similarities in the direction of change are present in all datasets. This way, the data within each line of evidence can be studied and quantified according to agreed-upon practices and methodologies within each subdiscipline, and the *answers* to each of these questions by each dataset, rather than the *data* of each line of evidence, can be integrated into a wider interpretative framework of the transformations seen at that time and place.

Daily Lives—Can We Identify Different Modes of Being?

While archaeobotany inevitably is much concerned with methodologies, the true aim of the discipline is to contribute to our understanding of the mutual interactions between humans and plants and the roles of these interactions in the cultural process. Previously, there has been a tendency towards materialism and environmental determinism, seeing production and consumption as key foci and economic and environmental factors as key drivers in changing practices. This, in turn, was replaced by a greater emphasis on human agency, an approach that recognizes and emphasizes the key role played by human action and human choices, thus moving away from notions of human actions as determined by external forces (climate change, demographic pressure, ecological stress). In this approach social factors are regarded as the key drivers in people's behavior, and people are viewed as agents that choose to use plants in order to achieve or maintain a certain outcome, such as a certain social status or a specific identity. Within this approach, however, plants are viewed merely as passive objects. Today, there is a growing understanding that both humans *and* plants have agency, and that both affect one another, that daily lives were and are shaped by the day-to-day interactions or "relationalities" between people and plants.[104] Plants were, and are, an integral part of our lives, our nutrition and health, our work, our body image, and our social relations. The properties that plants possess and display, both as growing organisms and as harvested resources, influence what we can do with them and how we can relate to them—not only in practical terms, but also in terms of the social and cultural meanings and values that they carry. Plants were, and are, used every day *and* discarded every day. Archaeobotany is thus ideally placed to identify these routine practices, to distinguish between routine and more unusual events, between group practice and individuality, and can, consequently, contribute to our understanding of past daily lives. Here a few of these interactions are briefly considered.

The routine, day-to-day engagement with food plants, in the sense of gathering, tending, cultivating, pruning, weeding, harvesting, and processing plants creates daily, monthly, and yearly rhythms, which, in the case of farmers and plant collectors, are tied to the life cycle of the crops they grow or gather. This process also includes the engagement with particular types of tools and the movements made with those tools (spade, plough, traction animal, scythe, pruning hook, threshing stick or sledge, sieve, basket), enacting the same set of actions over and over again, year after year, and all these engagements together make farmers who and what they are. These embodied routines condition how farmers see and interact with the world, the landscape, and the plants and animals, as well as other humans; they are their life.[105] By doing it they become farmers, a particular mode of being, but it is an ontology that is rooted in particular historically arisen relationships, relationships that are in a continuous process of transformation and becoming, through their interaction with both natural and cultural factors. A simple dichotomy between farming and nonfarming lifestyles is unhelpful. Each type of crop will bring its own rhythms and each environment, each social and each historical context its own set of possibilities and constraints. Plants are affected too, of course, as is clear from the fact that only some were domesticated, others became extinct, some (including weeds) spread across the globe, others did not, and so forth.

One of the best examples of these mutualistic human-plant relationships is the transition to farming and the associated emergence of sedentism, ownership, and wealth accumulation, in that this transition brought about fundamental changes in plants, animals, society, vegetation, and the material world. Complex interactions between natural factors and human agency played an important role at different stages of this transition.[106] Other examples of mutualistic human-plant relationships include the spice trade, where the potency and desirability of tropical spices combined with the social aspiration for luxury foods resulted in long-distance trade, new ports of trade, shipping and navigation innovations, and, ultimately, the rise of globalization; the introduction of so-called summer crops into the Middle East, where the potential of certain tropical and subtropical crops (e.g., sugar, cotton) combined with their physical requirements (irrigation) impacted on agriculture and labor relations in the Middle East and North Africa; the Columbian Exchange in which the European demand for cheaper produce of sugar, tobacco, and cotton, combined with the suitability of these crops to plantation cultivation, led to their introduction into the Americas and the need for a cheap labor force, which brought about the triangular slave trade; the role and attraction of sugar (and tea) in sustaining the workers during long working hours in the industrialization process; the current obesity crisis; and last, but not least, the constant battle between farmers and weeds associated with the evolution of cultivation techniques and the parallel response in seed dormancy mechanisms.[107]

