Botanical microfossil remains are defined as plants, plant fragments, or products invisible to the naked eye and thus requiring magnification for study (Braiser 1980; Dincauze 2000). Although plant microfossil research incorporates a variety of components, including determination of taphonomic processes, field recovery, laboratory preparation, identification, data presentation, and interpretation (Coil et al. 2003), this chapter restricts itself to general research practice in landscape archaeology. Archaeologists should acquire an understanding of the basic principles of plant microfossil data in order to recognize how any particular fossil type can become a useful part of excavation and research programs. At the same time, archaeologists should be aware and appreciative of the expertise required in microbotanical fossil analysis, when addressing problems at various levels of complexity in particular. The purpose of this chapter is to provide an introduction into microfossil analysis and associated literature base so that a knowledgeable step toward expertise and collaboration can be taken.

Landscape archaeology may be described as a discipline seeking out the material manifestation of the relation between humans and the environment (Knapp and Ashmore 1999). Importantly, not all relations can be expected to be represented in material, archaeologically detectable ways, thus highlighting the importance of microbotanical fossil analysis to the discipline. Plants have always been essential resources to people, and they are, at the same time, important indicators of the condition of habitats. Research on plant micro-remains yields important, complementary knowledge to archaeology on diet/nutrition, economy, the presence and activities of people in the wider environment, including agricultural practices, as well as on the environment itself (Knapp and Ashmore 1999; Willerding 1991). The palaeoecological methods that are ultimately chosen should be appropriate to the particular set of archaeological questions (Dincauze 2000).

This chapter encourages readers to question their own research and ask what type of plant microfossil may best strengthen their interpretation. As a guide, a review of seven microbotanical fossil types and their applications is presented (see Table 42.1 for a summary). We focus on physical characteristics, particularly those that may affect microfossil preservation, as well as the type and level of information each microfossil type can be expected to provide. A list of seven microfossil types is by no means exhaustive, but it incorporates the more widely used plant microfossil types associated with archaeological study.
**Pollen and Spores**

Traditionally, palynology, or pollen analysis, has focused on the study of pollen and also spores, the latter predominantly from ferns and fern allies. Pollen grains are the reproductive male gametes of angiosperms (flowering plants) and gymnosperms (conifers) responsible for the transfer of genetic material, the onset of fertilization, and seed production. Spores are the asexual reproductive cells of fungi, pteridophytes (ferns and fern allies), bryophytes (mosses), and algae that give rise directly to the next generation (Raven, Evert, and Eichhorn 1992; Williams et al. 1998). Few pollen and spores exceed 100 microns (μm) in diameter; most fall within the size range 15 μm to 30 μm.

Fossil pollen grains are represented, in the fossil state, by their outer layer, or exine, which consists of a waxy coat of material known as sporopollenin. The protective, resistant nature of sporopollenin has the effect of preserving pollen grain exines in sediments. This outer wall is also ornamented and perforated in various ways relating largely to the mode of dispersal of the grains as well as to taxonomic affinity. Faegri and associates (1989) present a detailed discussion of the terminology used to describe the structure, sculpturing, and apertures (openings) of the exine that, along with features such as size and shape, assist with identification, typically at the level of genus or family, but within some plant groups, at species level (Bennett and Willis 2001; Lowe and Walker 1984; Pearsall 2000). Spore walls have a similar sporopollenin structure but generally fewer sculptural features. However, they often have a loose additional coating, an exosporium, that allows refined identification when preserved.

