APPENDIX 1

Selected study material

Introduction

The majority of the readily available plant anatomy texts were originally written with northern hemisphere readers in mind, and used examples of plants mainly from north temperate or mediterranean climatic regions. Most of theses species will not grow readily in the tropics or other parts of the world. Consequently many people would have had problems in obtaining specimens of the plants for study. This is particularly true for those in the tropics and temperate areas of the southern hemisphere. Even if the species could be obtained, many excellent examples on their doorsteps would have been much more appropriate for study.

In this book, the problem is addressed by including the following lists and notes. They are organized as lists of families showing interesting anatomical characters in leaf and stem, followed by some selected thumbnail accounts. Then secondary xylem is covered, first with a list of anatomical characters found in particular gymnosperm woods, and finally a few thumbnail accounts of angiosperm woods.

Not all members of the families listed will show necessarily the features mentioned, but the features regularly occur where indicated. There are, of course, many other examples of families where features in these lists also occur. We have tried to include families that have widely cultivated members in order to make the list more useful on any continent. You will also find many additional examples on the Virtual Plant CD.

Local floras will help you locate members of the families listed, and you can see if particular species grow near to you.

Leaf

Anisocytic stomata: Brassicaeae, Plumbaginaceae.

Anomocytic stomata: Berberidaceae, Capparaceae, Liliaceae, Polygonaceae, Ranunculaceae.
Branched or dendritic hairs: Zamiaceae, Melastomataceae, Solanaceae, Piperaceae.
Calcified hairs: Boraginaceae, Loasaceae.
Capitate glands: Convolvulaceae, Lamiaceae, Sapindaceae.
Diacytic stomata: Acanthaceae, Caryophyllaceae.
Hairs of varied types: Asteraceae, Lamiaceae, Polygonaceae. Note: not all members of the families named above Malvaceae, Solanaceae. Hairs functioning as hydathodes: *Hygrophylla*. Glandular hairs, secreting mucilage: *Drosera*, *Drosophyllum*.
Hydathodes: Campanulaceae, Piperaceae, Primulaceae.
Hypodermis: Lauraceae, Monimiaceae, Piperaceae.
Latex-containing cells: Apocynaceae, Convolvulaceae, Papaveraceae.
Laticifers, articulated: Papaveraceae, *Hevea* and other Euphorbiaceae.
Laticifers, non-articulated: Apocynaceae, Asclepiadaceae.
Mucilaginous epidermis: Elaeocarpaceae, Malvaceae, Rhamnaceae, Salicaceae.
Papillose lower epidermis: Berberidaceae, Lauraceae, Papilionaceae, Rhamnaceae.
Papillose upper epidermis: Begoniaceae, Melastomataceae.
Paracytic stomata: Juncaceae, Magnoliaceae, Poaceae, Rubiaceae.
Peltate hairs: Bombacaceae, Elaeagnaceae, Oleaceae.
Salt glands: Frankeniaceae, Tamaricaceae.
Scales: Bromeliaceae.
Sclereids: Margraviaceae, Oleaceae, Theaceae, Trochodendraceae.
Silicified hairs: Poaceae.
Stinging hairs: Euphorbiaceae, Loasaceae, Urticaceae.
Tufted hairs: Bixaceae, Fagaceae, Hamamelidaceae.
T-shaped hairs: Malpighiaceae, Sapotaceae, Zamiaceae.

Stem

Cluster crystals: Bombacaceae, Cactaceae, Chenopodiaceae, Malvaceae, Rutaceae, Tiliaceae, Urticaceae.
Cortical bundles: Araliaceae, Cactaceae, Cucurbitaceae, Melastomataceae, Proteaceae.
Cystoliths: Cannabinaceae, Moraceae, Urticaceae.
Deep-seated cork: Bignoniaceae, Casuarinaceae, Hypericaceae, Rosaceae, Theaceae.
Intraxylary phloem: Apocynaceae, Asclepidaceae, Convolvulaceae, Cucurbitaceae, Lythraceae.

