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Tree Anatomy Manual: Twigs

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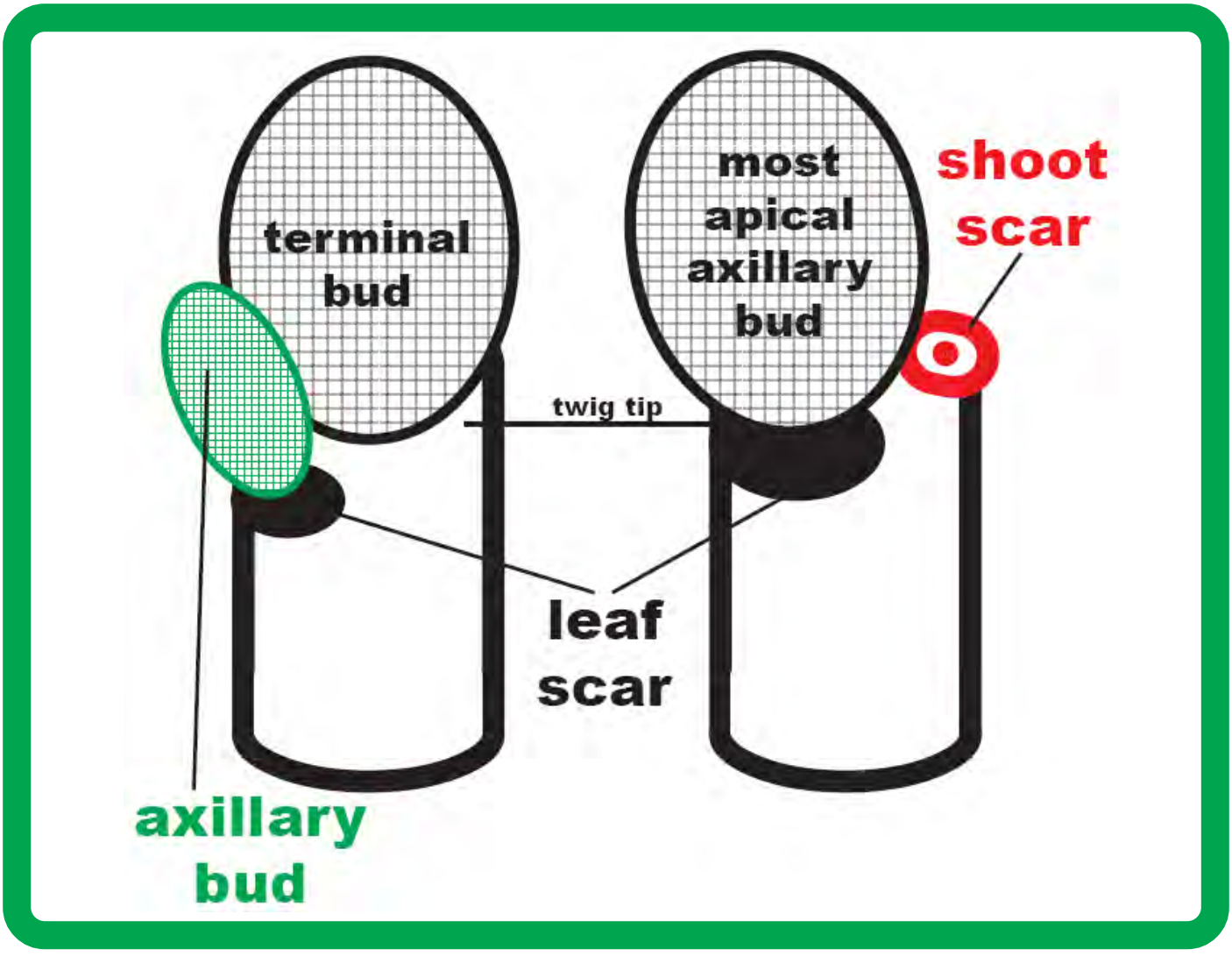

This manual is an educational product designed for helping tree health care professionals appreciate and understand tree twig anatomy and morphology. This product is a synthesis and integration of anatomical and educational concepts regarding macroscopic internal and external tree twig features. This educational manual is for professional development.

At the time it was finished, this manual contained educational materials and models concerning tree anatomy thought by the author to provide the best means for considering basic twig and branchlet anatomy in temperate zone trees. The University of Georgia, the Warnell School of Forestry & Natural Resources, and the author are not responsible for any errors, omissions, misinterpretations, or misapplications stemming from this educational product. The author assumed professional users would have some educational foundation in botanical terminology and tree anatomy. This product was not designed, nor is suited, for homeowner use. Always seek the advice and assistance of professional tree health care providers for any tree growth, heath and structure issues.

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Introduction

Tree anatomy can be as simple as crown, stem, and roots. Some people delve deeper to know leaf shapes, wood architecture names, and root forms. How much tree anatomy should a professional tree health care provider know about trees? Some just want a simple short version – just the facts, while others want excruciating minutia. For most tree specialists, knowing visible tree parts and their scientific names is a mark of a good professional.

What about twigs? There are many details visible on twigs. Some details can help identify trees in Winter, show growth rates, or suggest stress problems. Let's look at twig anatomy in deciduous angiosperms (hardwoods). Evergreen and persistent leaved gymnosperms and angiosperms have twigs used in species and stress identification, but they also include attached leaves, and are not covered here.

Defining Twigs

What is a twig? A twig is the current or most recent growth extension increment at the tips (apical end) of branches. The tip of a twig can be terminated with a primary growing point, usually inside protective bud scales, with potential to increase in length. In some trees, the growing point is actually just behind and to the side of a twig terminal. This side growing point (or false terminal) elongates when the terminal bud or terminal internode is purposely aborted. This growth form may generate a zig-zag shaped twig.

A twig is the current or most recent growing season's extension growth. Figure 1. A tree which presents a host of small twigs all over its crown is called "virgatus" or twiggy. Twigs are usually attached to older "branchlets." A branchlet is a small subdivision of a branch only 2 or 3 years old (2-3 annual growth increments.) Branches are fourth year or older growth increments just behind (more basipetal to) twigs and branchlets. Branches are multiple scale (large, medium, and small) divisions of a tree's main stem.

All subdivisions of a crown, from branches to twigs, can be sealed off from the rest of a tree by a compartmentalization process called cladoptosis, or the natural shedding process (sometimes called natural pruning or self-pruning) in a tree. The smaller each branching subdivision, the greater probability for shedding (i.e. twigs are most likely to be shed than branchlets). Mature trees can shed greater than 30,000 parts and pieces per year, not including leaves and seeds / fruits.

New Shoots

Some people use the generic term "shoot" to include twigs. The scientific definition of a shoot is a single modular twig section with one node, leaf(s), axillary (lateral) growing point(s), and an elongated internode section below. Figure 2. If a shoot is at the end of a twig it would include an apical or terminal growing point. Other names for this kind of shoot is a module, phytomer, or metamer.

Structurally, twigs are made of stacks of shoots with alternating nodes and internodes. Internodes elongate creating the effect called growth. Nodes are non-elongating areas which generate flowers, leaves, buds, and other twig parts. A node can be considered just the localized area where a twig component is generated. Actually, a broader view of a node is comprised of points where new tissues and vascular connections are developed encircling a twig. This is called a nodal torus. A nodal torus circles a twig and reaches slightly above and below node scars (bud, leaf, and stipule). Figure 3.