The principles of pollen analysis make it clear that there is a long progression between the release of pollen or spores, their incorporation into sediment, and the production of the final pollen assemblage; plants vary greatly in the amount of pollen they produce and in the distance to which pollen grains are dispersed. Preservation of pollen and spores is affected by characteristics related to both taxonomic origin and depositional environments (Bennett and Willis 2001; Coil et al. 2003). Optimal preservation requires anaerobic (oxygen free) or acidic environments that hinder decomposing bacteria (however, dry conditions may also allow preservation). Wetlands, lake sediments, dry cave earths, and even some soils are conducive to the preservation of pollen and spores (Dincauze 2000). Pearsall (2000: 263) provides a list of site types successfully studied using reviews of the history of pollen analysis, especially its application in archaeology, can be found in Bryant and Holloway (1983, 1996) and Pearsall (2000). Walker (1990) provides a brief history of Quaternary palynology. Five major research emphases are represented in contemporary palynological literature: (1) vegetation history; (2) climatic history; (3) biogeography (phytogeography); (4) plant ecology; and (5) human use of and alteration of natural systems (Dincauze 2000). An early emphasis on the use of pollen analysis for regional correlation in the Quaternary has declined with the establishment and progressive refinement of radiometric dating but is still important in pre-Quaternary studies and has recently been revived in correlation of Quaternary straigraphic schemes derived from marine and terrestrial environments (e.g., Tzedakis et al. 1997). Stratigraphic studies focused on vegetation history mainly provide information on the regional environmental setting of human occupation and impact, whereas those from archaeological sites generally focus on specific land uses and activities (Dincauze 2000; Pearsall 2000). In those parts of the world where agriculture has been a major feature of the landscape, initial impacts and subsequent land-use changes on a regional scale can be identified by reductions in the percentages of tree pollen, as a result of deforestation, and specific indicators of disturbance increase either in native opportunists or introduced plants of arable or pastoral systems. For example, Behre (1986) provides a valuable list of anthropogenic indicators in pollen records from Europe, while Maloney (1994) assesses indicators of human disturbance associated with agriculture in Southeast Asia. Changes in composition of forest may also be used as evidence of people, owing to selective use of species that may enhance or reduce their representation, but, because of other agents of change such as climate, volcanic activity, landslides, and so forth, there is often uncertainty in determination of initial or small-scale human impacts on the landscape. One classic debate involves the decline of elm trees in the mid Holocene of northwest Europe that had been attributed to climate change and disease as well as human disturbance. Resolution of the question on the side of human impact was finally determined to the satisfaction of most researchers via a very high (annual) sub-sampling interval of an optimal site (Peglar 1993). Studies such as this have largely revolutionized pollen analysis, and temporally precise studies, particularly where they can be supported by high dating resolution,
Table 42.1 Summary of plant microfossil types commonly associated with archaeological studies.