On a more local scale, archaeobotany can contribute to our understanding of the daily realities of people living side by side in the same village and engaged in the same agrarian activities (provided large-scale excavation and intensive sampling were carried out). For example, at the Neolithic site of Vaihingen an der Enz, southwest Germany, a study of the crops and associated weed floras, combined with artifact assemblages at each of the houses, identified several different but contemporary house groups, each cultivating the same crops, but, according to the weed evidence, in plots at different distances from the settlement, suggesting that land was owned by "clans."[108] This differential location of plots per house group was long-lived (continuing over several generations), but not ecologically "neutral"; the best land was not equally shared between the house groups. The areas closest to the village, located on the loess soils and with high pH, could benefit from greater levels of soil disturbance and manuring and thus had higher yield potential, but these were preferentially cultivated by people from one particular house group. Other house groups cultivated lands at great distances away, on thinner loess soils, with ambiguous pH levels, less soil disturbance, and, consequently, likely lower yields. Thus, some households/groups had an advantage over others, and notably, these differences were also expressed in the spatial patterning of the households/groups within the settlement and, as mentioned, continued over generations.[109]

The degree of social cohesion in a community may also be studied through storage practices. Here we need to acknowledge the different potential for storage between plants and animals. While plants can be consumed piecemeal and can be stored in individual households, animals, especially larger animals such as cattle, cannot; these need to be shared between households.[110] At the Neolithic site of Çatalhöyük, Central Anatolia, where families lived side by side in conjoined dwellings, plant foods (grain, fruit, nuts, condiments) were often stored in special bins in relatively inaccessible and invisible parts of the house, a potentially divisive practice. In contrast, the "storage" of animal protein was not at the household level, but through social sharing of meat, during feasts, with evidence of these communal activities that enhance social cohesion commemorated by the display of the heads and horns of aurochs near the entrances of the house.[111] This highlights how social practices are therefore not simply the imposition of arbitrary human practices on a passive world of plants and animals, but, instead, emerge, in particular historical contexts, from dynamic relationships between people, plants, animals, and things, all of which are active participants in these relations.

At a more individual or personal level, the physical ingestion of plants into the body is another arena in which plants affect our daily lives. The impact of plant substances on our physical and mental state are well known, but not yet widely studied in archaeology. Here cultural norms and belief systems govern what is regarded as edible or acceptable to eat, and research into this cultural context of food has included the identification and role of communal and elite feasting, the use of foods, including the avoidance of specific foodstuffs, in the construction of ethnic or religious identities, social relations and positions of power, as mentioned above. The "you are what you eat" view has also been used in stable isotope studies in terms of both the chemical signatures left in the bones and the nutritional deficiencies visible in the skeletal remains of individuals (see below, Chapter 4). The material properties of plants, such as their sweetness, bitterness, proteins, carbohydrates, vitamins, minerals, toxicity, and psychoactive substances, not only affect our enjoyment of and emotional reaction to foods, they are also implicated in certain addictions, sought after for their stimulant or mind-altering properties, and affect our physical well-being in other ways (overconsumption, especially of sugary and fatty foods—a current concern). Tooth decay and its associated discomfort and pain may serve as an example. High rates of caries tend to be associated with sedentary, agricultural communities as they rely heavily on cariogenic foods (foods producing or promoting the development of tooth decay), and analyses of bacterial DNA from ancient dental calculus deposits confirm that oral microbiota implicated in the development of caries become more prevalent after the transition to farming.[112] Archaeobotanical evidence for poor oral health comes from Gran Canaria, Spain, where fig seeds were found embedded in the pulpar cavities of pre-Hispanic human remains.[113] Evidence that it is the foods rather than the sedentary lifestyle that matter here can be seen in a Pleistocene community of hunter-gatherers in Morocco, where an unusually high prevalence of caries was linked to a reliance on highly cariogenic wild plant foods, such as the sweet acorns of the Holm oak (*Quercus ilex*).[114] The role of psychoactive substances in human culture and social life has so far primarily focused on the role of alcohol as a social lubricant and as a political tool.[115]