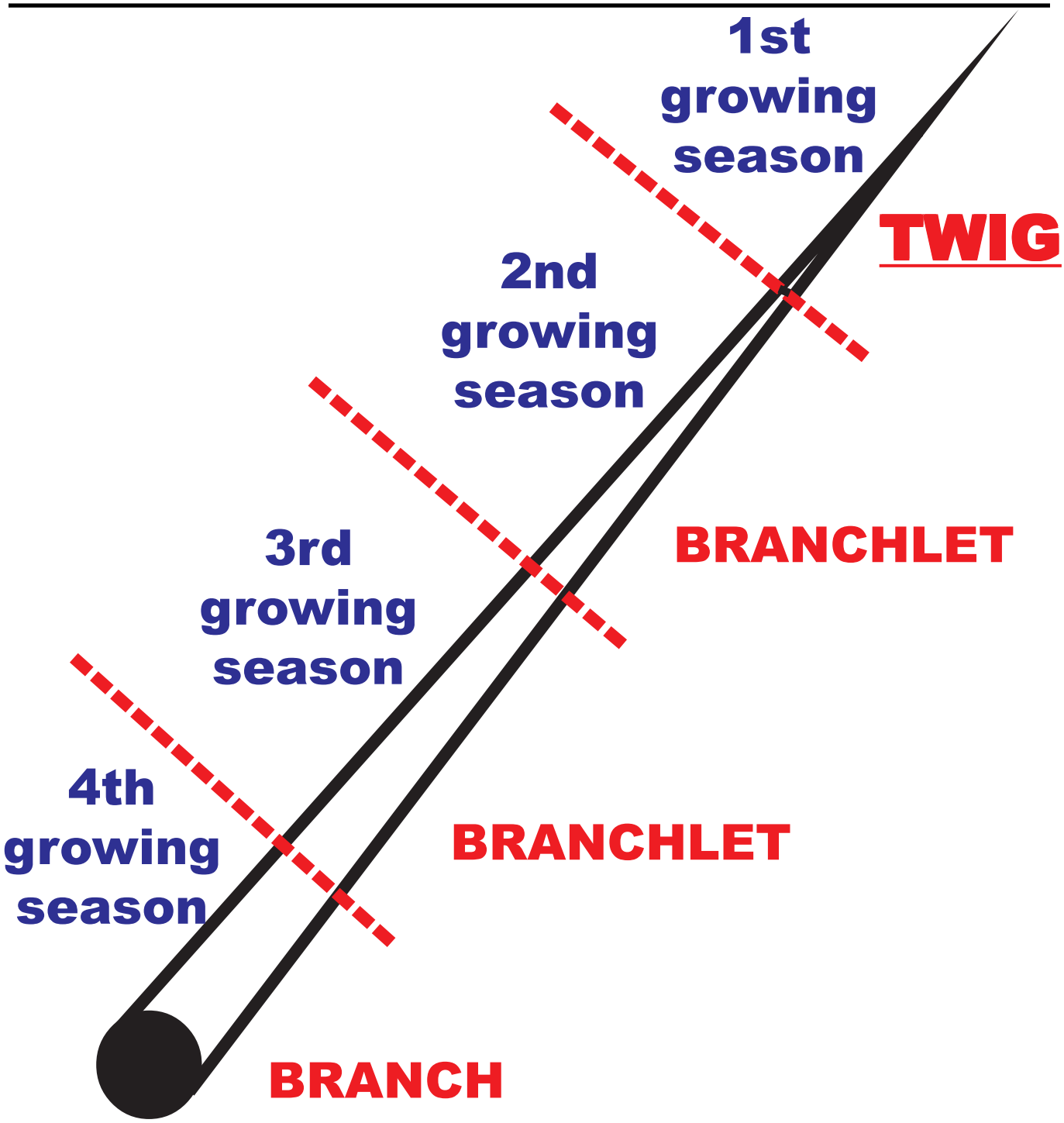


Figure 1: Definition of twigs, branchlets, and branches. Branches are subdivisions of the main stem and are defined in terms of small, medium, and large.

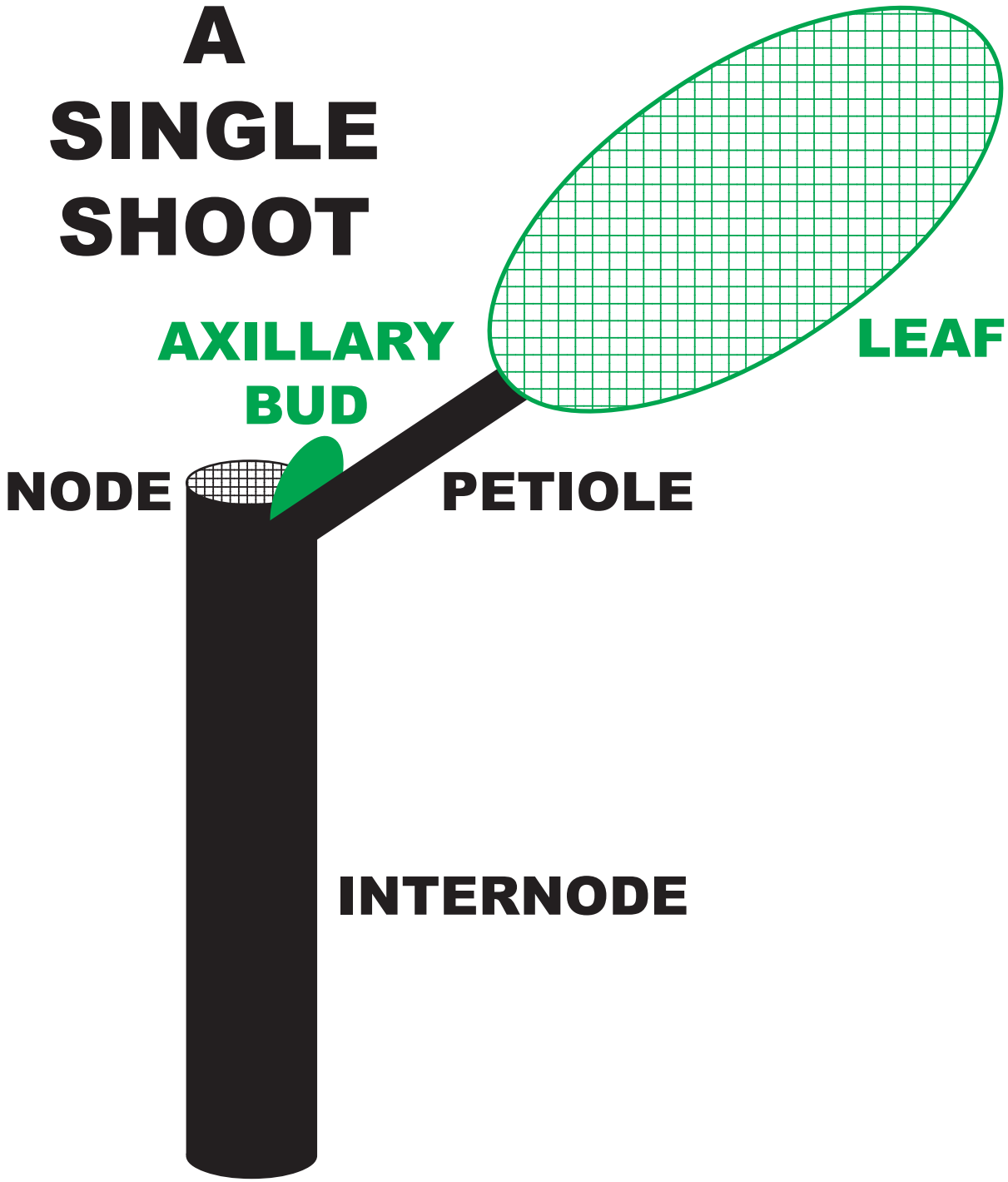


Figure 2: Defining a non-terminal shoot, module, phytomer, or metamer (one modular twig segement). A terminal shoot would also contain an apical growing point.

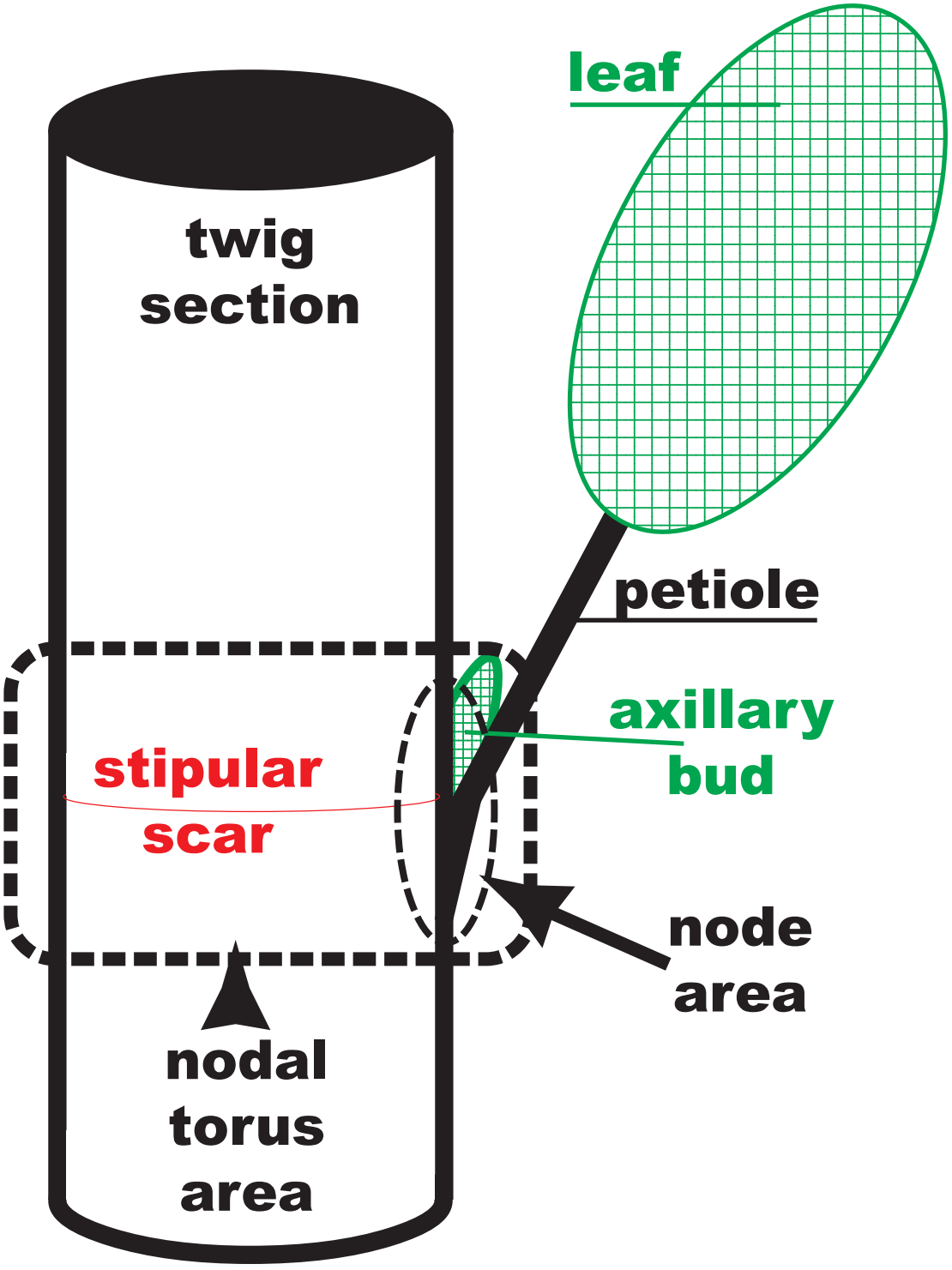


Figure 3: Node and nodal torus locations on twig.