<table>
<thead>
<tr>
<th>Proxy</th>
<th>Variable Measured</th>
<th>Laboratory Procedures</th>
<th>Preservation</th>
<th>Deposition</th>
<th>Major applications</th>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollen and Spores</td>
<td>Type, relative abundance</td>
<td>Moore et al. (1991) Bennett and Willis (2001)</td>
<td>Acidic and/or anaerobic environments; geological and archaeological (cultural) archives</td>
<td>Local to regional</td>
<td>Past vegetation composition, structure, and dynamic; climatic change; human land use and impact</td>
<td>Widely adopted technique with a strong history of use.</td>
<td>Differential production, dispersal, and preservation may limit data interpretation</td>
</tr>
<tr>
<td>Cellular Tissue</td>
<td>Presence, abundance</td>
<td>Chemical digestive techniques as used for pollen preparation</td>
<td>Sediments from which fossil pollen grains are typically recovered. Lake and swamp sediments</td>
<td>Local. Not adapted to long-distance transport</td>
<td>Reconstruction of past vegetation: to infer the presence and absence of different plant taxa</td>
<td>Auxiliary technique to pollen analysis</td>
<td>Present in low abundances; occurs too infrequently to infer absolute or relative abundance of plant taxa</td>
</tr>
<tr>
<td>Starch</td>
<td>Presence, abundance</td>
<td>Pearsall (2000) Korstanje (2003)</td>
<td>A variety of contexts (possibly) reduced when left in open conditions; geological and archaeological (cultural) archives</td>
<td>Local</td>
<td>Investigation of subsistence strategies and plant use within prehistoric populations</td>
<td>Direct evidence for plant collection and use, the plant food component of early human diets, as well as tool function</td>
<td>Current knowledge of processes affecting morphology and fossil survival of starch grains is limited</td>
</tr>
<tr>
<td>Type</td>
<td>Relative Abundance</td>
<td>References</td>
<td>Contexts</td>
<td>Identification</td>
<td>Preservation</td>
<td>Applications</td>
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<tr>
<td>Phytoliths</td>
<td></td>
<td>Pearsall (2000)</td>
<td>Predominantly local</td>
<td>Reconstruction of past environments; identification of agricultural systems (land use) and crop types; information on subsistence and diet</td>
<td>Durability. Preserved where other micro-fossils are commonly absent (including dry, alkaline, anaerobic conditions)</td>
<td>Lack of diagnostic features and range of types within individual plants presently inhibits application to a few taxa, e.g., Poaceae</td>
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<td></td>
<td></td>
<td>Lentfer and Boyd (1998, 1999)</td>
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<tr>
<td></td>
<td></td>
<td>A variety of contexts, including geological and archaeological (cultural) archives</td>
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<tr>
<td>Diatoms</td>
<td></td>
<td>Battarbee et al. (2001)</td>
<td>Predominantly local</td>
<td>Indicators of environmental change, particularly water quality, in lakes and flowing waters, marine and estuarine environments</td>
<td>Cosmopolitan and identifiable to refined taxonomic level; well-defined environmental optima and tolerances</td>
<td>Total or differential dissolution in some aquatic environments, especially in carbonate-rich or ephemeral lakes</td>
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<td></td>
<td></td>
<td>Aquatic and damp environments; best preserved in cold, soft water bodies</td>
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<tr>
<td>Chrysophytes</td>
<td>Type and relative abundance of Chrysophyte scale and cyst remains</td>
<td>Zeeb and Smol (2001); same preparation can be used as for diatom analysis</td>
<td>Local</td>
<td>As with diatoms, indicators of aquatic environmental conditions: lake-level changes, water and habitat availability, salinity, and pollution</td>
<td>Well-defined environmental optima and tolerances</td>
<td>A proxy approach still in early development; limited information on chrysophyte cyst morphology</td>
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<td></td>
<td></td>
<td>Freshwater environments (exclusively marine taxa are rare); most common in acidic and/or nutrient poor lakes</td>
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They are especially important in documenting and explaining rapid changes that have occurred in land use over the last one or two centuries.

In contrast to their value in documenting disturbance and indicating the establishment of pastoral and arable agriculture, pollen analytical studies have been limited in their ability to identify particular crop types. One reason for this is that pollen cannot be identified to an appropriate taxonomic level. For example, cereals form the basis of many agricultural systems and, although cereals can often be separated from native grasses, it is very difficult to make identifications at the species, never mind the cultivar level—another reason is the palynological “invisibility” of root crops, the other major basis of agricultural systems, due mainly to lack of preservation (Maloney 1994).

In those regions and those time periods dominated by hunter-gatherer societies, identification of human impact from pollen evidence can be extremely tentative or even impossible. More certainty can be introduced by examination of changes in charcoal records, as a direct measure of fire, in addition to pollen. At Lynch’s Crater in northeastern Australia, Kershaw (1994) interpreted the replacement of fire-sensitive drier rainforest by sclerophyll vegetation around 40,000 years ago as a response to Aboriginal burning with the first arrival of people on the continent. This interpretation was treated with some skepticism until the addition of a charcoal curve provided the required support for the hypothesis (see discussions in Turney et al. 2001).