Medullary bundles: Apiaceae, Begoniaceae, Asteraceaee, Nyctaginaceae, Papilionaceae, Piperaceae, Saxifragaceae.
Primary medullary rays, narrow: Asclepiadaceae, Brassicaceae, Ericaceae, Meliaceae, Oliniaceae, Rubiaceae, Sapotaceae.
Primary medullary rays, wide: Asteraceae, Begoniaceae, Cucurbitaceae, Ficoideae, Nyctaginaceae, Papilionaceae.
Raphides: Balsaminaceae, Dilleniaceae, Liliaceae, Margraviaceae, Rubiaceae.
Secondary thickening from multiple cambia: Amaranthaceae, Chenopodiaceae, Menispermaceae, Nyctaginaceae.
Solitary crystals: Flacourtiaceae, Mimosaceae, Papilionaceae, Rutaceae, Tamaricaceae.
Superficial cork: Apiaceae Asteraceae, Corylaceae, Fagaceae, Labiatae, Meliaceae, Proteaceae.

A few examples

The short notes which follow mention only a few of the interesting characters that may be seen in each species.

Abrus precatorius (Papillonaceae) – Stem: superficial cork, fibres in cortex and phloem, rhombic crystals, phloem wide, with inflated rays, broad intrusions of phloem into xylem, wide vessels solitary and in long radial chains, narrow vessels and tracheids in clusters, rays heterocellular and 16 cells wide, parenchyma of xylem aliform and in tangential bands, pith sclerified.

Aerva lanata (Amaranthaceae) – Leaf: various hair types, stomata anomocytic and present on both surfaces, cluster crystals. Stem: phloem fibres, large crystalliferous cells in cortex, anomalous vascular tissue with succession of collateral bundles from cambial tissue, vessel elements with simple perforation plates and alternate intervascular pitting.

Aesculus hippocastanum (Hippocastanaceae) – Leaf: hairs unicellular and short uniseriate with warty walls, stomata anomocytic, petiole vasculature composed of cylinder enclosing amphivasal bundles, tanniniferous cells, cluster crystals.

Ageratum conyzoides (Asteraceae) – Stem: hairs, rounded cells of chlorenchyma, endodermoid sheath, fibre strands at phloem poles; vessels narrow in radial multiples with simple perforation plates.

Arbutus unedo (Ericaceae) – Leaf: cuticle thick, stomata anomocytic, palisade chlorenchyma both adaxially and abaxially, sclerenchyma caps to vascular bundles, rhombic and other crystals, tannin in some abaxial epidermal cells.

Averrhoa carambola (Oxalidaceae) – Stem: hairs thick-walled, unicellular; epidermis and hypodermis thick-walled, cortical fibres, vessel element perforation plates simple and oblique, tannin abundant, rhombic and cubic crystals abundant in cortex phloem and xylem.

Bidens pilosa (Asteraceae) – Stem: polygonal in TS, hairs, well developed endodermoid sheath, fibre caps to phloem poles, vessels narrow, in radial multiples, perforation plates simple.

Bougainvillaea sp. (Nyctaginaceae) – Stem: hairs short uniseriate, hypodermis, fibres at phloem cortex boundary, vascular system anomalous, outer bundles embedded in thick-walled prosenchymatous tissue, inner bundles in parenchyma, rhaphide sacs in cortex and pith.

Briza maxima (Poaceae) – Leaf: prickle hairs, silica bodies rectangular in epidermal cells with sinuous walls, stomata paracytic, sclerenchymatous girders opposite vascular bundles both abaxially and adaxially, bundle sheaths, inner sclerenchymatous, outer parenchymatous, chlorenchyma radiate.

Catalpa bignonioides (Bignoniaceae) – Leaf: hairs peltate and uniseriate, stomata anomocytic and superficial, epidermal cells with sinuous walls.