Old Shoots

An older way to describe shoots is any above ground portion of a tree bearing leaves where one annual growth increment is equal to one shoot growth unit. There have been a number of this shoot type identified. Shoots could be terminal shoots or leaders, lateral shoots, or basal shoots. Basal shoots can be divided into coppice shoots generated from suppressed growing points at a stem base, or root shoots (suckers) from adventitious growing points newly formed from the base of, or upper surfaces of, roots.

Shoots within the crown of a tree can also be divided between long, short, and spur shoots. Long shoots have twigs and branchlets with normally elongated internodes. Short shoots have twig and branchlets without or with limited internode elongation. Short shoots come in two forms: determinant short shoots with a functioning terminal growing point; or, indeterminate short shoots without a terminal growing point. In some species, specialized very short shoots are generated called spur shoots, which are slow growing, do not expand internodes, and can be tipped with a spine or a suppressed terminal bud. Spur shoots can generate both leaves and flowers/fruits (termed a brachyblast).

Size & Shape

Twigs come in many sizes. Twig diameter across the last few internodes is used in some tree guides. A twig can be: slender with a diameter <2mm; moderately slender with a diameter 2-4mm; moderately stout with a diameter 4-5mm; stout with a diameter >5mm; or, robust stout which is thick, stiff, and large in diameter. Figure 4.

Twig shape in cross-section is usually considered to be round, but with close inspection, many cross-sectional shapes exist. An angled twig cross-section has distinct sides and corners, and is not round or oval. Some twigs are ridged or fluted with ridges or grooves along their length. Figure 5. Other twigs are round in cross section along the internode and angled at the nodes.

Droopy

Twigs can droop or decline on a tree. Many times this is a specialized trait facilitated by human caused genetic modifications. Three twig descriptions are used to show an increasing level of twig and branchlet drooping: cernuous (drooping); pendant (hanging downward); and pendulous (almost fully hanging down). Figure 6.

Pith

A portion of twig size is composed of a center pith. Pith is a soft cylinder of primary cells along the longitudinal center axis of a twig. Pith is surrounded by a medullary sheath (an encircling cell layer which ray cells do not breach), and structural and vascular tissue (wood). Pith can be thin or thick, and can change size and form (i.e. become thinner and solid) at each node or annual increment. Pith contains live cells which can have chlorophyll (green pith) during the first year of growth. Twigs can also have different cross-sectional shapes of pith. The three primary shapes in cross-section are round (terete), angled (distinct sides and corners), and stellate (star-shaped). Figure 7.

One tree identifying feature of pith is its appearance along its length within a twig. Twigs can have one of five dominant types of pith: 1) solid (homogenous or entire) pith is uniform soft tissues with no cavities or cross walls; 2) diaphragmed (septate) pith is solid with thin cross walls; 3) spongy pith is perforated with holes; 4) excavated pith is hollow or empty; and, 5) chambered (discoid) is an excavated pith with many cross walls. Figure 8.

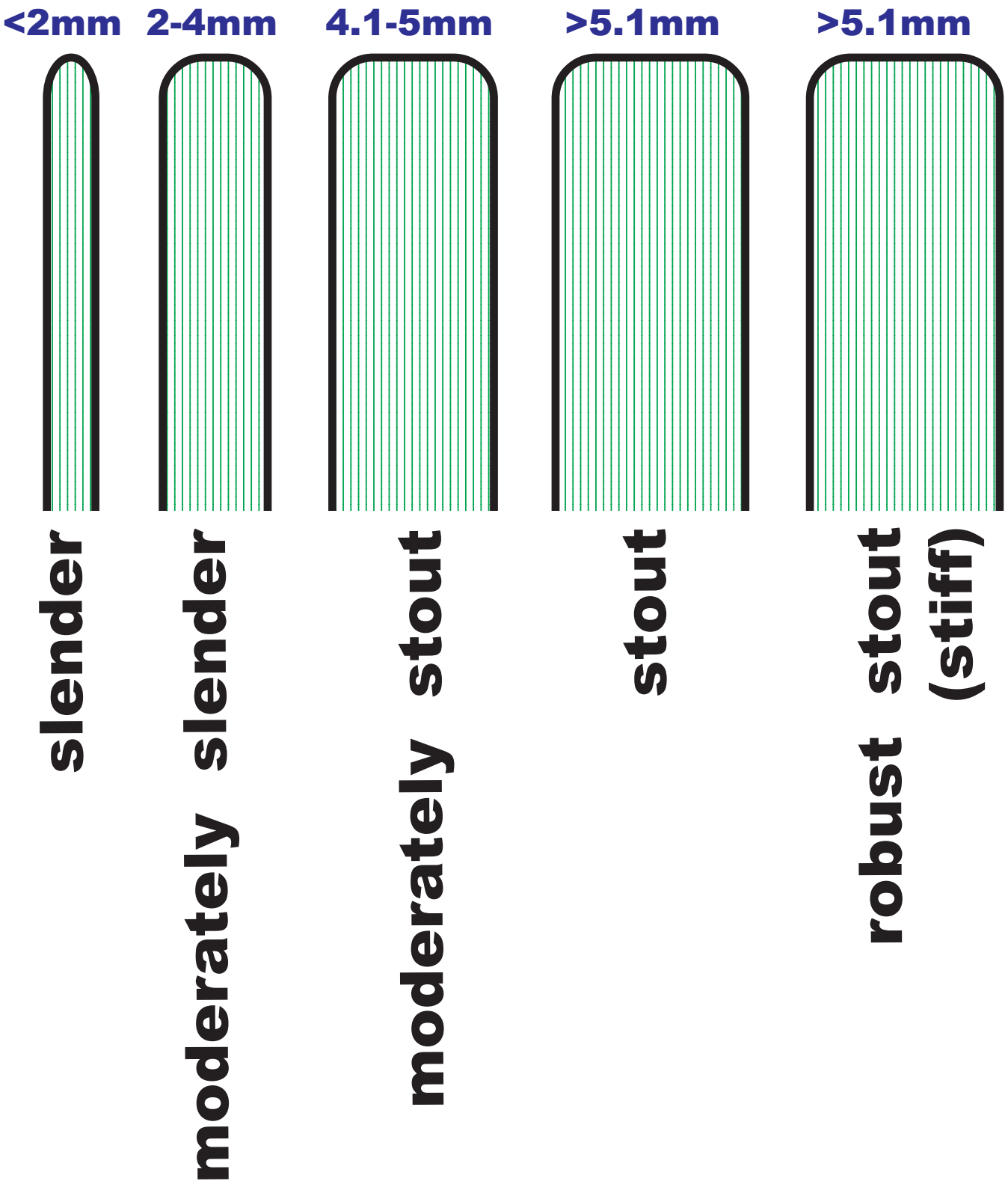


Figure 4: Catagories of tree twig diameter
(relative width scale expanded by five times (5X))

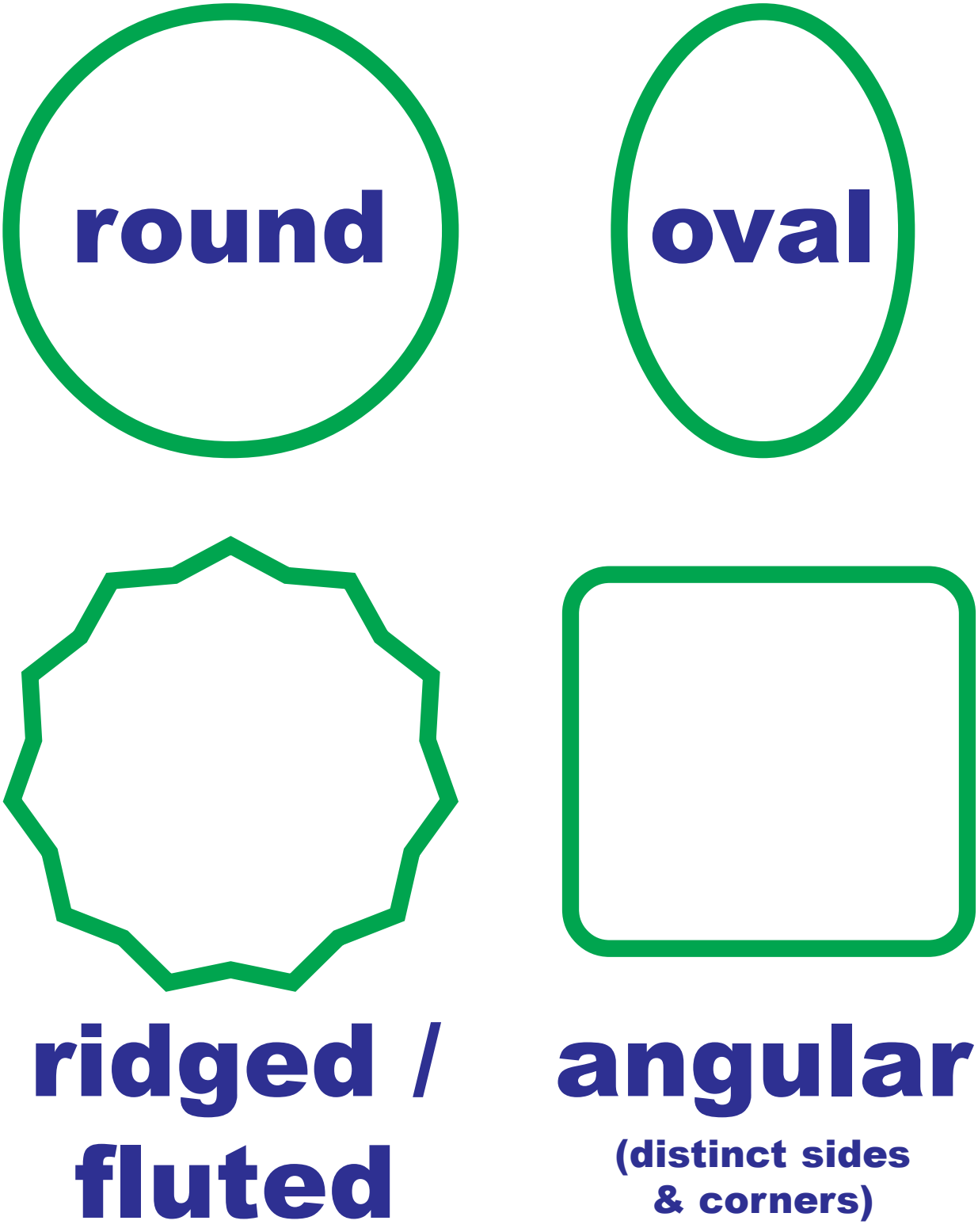


Figure 5: Twig internode cross-sectional shapes. Some twigs are round in internode but angled at nodes.