Greater certainty regarding human activities is derived from pollen analysis of archaeological sites. Because archaeological sites are the locus of human disturbance (Davis 1994: 2), direct pollen analysis of collected sediments can prove to be a reliable method of determining changes in landscape and vegetation as a result of known human presence and activity. Palaeovegetational changes may be linked temporally and spatially to the human changes inferred from archaeologically derived data, and subsequently translated to non-archaeological or “off-site” sediment and fossil sequences. Rowe (2005, 2006) provides examples where pollen analysis of an archaeological rockshelter site in northern Australia highlighted local decline in forest cover, as a result of the onset of permanent occupation of the site, providing a standard from which to interpret swamp sequences in the same region. A number of case studies that address the use and interpretation of archaeological pollen data are presented in Davis (1994).

Non-Pollen Palynomorphs

In recent years, palynological study has expanded to incorporate other botanical entities composed of sporopollenin-like material. Although studies on the gross composition of organic matter in palynological samples, known as “palynodebris” or “palynofacies” analyses, have been undertaken for many years to contribute to a fuller sedimentary picture (Traverse 1988), little attempt was made at botanical sourcing of material. A full or selected identification of non-pollen palynomorphs found on pollen slides may result in substantially greater palaeoenvironmental information (van Geel 2001). Van Geel (1986, 2001) and Cronberg (1986) highlighted efforts made to combine the analysis of pollen with the study of all “extra” microfossils in Quaternary deposits in northwest Europe. Among the extra fossils recorded were the remains of algae and cyanobacteria. The recognition of spores, including the spores of fungi, was also expanded.

Van Geel (2001) refers to a number of papers in which the description and illustration of non-pollen palynomorph types and their indicator value are discussed. Of note, spores of the family Zygnemataceae (filamentous green algae) are common in shallow, stagnant freshwater deposits and based on fossil spore records characterize different habitat types (for example, specific sediment types, different trophic conditions). Fossil spores of Zygnemataceae have been described and utilized in an archaeological context by van Geel (1976). Factors resulting in the presence of *Pediastrum* (colonial green algae) spores in sediments include changes in catchment erosion, water turbidity, nutrient status, and pH. Remains of cyanobacteria function as indicators of nitrogen-poor conditions, possibly occurring where there is a general low level of nutrients. Among the fossil fungi are parasitic types that indicate the presence of their host plant (for example, *Amphisphaerella* for the presence of *Populus*), indicators for dung (*Chaetomium*), indicators for fire (*Neurospora*), and soil-inhabiting taxa whose presence in lake deposits points to erosion (*Glomus*) (van Geel 2001).

Cellular Tissue Remains

Undecomposed plant cells, or plant tissues, can form a significant component of the nonmineral or “palynodebris” fraction of sediments (Coil et al. 2003). Microfossils of trichomes (an outgrowth, such as a root hair, from plant epidermal cells; Bailey 1999) or stomata cells, for example, form a bene-
tissues are similar to plant macrofossils, only to be found in sediments more frequently. They are not prone to long-distance transport and provide a good indication of the local presence, absence, and abundance of different plant taxa (McDonald 2001). For example, Nymphaeaceae have mucilaginous hairs. The basal cells of these hairs, with their central pore and concentric ring pattern, are common in pollen slides from water bodies where Nymphaea is present in the local vegetation. The frequency of these basal cells is in sharp contrast to typically rare Nymphaeaceae (entomophilous) pollen (van Geel, 2001).

McDonald (2001) outlines the identification of conifer stomata and suggests taxonomic resolution is as good as for pollen. Stomatal records have been constructed from late Quaternary lake sediments in Europe, Siberia, and North America, and from peatlands in Canada (see McDonald 2001 for a recent review). In alpine and polar regions, fossil stomata have been utilized as indicators of tree fluctuations during the Holocene. The stomata of Picea abies (European spruce), Pinus, and Larix decidua (European larch), for example, have been used to reconstruct changes in the position of the upper tree line, whereas stomata from Juniperus, Pinus, and Abies alba (fir) signal vegetation change at lower elevations. McDonald (2001) highlights that both natural and anthropogenic vegetation change have been detected using stomatal analysis.