Cistus salviifolius (Cistaceae) – Leaf: hairs, non-glandular tufted and raised on mounds and glandular and capitate, stomata anomocytic, cluster crystals.

Coffea arabica (Rubiaceae) – Stem: phloem fibres, vessels solitary with simple perforation plates, rays narrow, rhombic crystals and crystal sand.

Coldenia procumbens (Boraginaceae) – Leaf: warty hairs with rosette of basal cells, stomata anomocytic, palisade adaxial, cluster crystals. Stem: collenchymatous outer cortex, vessels with simple perforation plates, rays narrow, pith of parenchymatous cells with conspicuous pits.

Cyperus papyrus (Cyperaceae) – Stem: outline triangular, stomata paracytic, conical silica bodies in epidermal cells above hypodermal fibre strands, network of parenchyma with large air spaces, vascular bundles scattered and embedded in parenchyma.

Elaeis guineensis (Arecaceae) – Petiole rachis: vascular bundles in very thick sclerenchymatous bundle sheaths embedded in parenchymatous matrix. Lamina: hairs, expansion cells above and below midrib, hypodermis, spherical silica bodies.

Epaeris impressa (Epacridaceae) – Leaf: epidermal cells axially elongated with sinuous anticlinal walls, stomata anomocytic and superficial on abaxial surface only, vascular bundles with sclerenchyma caps at phloem pole.

Euphorbia hirta (Euphorbiaceae) – Leaf: hairs, abaxial epidermal cells papillose, stomata anisocytic or anomocytic, laticifers, bundle sheaths with contents staining red in safranin, arm cells of spongy mesophyll

clearly visible in paradermal preparations. Stem: vessels solitary or in radial multiples, perforation plates simple.

Fagus sylvatica (Fagaceae) – Leaf: cuticle thin except over petiole, epidermal cells with sinuous anticlinal walls, hairs, stomata anomocytic and superficial on abaxial surface only, bundle sheaths with paired crystals, tannin abundant in cells of petiole. Stem: cork arising in outer cortex, phloem fibres, vessels diffuse porous and solitary or in pairs, perforation plates simple (scalariform in some narrow elements), rays uniseriate to multiseriate and heterocellular, xylem parenchyma scattered.

Gloriosa superba (Colchicaceae) – Leaf: epidermal cells over veins elongated with straight anticlinal walls, epidermal cells between veins with sinuous walls, stomata anomocytic abaxial, vascular bundle sheaths parenchymatous, spongy mesophyll composed of arm cells.

Hamamelis mollis (Hamamelidaceae) – Leaf: hairs tufted consisting of 48 thick-walled radiating pointed cells sometimes raised on mounds, stomata superficial and anomocytic or tending paracytic, sclereids in mesophyll, large mucilage cells, cluster crystals, rhombic crystals, tannin cells.

Heteropogon contortus (Poaceae) – Leaf: adaxial epidermal cells larger than abaxial, stomata paracytic, prickle hairs, silica bodies square to oblong to saddle-shaped, sclerenchyma in margins and as abaxial and adaxial girders to main vascular bundles, parenchyma bundle sheaths, chlorenchyma radiate. Stem: sclerified hypodermis, cylinder of fibres to inner side of cortex.

Hyphaene sp. (Arecaceae) – Leaf: stomata appearing tetracytic, hypodermis, sclerenchyma bundle sheath extensions, fibre strands.

Lantana camara (Verbenaceae) – Stem: hairs both glandular and non-glandular, phloem fibres, vessels with simple perforation plates, intervascular pitting alternate, rays narrow and heterocellular, xylem parenchyma abundant.

Mangifera indica (Anacardiaceae) – Stem: cuticle thick, cortex with rhombic and prismatic and cluster crystals, tannin cells and cells with granular inclusions, phloem fibres, vessels angular and thin walled both solitary and in short radial multiples, perforation plates simple or a few scalariform intervascular pitting coarse and alternate, rays one or two cells wide and heterocellular, axial secretory ducts lined with thin-walled epithelial cells in phloem and pith.