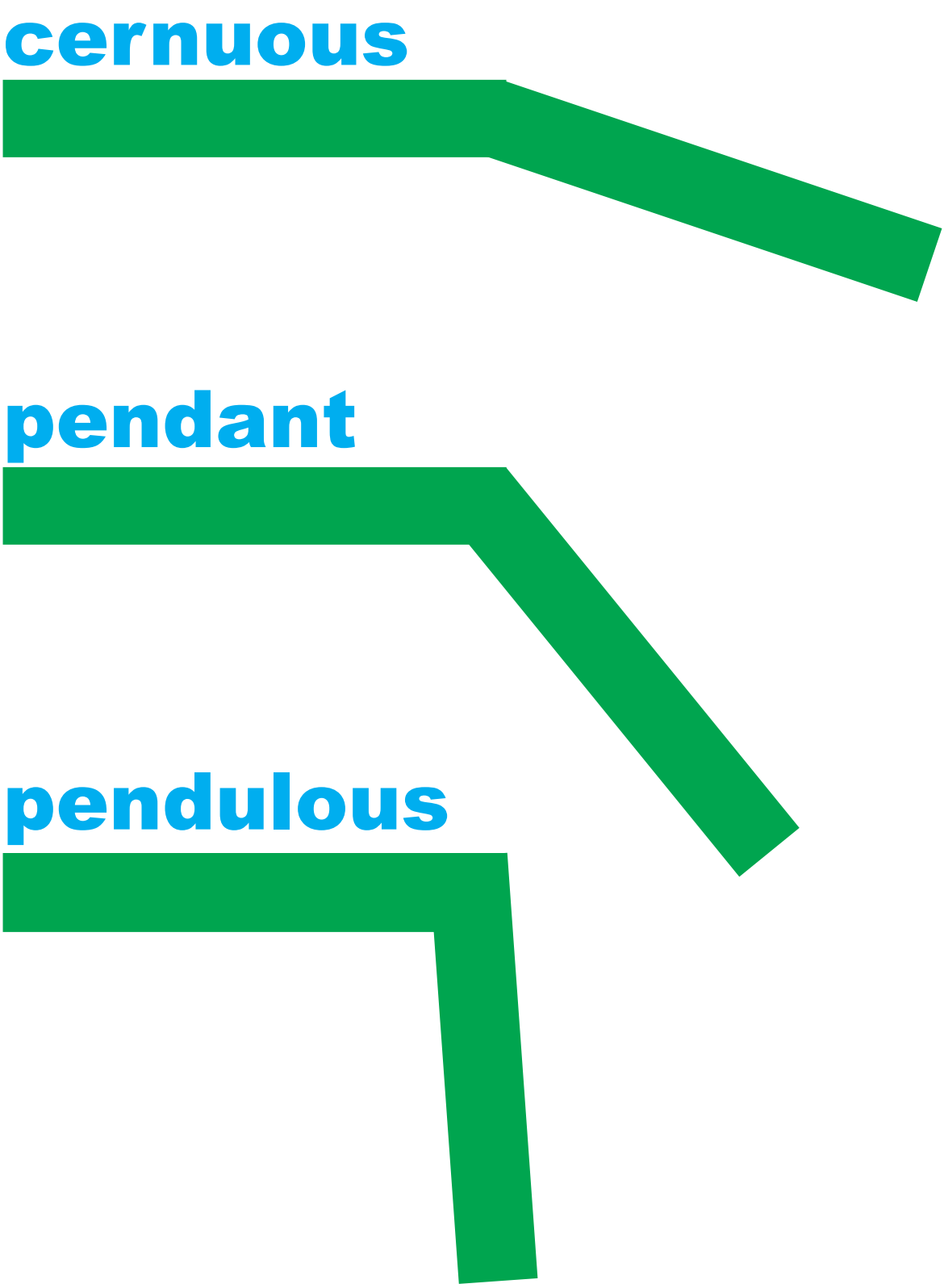
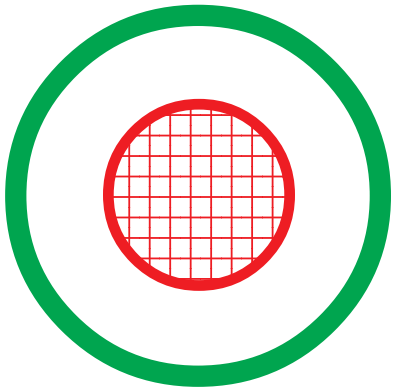
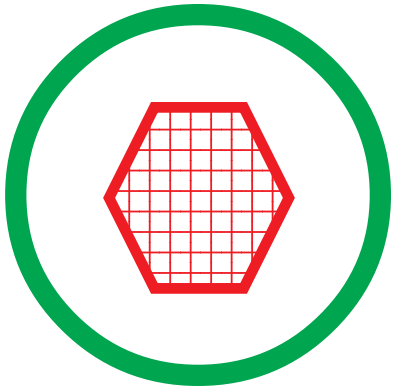


Figure 6: General description of droop (decline) amount in tree twigs, branchlets, and branches.

round
(terete)



angled
(distinct sides & corners)



star-shaped
(stellate)

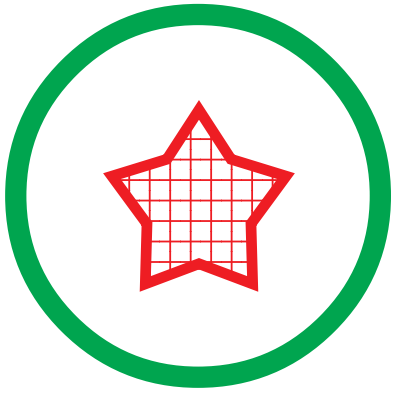


Figure 7: Twig primary cross-sectional pith shapes.

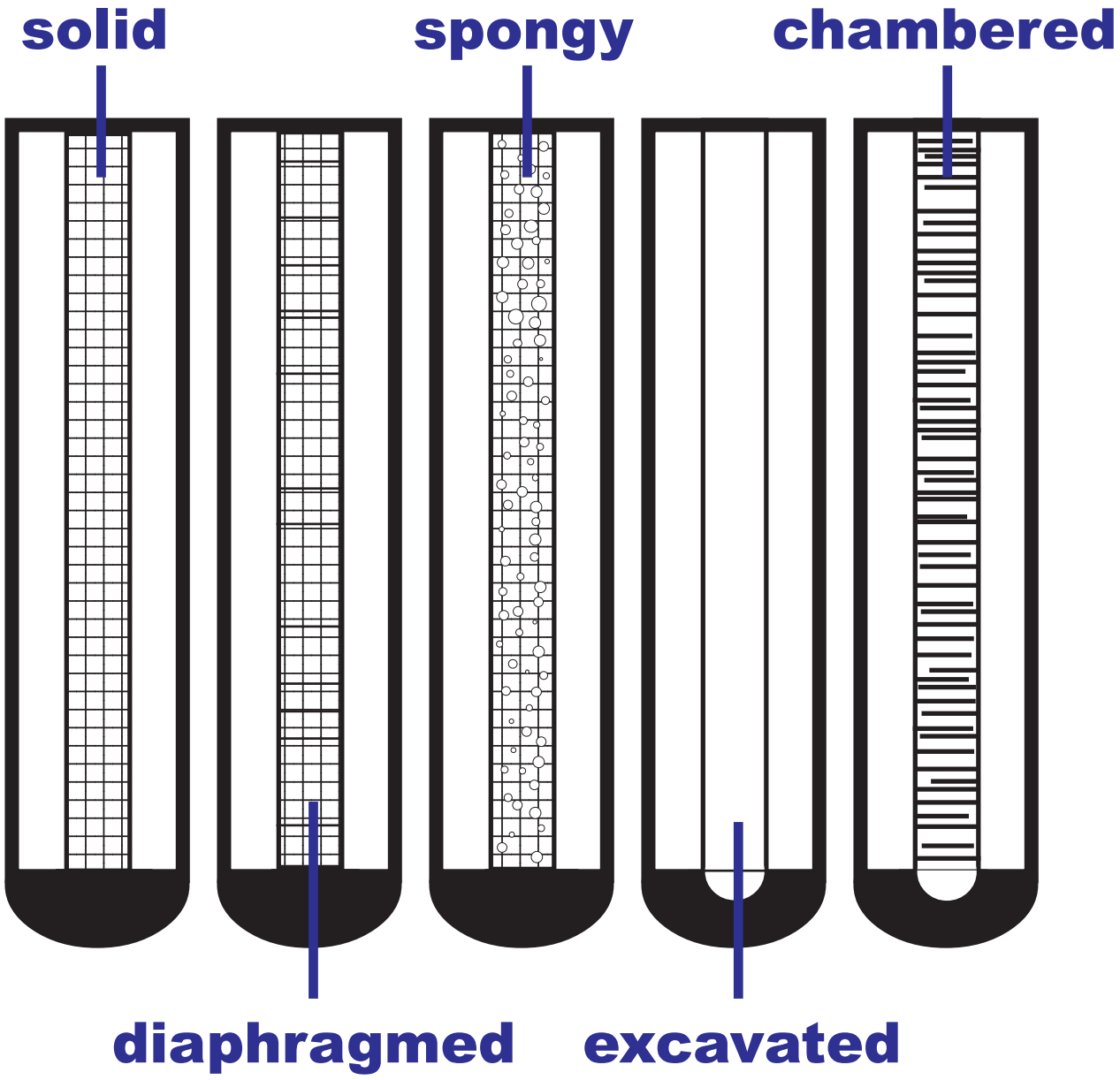


Figure 8: Twig internode pith types.