Archaeological samples may also contain undecayed cellular material. Cellulose rings from primary vascular tissues, notably xylem cell walls (Raven, Evert, and Eichhorn 1992), were applied as one of a range of microfossils to address research questions of prehistoric agricultural and pastoral production in Argentina's Valle del Bolsón (Coil et al. 2003). Bruier (1976) found plant residues on stone tools from rockshelter sites in Arizona. Pollen grains, cell walls, cell lumen, raphides, tracheids, and vessal elements were observed as clues to plant collection and use, as well as stone tool function, across the southwestern United States.

Starch

Starch grains are the predominant food storage units of plants, formed within specialized organs (plastids) that occur within individual cells. Of the two kinds of plastids, the chloroplasts occur primarily in leaves and green stems and produce generally transient starches. The more commonly observed starches are produced by amyloplasts, structures provide a reservoir of energy for the plant (Bailey 1999; Cortella and Pochettino 1994; Loy 1994). Starch consists of two organic polymers, amylose and amylopectin, which form a series of laminated layers facilitating preservation. The relative amounts of amylose and amylopectin in a given starch grain depend on the species of plant from which the starch grain was obtained. The shape and size (< 100 μm) of starch grains formed by different plant taxa also differ (Bailey 1999; Coil et al. 2003). Czaja (1978) provides an overview of the structure of starch grains in relation to the classification of plant families. Korstanje (2003) and Pearsall (2000) touch on the laboratory preparation of starch samples. Procedures focusing on locating and removing starch residues adhering to stone artifacts are described by Loy (1994).

In an analysis of archaeological sediments from agricultural field sites in northwestern Argentina, Korstanje (2003) outlines conditions considered advantageous for starch preservation, namely semiarid environments, sandy-type soils, and an average pH of seven. Within a subtropical context, an experiment on starch grain preservation by Lu (2003) revealed preservation was reduced significantly when left in open environments and survived better in buried or sheltered conditions. Nonetheless, Piperno and Holst (1998) and Piperno and associates (2000) highlight the presence of starch grains on prehistoric stone tools, as an indicator of early tuber use and root-crop agriculture in the lowland tropics of Panama. Starch was recovered from stone grinding tools from both cave and open-air sites, dating to 8,000 years ago.

Starch granules, recovered from artifact surfaces in particular, are receiving increasing attention from archaeologists, because they can reveal aspects of subsistence and domestic activities not accessible via other proxy methods. As starch-rich plants formed an important component of many prehistoric diets, the study of starch grains provides a direct means of plant use reconstruction. Haslam (2003) reports on the identification of Zea mays starch grains on 2,000-year-old artifacts from Maya sites in Honduras. Similarly, Urgent (1987) identifies potato remains from a Pleistocene settlement in south-central Chile. Loy and associates (1992) utilize Colocasia and Alocasia taro starch, dating to 28,000 years ago, as evidence of plant collection and use in the northern Solomon Islands. Likewise, starch granules on artifacts provide evidence of taro and yam processing at Bitukara in New Guinea (Fullagar et al. 1998 cited in Haslam 2003).
Silica Phytoliths

Opaline phytoliths are formed when silica, dissolved in groundwater as monosilicic acid, is absorbed through the roots of plants and transported through the vascular system to be deposited in epidermal and other plant cells. In many plant taxa, phytoliths take on distinctive shapes (Pearsall 1994; Piperno 2001) and Coil and associates (2003) describe silica phytoliths as microscopic “casts” of cells, aggregates of cells or intercellular spaces. Aerial plant structures, including leaves, fruits, seeds, and inflorescence bracts, accumulate silica deposits more readily than do subterranean roots and tubers, as a possible deterrent to herbivores and pathogens and as a function of plant structure and support. Following death and decay of the plant, phytoliths retain cell shapes and are ultimately deposited into soils and sediments as discrete particles (decay-in-place model, see Pearsall 2000: 392).