Plants have the ability to raise strong emotional reactions, and these embrace all aspects of life, including the significance of certain food taboos in religious beliefs, the association of certain foods with a foreign culture or foreign power, moral objections to luxury foods, and the role of foods in celebrations and other social occasions. Nonfood plants affect our emotions and our being too, as can be seen in the placement of flowers and garlands with the dead, in the use of ointments, in the construction of gardens, in the planting of sacred pine and elm groves at cemeteries, and of palm groves at places of recreation.[116] Finally, the place of body treatment and the use of plants, dyes, and resins deserve further investigation.[117] Combined gas chromatography–mass spectrometry (GC-MS) can now be used to identify archaeological plant resins, opening up new avenues for research. For example, these substances were used in mortuary practices to disguise the odor of decomposition, to aid soft-tissue preservation, to signify the social status of the deceased, and, most importantly, to facilitate the transition to the next world.[118]

Conclusion

Archaeobotany has contributed greatly to our understanding of daily life in the Greco-Roman world (and in past daily life more generally). It informs about mundane activities rarely discussed in surviving texts, about the annual routine of producing food, the daily chore of preparing food and disposing of the leftovers, about the daily social encounters over a meal, about nutrition and health, about social status and identity, about the ideological role of plants in personal lives, about different ontologies. It speaks about those not represented in the written record and adds extra information about those that are. The apparent "vocality" of texts[119] has meant that the contribution of archaeobotany has been less prominent in the core regions of classical archaeology than elsewhere. We must hope that this brief survey and this volume highlight and convince that the application of multiple lines of evidence will enhance our understanding of the past and will illuminate more clearly the great complexity and diversity of practice and being.

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Notes

1. Goody 1982.

2. Margaritis and Jones 2009.

3. E.g., Campbell 2008; M. Jones 2007, 260–266; Nesbitt and Samuel 1996; Pelling 2008; Van der Veen 1995; Van der Veen 2014b; Zech-Matterne et al. 2014.

4. Zech-Matterne et al. 2014.

5. Rösch et al. 1992.

6. Zech-Matterne et al. 2014.

7. M. Jones 2007, 260–269.

8. Van der Veen 1992.

9. Bogaard et al. 2011; see also Section 7 below.

10. M. Jones 1988, 2009.

11. Autecology focuses on the relationship between an individual plant species and its environment, while phytosociology deals with plant communities and the relationships between the species within them.

12. Bogaard et al. 1999; Charles et al. 2003; G. Jones 2002; G. Jones et al. 1999, 2000, 2010.

13. Bogaard, et al. 2013; Fraser, et al. 2011; Wallace, et al. 2013.

14. Bogaard et al. 2007.

15. Bogaard and Outram, 2013; Fiorentino et al. 2015; Fraser et al. 2013.

16. Araus et al. 1997; Riehl et al. 2014.

17. Riehl 2009.

18. Cunniff et al. 2010.

19. Fiorentino et al. 2015; Nitsch et al. 2015.

20. E.g., Marvelli et al. 2013; Rodríguez-Ariza and Moya 2005.

21. Burger et al. 2011.

22. Newton et al. 2014; Terral et al. 2004 (olive); Orrù et al. 2013; Pagnoux et al. 2015; Terral et al. 2010 (grape); Burger et al. 2011 (cherry); Gros-Balthzard et al. 2016; Terral et al. 2012 (date).

23. Allaby et al. 2014; Brown et al. 2015.

24. Allaby et al. 2014; Li, et al 2011; Palmer et al. 2009; Palmer et al. 2012.

25. Cappers 2006; Rowley-Conwy 1994; Van der Veen 2011; Van der Veen and Morales 2015 (Egypt); Jiang et al. 2015 (China); Morales et al. 2014; Oliveira et al. 2012 (Spain); Ernst and Jacomet 2005; Letts 1999 (buildings Europe).