Stickers

A clear attribute of a twig is its armature (sharp points). Twigs which are unarmed without spines, prickles, bristles or thorns are called inermis or innocuous. Spines are modified parts of a leaf, stipule, or fruit stem. They form sharp points generated from a node. If there are two spines per node, the twig is bicalcarate. Bristles are thin small pointed growths from the epidermis or periderm surface of a twig. Prickle is a generic term for either a spine or bristle. Thorns are modified twigs (axil-derived modified shoot) with a tough pointed end which contains vascular tissue. A spiniferous twig or branchlet generates thorns. A spinescent twig or branchlet generates short spur twigs which resemble thorns.

Growing Out

The exterior of a twig is first covered with a primary tissue called an epidermis. This surface layer covers a primary cortex of simple cells. Once secondary growth begins (expansion in girth), the epidermis may grow to keep pace with stem circumference expansion, or a twig may form a periderm. Periderm is a secondary tissue set generated from a lateral meristem called a phellogen. Phellogen is generated either in small patches or around the entire circumference of a twig. Figure 9.

Bark

As periderm is generated, primary epidermis and primary cortex around the exterior of a twig is crushed and split apart by secondary tissue expansion. A new form of cortex (secondary cortex) is formed made of old phloem and phelloderm tissues intermingling. This secondary cortical tissue usually has chlorophyll and can be seen as a green layer just under corky bark in twigs. The place behind a terminal along a twig where periderm generation begins will cause a change in twig appearance. In many species, the epidermis to periderm transition does not become apparent until second or third year branchlets are reached.

Twigs and branchlets slowly develop periderm beneath epidermis over one growing season or over many growing seasons (some species do not form periderm for 5-8 years). Twig and branchlet periderm is usually cited as smooth, papery, or rough. Smooth periderm has no raised or sunken areas with an appearance color and texture called even, striated (with thin lines), or mottled (multiple color patches). Papery periderm has thin sheets of periderm peeling away from the twig in small flakes, sometimes revealing other colors beneath. Rough twig periderm can be warty (raised projections), scaly (stiff plates curling and peeling away), or furrowed with long ridges, flat rectangles, or square blocks. Figure 10.

Lenticels

All twigs have lenticels. Lenticels are small areas in twig periderm composed of unsuberized, low density, thin-walled cells. Lenticels are initiated above a residual stomate or gas exchange port in the epidermis when a twig begins to expand. Complimentary tissue fill in around and over these gas ports to generate a lenticel.

Twig lenticels can be unique and highly visible, or invisible. Main forms of lenticels are round, longitudinally elongated ovals, or horizontally elongated ovals. Figure 11. Twig lenticel visibility ranges from invisible to a distinct periderm contrasting color. Figure 12. Lenticels can appear at the same surface level as the epidermis or periderm, sunken, or raised. Figure 13. A lenticellate twig would have many distinctly visible lenticels.

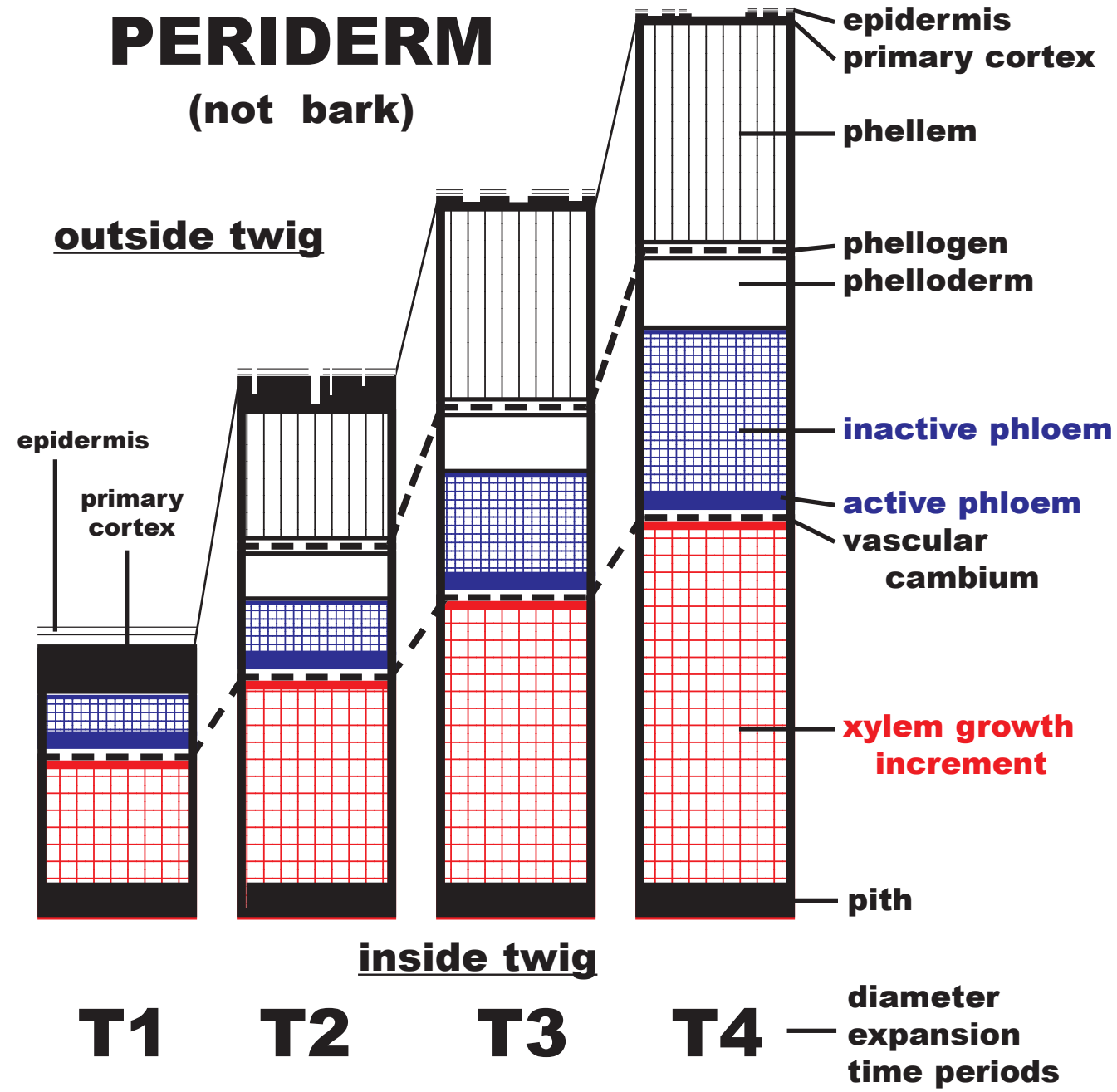


Figure 9: As twig expands in girth (secondary growth), original protective layers (epidermis & primary cortex) are crushed and torn leaving a new protective layer called periderm beneath. Periderm is generated from a phellogen (secondary lateral meristem).
Intermixed phelloderm & inactive phloem areas comprise secondary cortex. Dotted lines are lateral meristems.