Phytolith identification is based primarily on shape and size (5–50 μm). Distinctive phytoliths are increasingly known to be produced in many plant families; genus-level diagnostics are becoming increasingly common. Identifiable phytoliths are produced in quantity in a considerable number of angiosperms, perhaps the best known among the grasses. Gymnosperms and pteridophytes also possess some diagnostic forms (Pearsall, 2000).

Regional summaries of plant phytolith production and morphology from locations such as Africa (Runge 1999), North America (Bozarth 1992), the South American tropics (Piperno 1988), New Guinea (Boyd, Lentfer, and Torrence 1998), and Australia (Bowdery 1998; Wallis 2000) are available. Species-specific identification is also possible in a number of domesticated crop species. Investigation of the potential of phytolith analysis for the purpose of crop detection began with the search for a method of identifying maize (Pearsall 1994). Piperno (1984) and Pearsall (1978) utilized the characteristics of cross-shaped phytoliths to separate maize from wild grasses and to demonstrate its presence in archaeological sediments from Ecuador and Panama. Pearsall (2000) summarizes, by geographic region, crops identifiable using phytolith analysis (southeast Asia/east Asia, southwest Asia, sub-Saharan Africa, New World temperate, and New World tropical regions).

Piperno (2001) argues that silica phytoliths are among the most durable plant fossils. Since phytoliths are inorganic, they are resistant to oxidation and are well preserved in many depositional environments, including dry and alkaline conditions.

Phytolith analysis is often promoted as a solution to palynological constraints (e.g., Boyd, Lentfer, and Torrence 1998). Methods used to extract phytoliths from sediments and cultural residues are discussed in detail in Pearsall (2000) and Lentfer and Boyd (1998, 1999).

In application, phytolith analysis focused on nonhabitation cultural contexts, including agricultural field or garden site areas, provides a means of obtaining information on subsistence, cropping techniques and other questions of people-plant interrelationships, yielding more direct data than samples from site occupation areas (for example, home floors or storage pits as secondary preparation areas) (Pearsall 2000). For example, Fujitwara (1993) provides evidence of early rice cultivation in Japan, and Fei and Minchang (2003) highlight several distinct phases of rice paddy field development during the Neolithic in southern China. In tropical regions, Pearsall and Trimble (1984) utilize soil phytolith analysis in investigating the intensification of past agricultural activity in Hawai’i, demonstrating vegetation modification associated with both cropping and fallow techniques. Similarly, Pearsall (1994) discusses the introduction and maintenance of agricultural systems to the Ecuadorian coast, incorporating maize, root crops, and palms. In the historical context, Miller and associates (1990, cited in Bowdery 1998) examine garden soils; phytoliths assisting in the identification of 18th–19th century lawns, and ornamental and kitchen gardens in New Jersey. Examples of analyzing phytoliths from non-archaeological sites, for the purpose of reconstructing vegetation, climate, and regional human impacts on environments, include Kealhofer and Penny (1998) in documenting 14,000 years of vegetation change in Thailand, and Zhao and Piperno (1999) and Piperno (2001) in the discrimination of forest type expansion and grassland formations in late Quaternary environments in southern China. Clarkson and Wallis (2003) extend the use of phytoliths from vegetation composition to the reconstruction of climate, suggesting greater mid-Holocene aridity across northern Australia incorporating the possible onset of El Niño-Southern Oscillation conditions. Phytoliths have also been recovered from contexts other than sediments, including mud-wasp nest remains (Roberts et al. 1997), dental calculus (Middleton and Rovner 1994), ceramic cooking and storage vessel residues (Jones 1993), and the working edges of stone tools (Dincauze 2000).