Nerium oleander (Apocynaceae) – Leaf: cuticle thick, stomata and hairs in pits on abaxial surface, hypodermis, cluster and prismatic crystals, laticiferous canals near to veins. Stems: internal and external phloem.

Oxalis corniculata (Oxalidaceae) – Stem: some epidermal cells containing tannin, complete cylinder of cortical fibres, vessel element perforation plates simple.

Pittosporum crassifolium (Pittosporaceae) – Leaf: cuticle very thick, hairs, stomata paracytic with massive cuticular rim, sunken, hypodermis abaxially and adaxially, phloem poles to bundles disproportionately large, secretory canals of various diameters, cluster crystals.

Plantago media (Plantaginaceae) – Leaf: hairs uniseriate and short, with bicellular head, stomata anomocytic and superficial, epidermal cells with sinuous anticlinal walls.

Plumbago zeylanica (Plumbaginaceae) – Leaf: glandular hairs, stomata, anisocytic, enlarged tracheids at vein ends.

Polemonium coeruleum (Polemoniaceae) – Stem: hairs, stomata slightly raised, outer cortex of rounded chlorenchyma cells, inner cortex collenchymatous, phloem with transverse sieve plates, vessels solitary or paired and diffuse and angular, perforation plates simple and oblique, intervascular pits fine and rounded, rays narrow.

Rubus sp. (Rosaceae) – Stem: cork arising in middle cortex, suberized alternating with unsuberized layers, phloem fibres, primary rays broad, secondary rays 12 cells wide and heterocellular, vessels wide, in radial or tangential multiples, perforation plates simple, intervascular pitting alternate, pith composed of large and small parenchyma cells, cluster and rhombic crystals present in cortex and pith.

Salvadora persica (Salvadoraceae) – Stem: epidermal cells of uneven heights and some raised into mounds, phloem fibres, xylem with included phloem, vessel element perforation plates simple, intervascular pitting alternate.

Sphenoclea zeylanica (Sphenocleaceae) – Leaf: epidermal cells papillate, adaxial palisade chlorenchyma, parenchymatous bundle sheaths, cluster crystals. Stem: cortex with air spaces, phloem fibres, vessel elements with simple perforation plates, intervascular pitting alternate.

Tamarix gallica (Tamaricaceae) – Stem: cork superficial with large cells, phloem fibres, vessels solitary or in small radial multiples, perforation plates simple, rays 13 seriate and conspicuous composed of wide cells, crystal sand and irregular crystals abundant.

Tecoma capensis (Bignoniaceae) – Stem: cuticle thick, hairs unicellular, cork superficial and to outer side of chlorenchyma, cortical fibre caps and strands of phloem fibres alternating with soft tissue, innermost fibres forming interrupted ring, phloem appearing storied, xylem with narrow vessels in solitary or in short radial multiples, vessel walls thick, perforation plates simple and oblique, intervascular pitting coarse and alternate.

Theobroma cacao (Sterculiaceae) – Stem: hairs unicellular and thick-walled, mucilage cavities (canals) in cortex, phloem fibres, vessel elements with simple perforation plates, intervascular pits coarse and alternate.

Some selected softwoods (gymnosperms) in which particular features can be found

Axial parenchyma: *Sequoia*, *Taxodium*.
Bars of Sanio: *Sequoia sempervirens*, *Podocarpus*, *Taxus*.
Helical thickening in mature tracheids: *Juniperus*, *Taxus*.
Pitting (of tracheid to tracheid walls): alternate biseriate – *Agathis palmerstonii*; multiseriate – *Taxodium distichum*; multiseriate alternate – *Araucaria angustifolia*; opposite biseriate – *Sequoia sempervirens*.
Rays, tall (approximately 30 cells): *Abies alba*.
Rays, low (most less than 10 cells): *Juniperus*.
Ray tracheids: *Picea*, *Pinus*, *Larix*.
Resin ducts (axial): *Picea*, *Pinus*.
Resin ducts (radial): *Picea*, *Pseudotsuga*.
Torus margin (irregular): *Tsuga heterophylla*.
Torus margin (scalloped): *Cedrus*.
Window pits: *Pinus sylvestris*.