E) Epidermis & Primary Cortex
(original protective surface on twig)

- **A) expands with diameter growth**
- **B) cracks / breaks away with diameter growth**

1) Smooth Periderm
(secondary protective layer)

- **A) no raised or sunken areas**
- **B) appearance color and texture**
  1. **even**
  2. **striated (with thin lines)**
  3. **mottled (multiple color patches)**

2) Papery Periderm
(secondary protective layer)

- **A) thin sheets peeling away in small flakes**
- **B) same or different colors revealed beneath**

3) Rough Periderm
(secondary protective layer)

- **A) warty (raised projections),**
- **B) scaly (stiff plates curling & peeling away)**
- **C) furrowed (multiple forms)**
  1. **long ridges or indentations**
  2. **flat rectangles**
  3. **square blocks.**

Figure 10: General description catagories for twig and branchlet exterior protective layer.
(periderm is generated by a lateral meristem)

lenticel shape

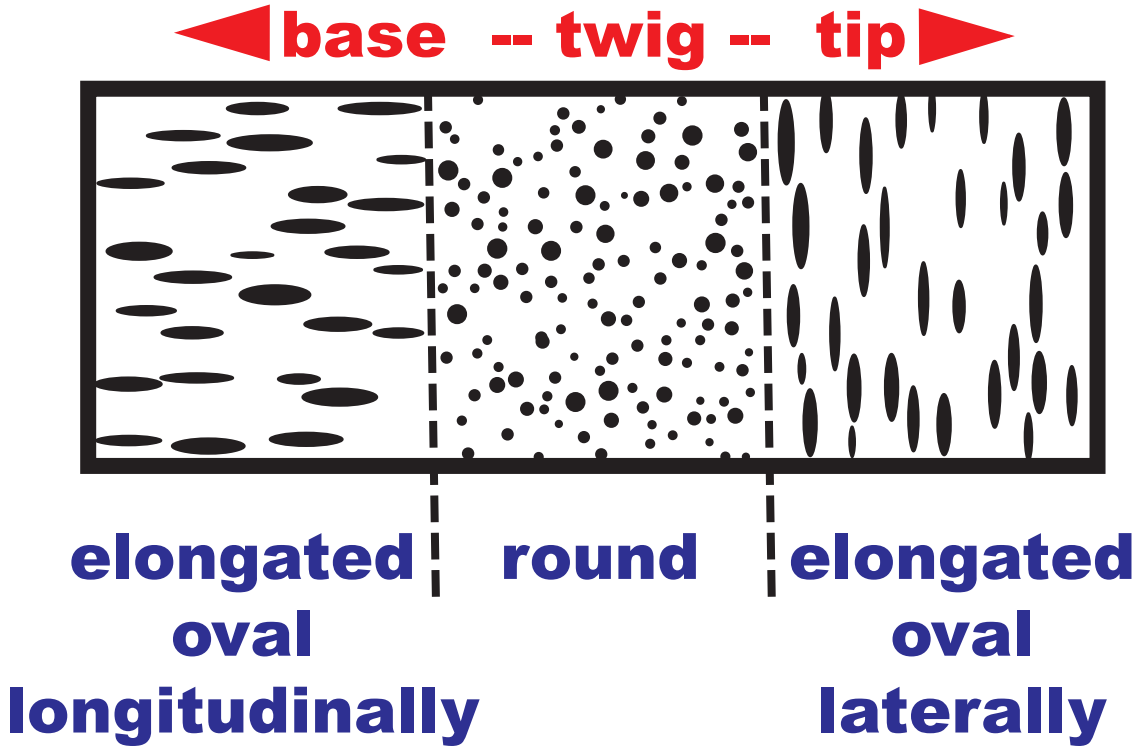


Figure 11: Visible lenticel attribute -- shape.
(not including density, visibility, and size)

lenticel visibility

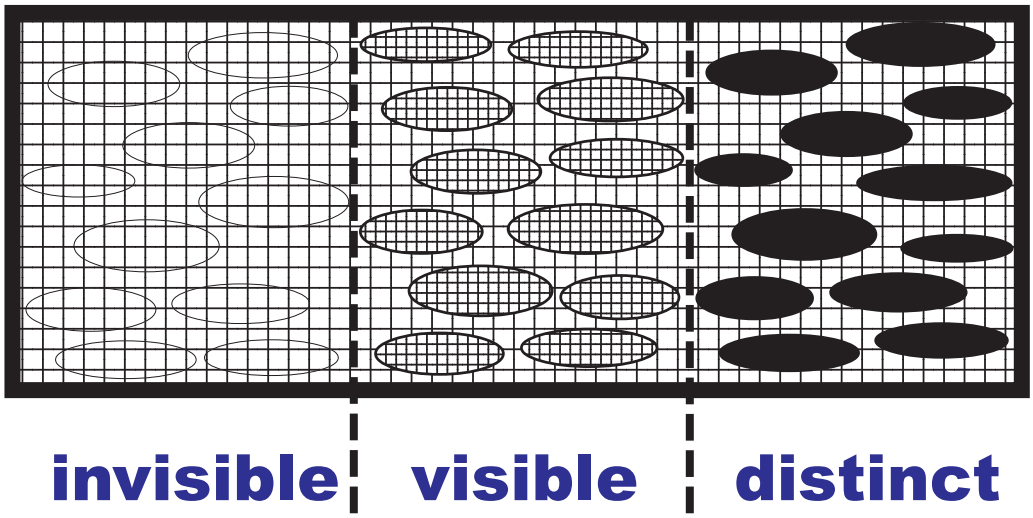


Figure 12: Visible lenticel attribute -- visibility.
(not including density, shape, and size)

lenticel periderm position

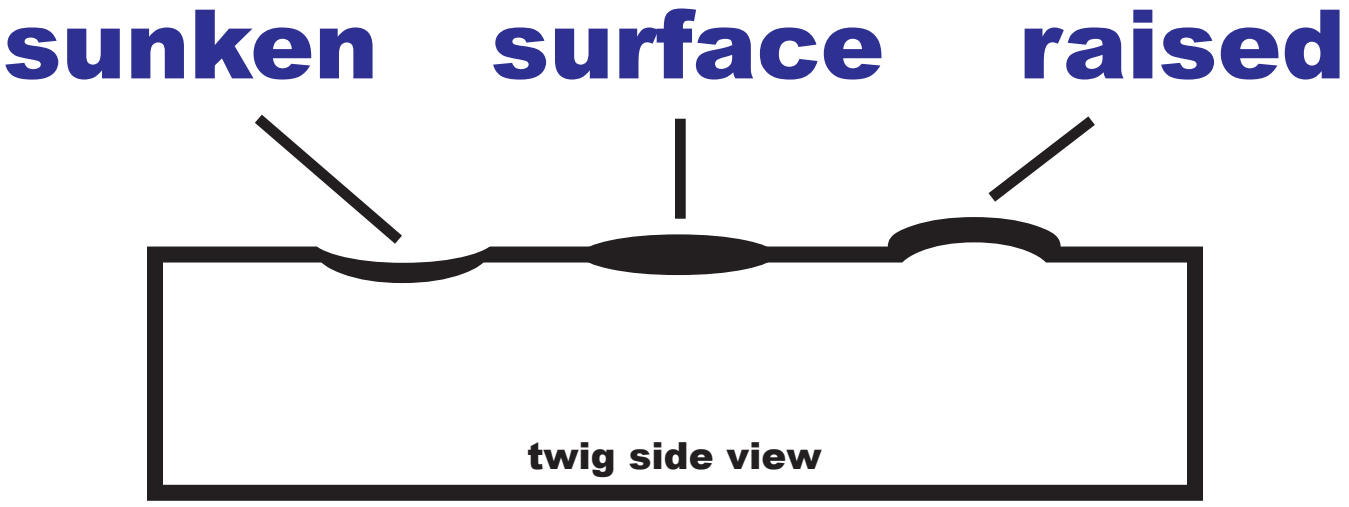


Figure 13: Visible lenticel attribute -- periderm position.

Wings

Some species, and some twigs on some individuals, may generate flat corky growths called wings. If twigs have long, continuous, flat corky wing, then the twig is alate (winged) or ancipital (two-edged or double wing). A twig with scattered areas (discontinuous lengths) of flat corky wings is called pterocaul, or if short lengths of wings are present called pterate.

Coatings

Many terms have been developed to describe twig surface appearance. One set of descriptive terms is for surface coatings. Coatings may have various levels of stickiness, or be various types of wax. Twigs simply sticky or tacky to the touch are said to be glutinous, while thickly sticky is a viscid surface. Viscidulous means a slightly sticky twig surface. Most species do not have noticeably sticky twigs. Do not mistake animal derived product (like honey-dew from aphids) accumulation for normal twig surface conditions.

Twigs can have unique wax coatings. A "bloom" is a waxy coating which is light colored compared to the twig surface. Glaucous denotes a light colored white or bluish wax surface layer. Glaucescent is a thin, slight covering of a light colored white or bluish wax surface. A blue-gray wax coating is called caesious. A frosted appearing wax coating on a twig is called pruinose.

Hairy

Plant hairs are called tricombes, and are generated from the outermost or second outermost living layers of cells around the circumference of a twig. They are an anatomical equivalent to root "hairs." Any or all twig surfaces and bud surfaces, may have the same or different tricombes, or none at all. Twig tricombe presence or absence, and tricombe type, help differentiate tree genera and species. A glabrous twig has no tricombes. A pubescent twig is generic jargon for a twig with some type of tricombes (pubescent does have a more precise tricombe definition).

Twigs with tricombes are described by one or more terms for tricombe types. There are many tricombe density (densely wooly to sparse), stiffness (stiff to soft), length (long to minute), shape (straight to star-shaped branched), texture (coarse to silky), and form (flat scales to bristly) combinations which any twigs could possess. Tricombes also provide a twig with a scurfy surface, which is many short, fat, fragile, scaly tricombes. There are many more accurate and precise descriptive terms used for tricombes covering the surface of twigs other than "hairy." Figure 14.

Buds

One of the most noticeable features of a twig are buds. Buds are compound protective devices used to shield growing points during non-growth period. A growing point is meristematic tissue capable of generating nodes and expanding internodes, generating leaves and flowers/fruit, and/or bud scales. Buds are composed of a growing point, developing tissues (leaves, flowers, or both), unexpanded primordial internodes, compacted primordial nodes, additional primordial lateral growing points, and bud scales (waxed paper-like coverings). Figure 15. Bud scales (cataphylls) are modified leaves or immature bracts which cover all or part of a growing point and associated tissues.