While the focus of phytolith analysis lies with opaline, silica-based phytoliths, some plants form deposits of alternative mineral composi-
Diatoms are single-celled algae ranging in size from 5 μm to 200 μm. The diatom cell possesses a siliceous outer wall, or frustule, divided into two overlapping valves serving to enclose the protoplasmic cell mass. The siliceous nature of the frustule facilitates diatom preservation in the fossil record. The intricate detail of the outer silica wall also provides the characteristics most commonly used in diatom taxonomy (Battarbee et al. 2001; Mannion 1987). Frustrules are either radially symmetrical (centric diatoms) or bilaterally symmetrical (pennate diatoms) and are perforated by small apertures (punctae). The arrangement of the punctae is particularly relevant to the classification of diatoms (Bailey 1999; Lowe and Walker 1984). Round and associates (1990) discuss the biology, ecology, and taxonomy of diatoms, and an outline of analytical and interpretative methods is provided by Battarbee and colleagues (2001) and Battarbee (1986).

Diatoms occupy almost all aquatic or damp environments. They exist in benthic (bottom-dwelling) and planktonic (free-floating) forms in lakes and marine environments. Epiphytic (attached) diatoms occur in soil, clay deposits, and tree trunks as well as on aquatic plants (Lowe and Walker 1984). Diatoms are sensitive to a range of water chemistry parameters including nutrient concentration, salinity, ionic composition, temperature, and pH; community composition is also influenced by biotic factors such as the relative proportion of littoral to open water environments. Accordingly, diatom records have been used to provide insights into climate change, land-use history, catchment processes, lake successional sequences, and aquatic

Chrysophytes are a diverse group of algae most commonly referred to as “golden brown algae” that exist as single flagellated cells, or motile, spherical colonies of flagellated cells. Chrysophytes are represented as microfossils by two forms of siliceous, often species-specific remains: the endogenously formed cysts (stomatocysts, statospores, or statocysts) that characterize this group as a whole, or the often sculptured and ornamented scales that characterize genera such as *Mallomonas* and *Synura*. Bristles and spines from scaled chrysophytes are also sometimes used (Coil et al. 2003; Zeeb and Smol 2001). Numerous texts focus on chrysophytes...
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Smol, and Kristiansen 1995) summarizing aspects of biology, taxonomy, and palaeoenvironmental application (see also Zeeb and Smol 2001). Smol (1986) and Zeeb and Smol (2001) provide numerous drawings and photographs highlighting some of the main chrysophyte features distinguishable with light microscopy.

Most known chrysophytes live in freshwater with well-defined environmental optima and tolerances and can therefore be used as palaeoenvironmental indicators of water pH, trophic status, and salinity/conductivity. Like diatoms, chrysophytes serve as indicators of general environmental conditions, as evidence of hydrological change, flooding, soil transport, and land-use effects (Coil et al. 2003). Both chrysophyte scales and cysts have been included in several palaeolimnological projects, designed to assess long-term trends in lake water pH and metal concentrations in Canada (Dixit et al. 1992, cited in Zeeb and Smol 2001), and on the eutrophication and extent of anthropogenic acidification in Europe (Steinberg, Hartmann, and Krause-de Ilién 1988) and the United States (Cummings et al. 1994, cited in Zeeb and Smol 2001).

Conclusions

As Dincauze (2000: 18, 401) points out for environmental archaeology in general, data integration is possible; it is never easy, but it is essential for any success in the search for knowledge of the past. Botanical microfossils are presented in this chapter as providing a substantial and diverse set of reinforcing data on human activity and associated environments, with the ability to extend discussions and answer questions that often cannot be answered by the archaeological artifact record alone. No single technique, however, can provide all the evidence needed to fully understand the nature of past environments or human landscapes in all their manifestations. Each of the botanical microfossils summarized above offers a slightly different perspective (Coil et al. 2003; Lowe and Walker 1984). Consequently, we stress the potential of multiproxy botanical microfossil studies, and their employment with related proxy studies of macro-plant remains, charcoal, and faunal fossil types as outlined elsewhere in this volume, in order to strengthen archaeological interpretations of landscape.

Notes

1. For a general description of palynological be referenced (e.g., Birks and Birks 1980; Faegri and Iverson 1989; Moore, Birks, and Collinson 1991; Williams et al. 1998).

References


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