Some characters in the secondary xylem of selected hardwoods

The descriptions given here supplement the main text, and give examples of some of the features mentioned there. They are not intended to be complete.

Azadirachta indica, Meliaceae: Vessels solitary and in radial multiples, perforation plates simple, intervascular pitting fine; rays 1–4 cells wide, heterocellular; parenchyma vasicentric and in narrow tangential bands; crystals rhombic, chambered, abundant; gum in some vessels.

Buxus sempervirens, Buxaceae: Vessels narrow, mostly solitary, perforation plates scalariform with many bars, oblique; rays l–2 cells wide, heterocellular, marginal cells upright, central cells procumbent; parenchyma diffuse.

Ceiba pentandra, Bombacaceae: Vessels mostly solitary, perforation plates simple; rays up to about 8–15 cells wide, heterocellular; parenchyma vasicentric and in narrow tangential bands alternating with narrow bands of fibres; tannin or resin in many cells, crystals present.

Dipterocarpus alatus, Dipterocarpaceae: Vessels wide, mostly solitary, perforation plates simple, transverse; tyloses present; rays 1–4 or 5 cells wide, heterocellular; parenchyma vasicentric and apotracheal, scattered and in tangential bands; fibres thick-walled; vertical canals with thin-walled epithelial cells set in broad bands of tangential parenchyma .

Dombeya mastersii, Sterculiaceae: Vessels solitary and in short radial multiples, perforation plates simple, intervascular pitting alternate, pits circular; rays 1–4 cells wide, heterocellular; parenchyma aliform to aliform confluent; fibres thick walled.

Eucalyptus marginata, Myrtaceae: Vessels solitary and in radial and oblique multiples, perforation plates simple, tyloses present; rays 1–2 cells wide, heterocellular; parenchyma mostly amphivasal, fibres thick-walled, dense, septate.

Liriodendron tulipifera, Magnoliaceae: Vessels wide, thin walled, in radial, tangential and oblique multiples, occupying most of volume of wood, perforation plates scalariform, oblique, intervascular pits wide, opposite; tyloses present; rays mostly 2–3 cells wide, expanded at growth rings, heterocellular.

Pistacia lentiscus, Anacardiaceae: Vessels in long, radial multiples, some elements much wider than others, perforation plates simple; tyloses present; rays mostly 1–2 seriate, heterocellular, some with secretory canals; some fibres septate.

Pittosporum rhombifolium, Pittosporaceae: Vessels rounded, angular, solitary, or in radial to oblique groups, perforation plates simple, vessels with tails and very fine spirals; rays mainly 3–4 cells wide, heterocellular, some only 1 cell.

Rhododendron sp., Ericaceae: Vessels angular, solitary or in small groups, perforation plates scalariform, with many bars, some spirals present; rays 1–4 cells wide, some only 1 cell.

Robinia pseudacacia, Papilionaceae: Ring porous; wide vessels solitary or in short radial multiples, narrow vessels in clusters, perforation plates simple, transverse, intervascular pits vestured; tyloses present; rays storied, most 4–5 cells wide, more or less homocellular; parenchyma aliform confluent, storied.

Sparmannia africana, Bignoniaceae: Vessels angular, solitary or in short multiples, or in clusters, perforation plates transverse, simple, intervascular pits large, with narrow borders; rays 1–8 or more cells wide, composed of wide cells, heterocellular; rays making up large proportion of wood; fibres sparse.

Tectona grandis, Verbenaceae: Growth rings conspicuous; vessels solitary, in pairs or radial multiples, perforation plates simple, intervascular pitting fine, alternate; tyloses; rays mostly 1–3 cells wide, heterocellular; parenchyma initial and a little vasicentric; fibres septate; deposits in some vessels.