26. Manen et al. 2003; Pollmann et al. 2005; Schlumbaum and Edwards 2013.

27. Bunning et al. 2012; Fernández et al. 2013.

28. Brown et al. 2015.

29. G. Jones et al. 2012; G. Jones et al. 2013.

30. Brown et al. 2015; Cooper and Poinar 2000.

31. Fuller and Stevens 2009; Fuller et al. 2014; Hillman 1981; Van der Veen 1992, 2007; Van der Veen and Jones 2006.

32. Hillman 1984; Van der Veen and Jones 2006, 2007.

33. Neef 1990; W. Smith 1998; Rowan 2015.

34. Rowan 2015.

35. Van der Veen 2014b.

36. Ciaraldi 2007; Robinson 1999; Robinson 2012.

37. Motta, 2002.

38. Giesecke 2013; Jashemski 1979; Kron 2013.

39. E.g., Bouchaud 2011; Bouchaud et al. 2011; M. Jones 1981; Van der Veen et al. 1996.

40. See Bottema et al. 1990; Cheddadi et al. 2015; Foxhall et al. 2007; Harris 2013; Mercuri et al. 2015; Roberts et al. 2004; Sadori and Giardini 2007; Veal 2012, 2013, 2014.

41. Halstead 2014, chapter 7; see also Van der Veen 2010.

42. Smith and Kenward 2011.

43. Booth et al. 2007, 24, 281; Kenward and Williams 1979; Smith and Kenward 2011.

44. Smith and Kenward 2011.

45. Kenward and Williams 1979; Straker 1984. See also Kislev and Simchoni 2007 for an example from Masada, Israel.

46. Pals et al. 1989; Pals and Hakbijl 1992.

47. Zech-Matterne et al. 2014.

48. Straker 1984.

49. Kooistra et al. 2013; Van Dinter et al. 2014.

50. Zech-Matterne et al. 2014.

51. Domínguez-Delmás et al. 2014.

52. Jansma et al. 2014; Visser 2015.

53. Vermeeren 1999; Van der Veen and Gale 2011.

54. Cappers 2006; Van der Veen 2011.

55. Livarda 2011; Van der Veen 2011; Van der Veen and Morales 2015.

56. Bouby et al. 2011; Sadori et al. 2010; Sadori et al. 2014; Van Zeist et al. 2001; Vittori et al. 2015.

57. Van der Veen 1998a and b, 2001; Van der Veen and Tabinor 2007.

58. Tomber 1996.

59. Bülow-Jacobsen 1997, 2003; Cuvigny 1996, 2000.

60. Bakels and Jacomet 2003; Livarda 2011; Livarda and Van der Veen 2008; Van der Veen 2008; Van der Veen et al. 2008.

61. Kreuz 2004; Lodwick 2014; Zech-Matterne et al. 2009.

62. Harris et al. 2002.

63. Macauley-Lewis 2006.

64. Buckland and Magilton 1986, 198; Robinson et al. 2006.

65. G. Jones et al. 2012, 2013.

66. Pals and Hakbijl 1992; Sealey and Tyres 1989; Ward 2001, 2003.

67. Rowan 2014; Stahl 1989.

68. al-Azm 2009; Samuel 2000; Valamoti et al. 2008.

69. Valamoti 2011.

70. Samuel 2000.

71. Heiss 2014; Heiss et al. 2015.

72. Bouby et al. 2011; Stika 2011.

73. M. Jones 1981.

74. Campbell 2008; Cunliffe 2009; Van der Veen 1989.

75. Behre 1992.

76. Margaritis and Jones 2006, 2008a and b; Marinova et al. 2011; Miller 2008; Valamoti et al. 2007.

77. Evershed 2008; McGovern et al. 1995, 1996; Pecci et al. 2013.

78. Cox and Van der Veen 2008. For other examples, see Van der Veen 2011, chapter 4.4.

79. Valamoti et al. 2011

80. Ciaraldi 2007; Davis 2011; Pearson and Letts 1996; Rowan 2014; Robinson and Rowan 2015; Tomlinson 1987; Van der Veen 2001, 2011; Van der Veen and Tabinor 2007; Vandorpe and Jacomet 2011a; Van Zeist et al. 2001.