Buds are usually described by their position. Bud positions include terminal buds (at tip or apical end of twig), and pseudoterminal buds (the most apical axillary bud beside a terminal twig scar [improperly called a terminal branch scar]). Terminal bud abortion and generation of a pseudoterminal

tricombes general description	number of different terms used	one example term
very short - soft	5 descriptors	farinose
very short - stiff	5 descriptors	scabrous
short - soft	7 descriptors	pubescent
short - stiff	10 descriptors	strigose
medium length - soft	6 descriptors	downy
medium length - medium soft	4 descriptors	pilose
medium length - stiff	4 descriptors	setose
long - soft	13 descriptors	silky
long - stiff	2 descriptors	hirsute

Figure 14: Example showing complexity of descriptors for twig surfaces with hair-like or bristle-like tricombes. Given are general physical tricombe description catagories, number of different terms used commonly in catagory, and an example term from the catagory.

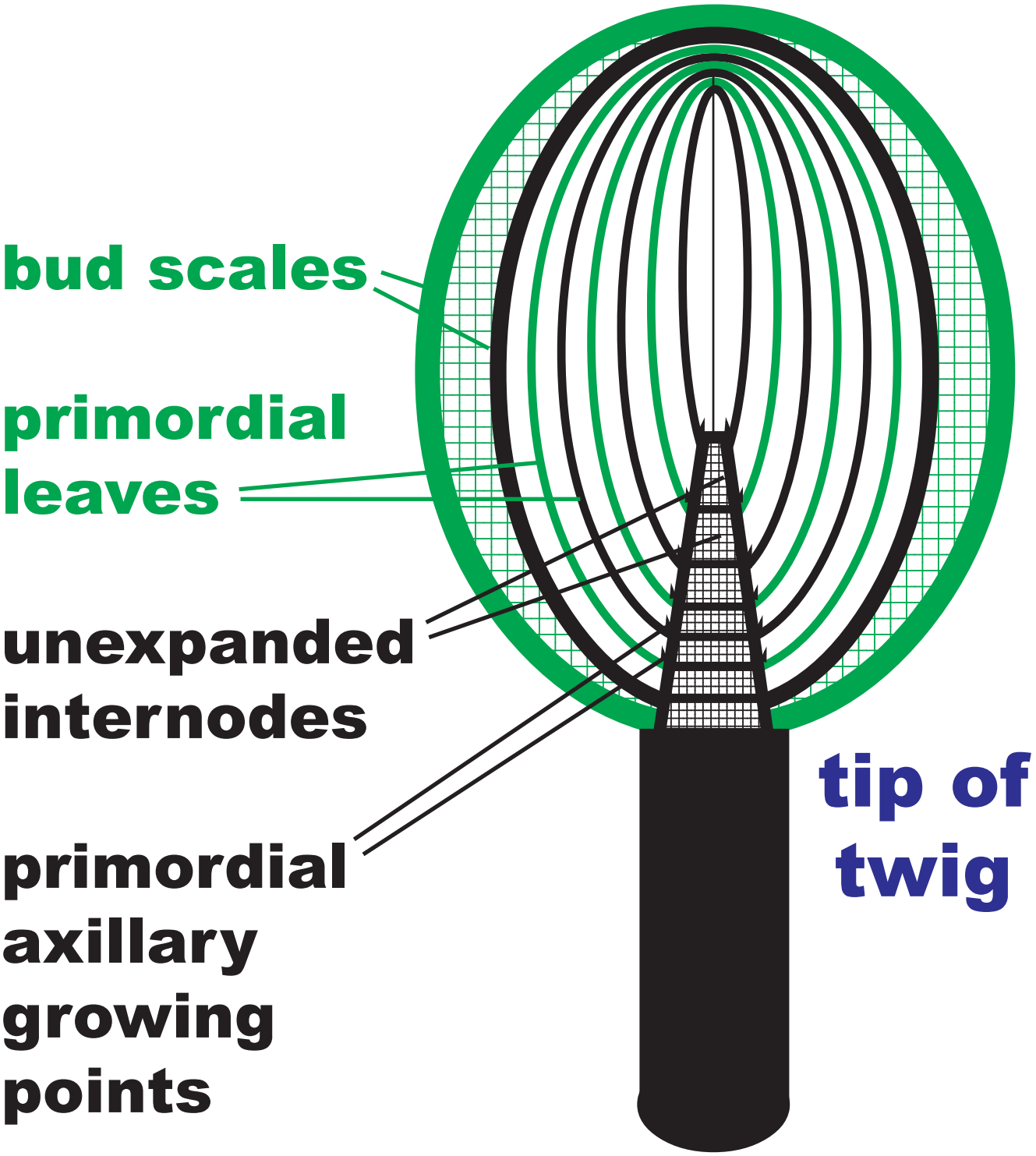


Figure 15: An idealized cross-sectional view of a terminal vegetative bud at the end of a twig. Note bud scales, unexpanded leaves and internodes, and axillary growing points.

bud, or false terminal bud, can generate a zig-zag appearance to a twig and branchlets. This growth form is called flexuose or geniculate.

More Buds

Other bud positions in addition to terminal / pseudoterminal include axillary, extra-axillary, and accessory. Axillary buds (also called suppressed or lateral buds) are located at the base of a leaf, or in a leaf axil (on a twig in the area between the twig surface and leaf base). Extra-axillary buds are formed anywhere else but in a leaf axil or in a terminal position. Accessory buds are additional buds clustered around a primary axillary bud within the same node (nodal torus). Accessory buds can be found in two forms -- a superposed accessory bud position occurs just above and below an axillary bud, and a collateral accessory bud position occurs to either side of an axillary bud. Figure 16.

Buds vary in how they are held on a twig – on the surface, sunken or submerged, or held up on a pedestal or peg. Buds can appear to be tightly grown against a twig surface (appressed) or more loose or open. There are a number of descriptive bud shapes ranging along gradients from: round end or pointed end; long to short; narrow (thin) to wide (fat); cone to oval to round overall shape; and, stalked base to sessile base. Figure 17. Naked growing points (sometimes called naked buds) are without protective scales but can be covered with primordial leaves and tricombes.

Scales

On twig buds, covering buds scales occur in different forms including: absent (i.e. naked bud), a single scale covering, two ranked (paired overlapping scale covering), valvate scales (two non-overlapping scales), or imbricate scales (several alternating and overlapping scales). Bud scales can be smooth, covered with tricombes, or striate (with distinct lines or ridges). Bud scale edges are classified as entire (smooth) or fringed. Fringed (fimbriate) bud scale edges can have fine short tricombes (ciliate), fine minute tricombes (ciliolate), or widely spaced tricombes (ciliatulate). Figure 18.

Twig Scars

For many tree specialists, tree identification surrounds scar (cicatrix) locations on a twig. A cicatrix (plural is cicatrices) are visible periderm disruptions after the abscission or removal of an organ. These visible scars represent former positions of twig structures which abscised, and includes leaf, stipule, shoot, flower, or fruit. General types of twig cicatrices would include leaf scars, inflorescence scars, stipule scars, bud scars, and terminal bud scars. As any twig part dies or falls off, residual disruption in periderm tells many things about past anatomical positions.

Leaf Scars

Leaf, petiole, or rachis cicatrices (generically called leaf scars) remain visible on a twig when leaves fall. Leaf positions on a twig, and hence leaf/petiole/rachis scar position on a twig, are divided into a number of types. Leaf scar position types include alternate, opposite, subopposite, and whorled. Figure 19. Within each position type there are sub-categories.

Leaf scar position types include: Figure 20.

A) alternate - one leaf scar per node (nodal torus).
   1) distichous alternate - leaf scars one per node with every other subsequent scar on the same side (two-ranked along twig).