81. E.g., Papathanasiou et al. 2013.

82. Plants do not all have the same photosynthesis pathway; they do not all fixate carbon in the same way. Most food plants in temperate environments (for example, wheat, barley, rice, apples, carrots, spinach, sugar beet, trees) have a so-called C3 pathway, while many tropical food plants (for example, maize, sorghum, millet, sugar cane) have a so-called C4 pathway. The introduction of tropical, C4, plants into a temperate environment can thus be identified in the carbon isotope ratios of those that consumed those plants.

83. Bakels and Jacomet 2003; Jacomet et al. 2002; Kreuz 2004; Livarda and Van der Veen 2008; Van der Veen et al. 2008. See also Van der Veen 2003.

84. Van der Veen 2008; Van der Veen et al. 2008.

85. Van der Veen 2011; Van der Veen and Morales 2017.

86. E.g., Bouby and Marinval 2004; Heiss 2014; Kohler-Schneider et al. 2015; Kučan 1995; Megaloudi 2005; Megaloudi et al. 2007; Petrucci-Bavaud and Jacomet 1997; Robinson 2002; Rottoli and Castiglioni 2011; Vandorpe and Jacomet 2011b; Zach 2002.

87. Megaloudi 2005; Megaloudi et al. 2007.

88. Brettell et al. 2015.

89. Bouby and Marinval 2004; Robinson 2002; Rottoli and Castiglioni 2011.

90. E.g., Kislev 1988.

91. Livarda 2013.

92. Rossignani et al. 2005.

93. Valamoti 2012/13.

94. Fuller et al. 2014; Hillman 1981; Jacomet 2013; Van der Veen 2007; Van der Veen and G. Jones 2006.

95. Van der Veen et al. 2013, Fig. 7.

96. Colledge and Conolly 2014.

97. Van der Veen 2007 (North Africa); Rowan 2014 (Herculaenum).

98. M. Jones 1991; Van der Veen 1984.

99. Van der Veen and Fieller 1982.

100. E.g., Campbell, Moffett and Straker 2011.

101. E.g., Boardman and Jones 1990; Braadbaart 2008; Charles 1998; Hillman 1981, 1984; Jacomet 2013; G. Jones 1984, 1998; Kreuz 1990; Miller and Smart 1984; Van der Veen and Jones 2006; Van der Veen 2007; Wallace and Charles 2013.

102. G. Jones 1991; Van der Veen and Fieller 1982.

103. Pelling et al. 2015.

104. E.g., Ingold 1993, 1996; Van der Veen 2014a.

105. Ingold 1993, 1996; Halstead 2014.

106. E.g., Cunniff et al. 2010; Fuller et al. 2010; G. Jones et al. 2013; Zeder 2006.

107. E.g., Crosby 2003; M. Jones 1988, 2009; Mintz 1985; Van der Veen 2014a; Van der Veen and Morales 2015, 2017; Viola 1991; Watson 1983.

108. Bogaard et al. 2011.

109. Ibid.

110. Bogaard et al. 2009.

111. Ibid.

112. Adler et al. 2013.

113. Morales and Gil 2014.

114. Humphrey et al. 2014.

115. Dietler 2006; Sherratt 1991; though see the work by Lewis-Williams (2004) on mind- and behaviour-altering substances.

116. E.g., Androu et al. 2013; Hamdy 2007; Jashemski 1979; Koch et al. in press; Robinson 2016; Rossignani et al. 2005; Schlumbaum et al. 2011; Wilson 2016.

117. E.g. Van der Veen, Hall and May 1993.

118. Brettell et al. 2015; see also Vermeeren and Van Haaster 2002.

119. Moreland 2001, 33–34.

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