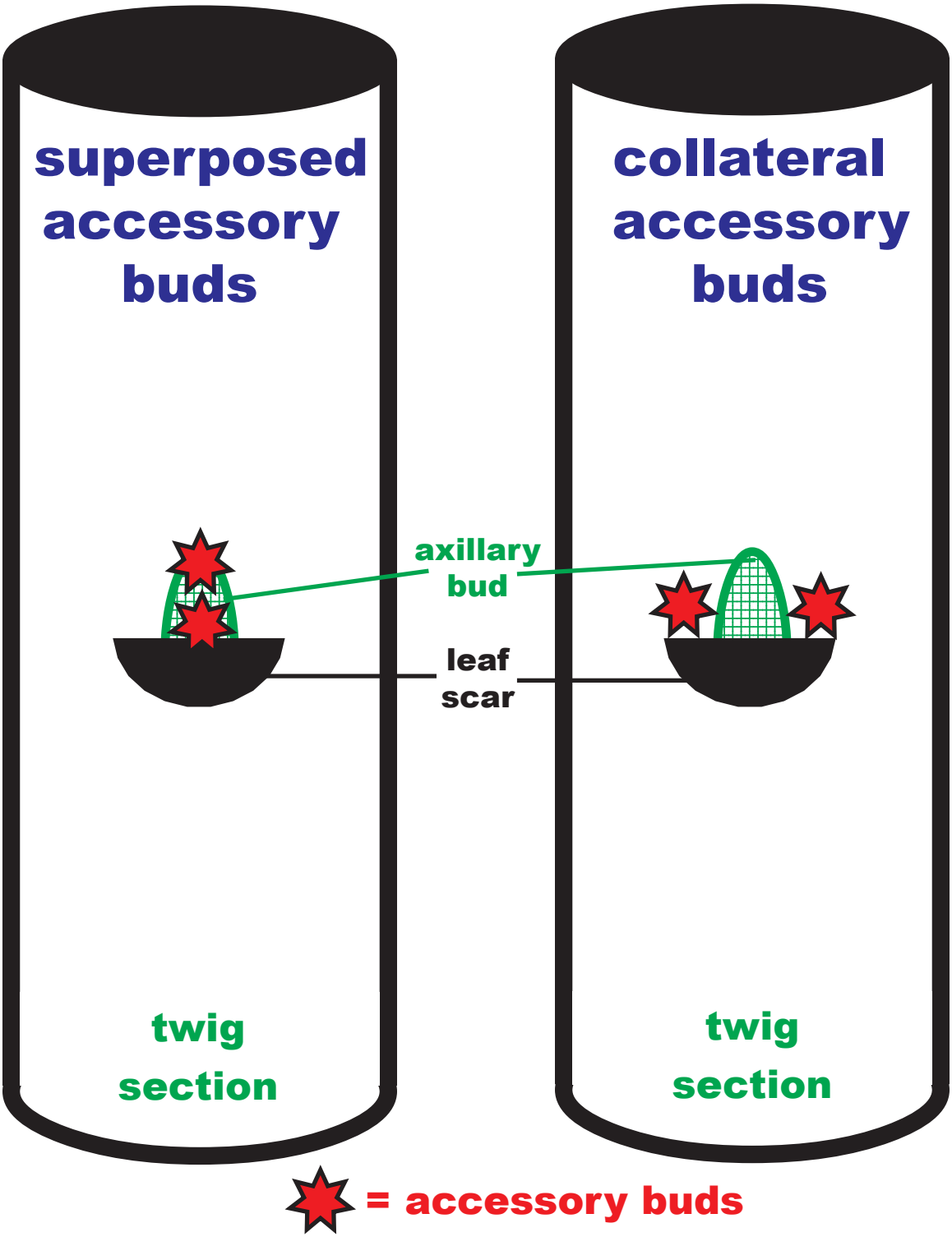


Figure 16: General accessory bud locations within the same nodal torus around an axillary bud.

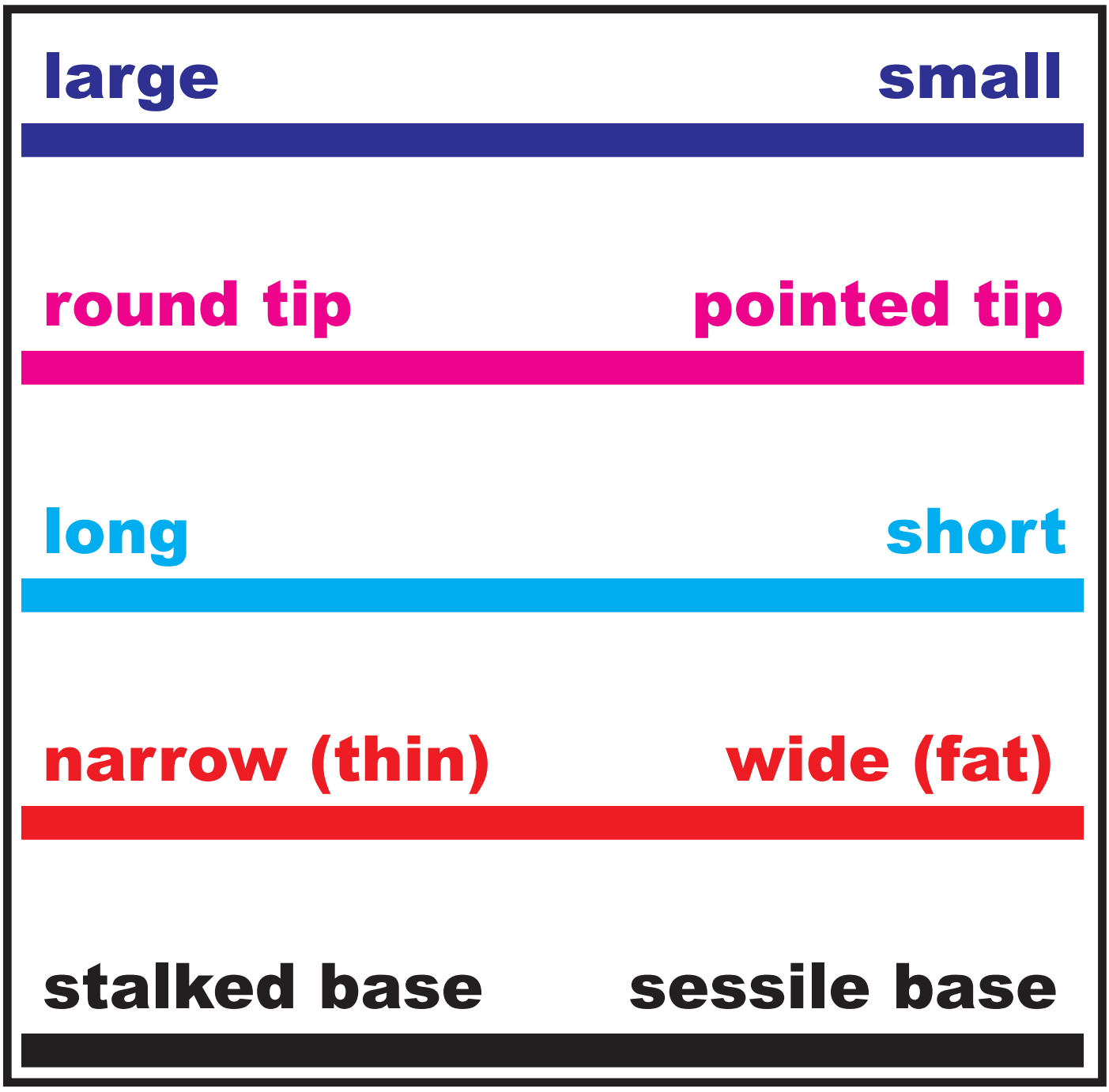


Figure 17: Primary lateral (axillary) bud shape ranges.

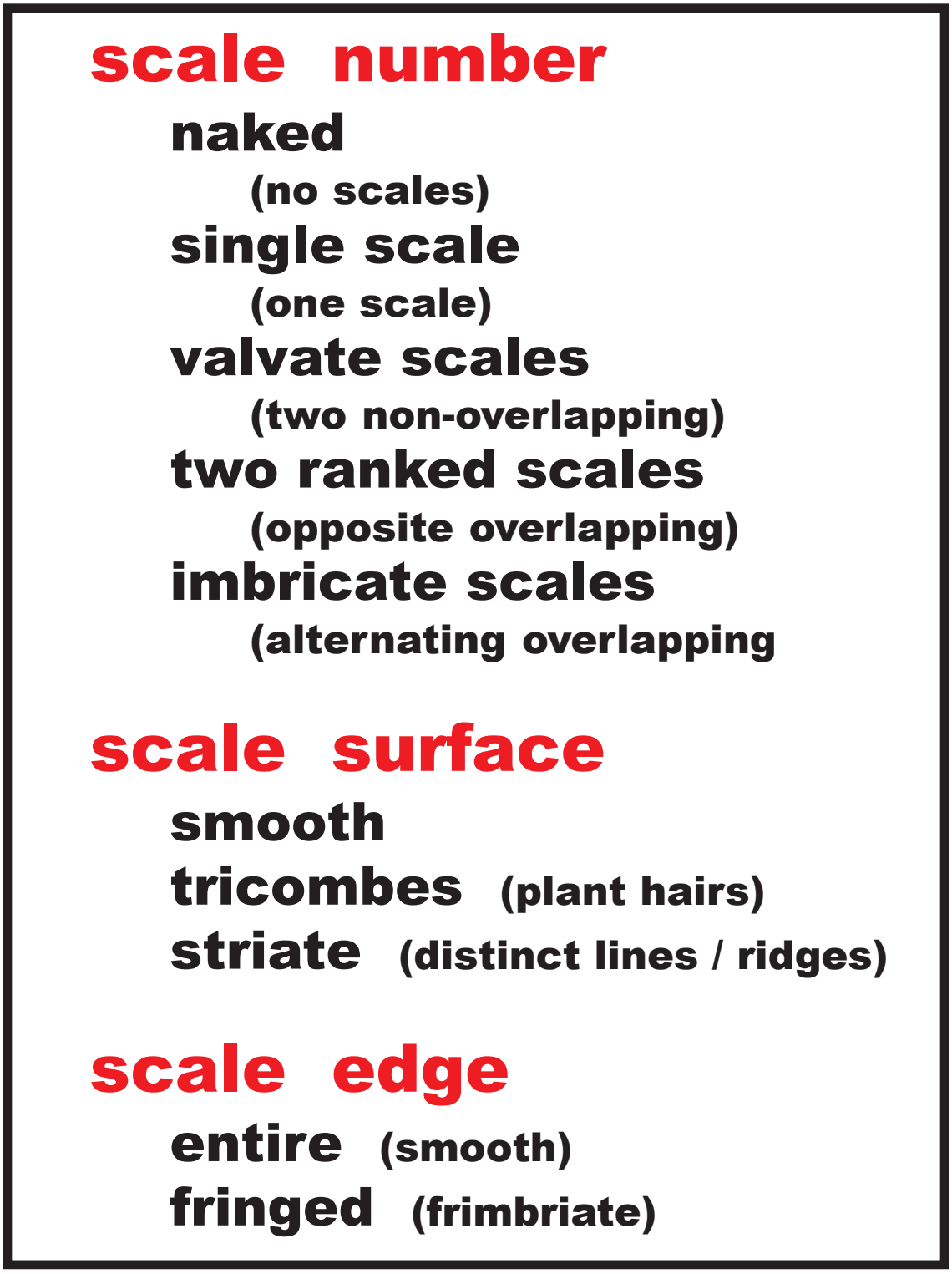


Figure 18: Bud scale attributes.

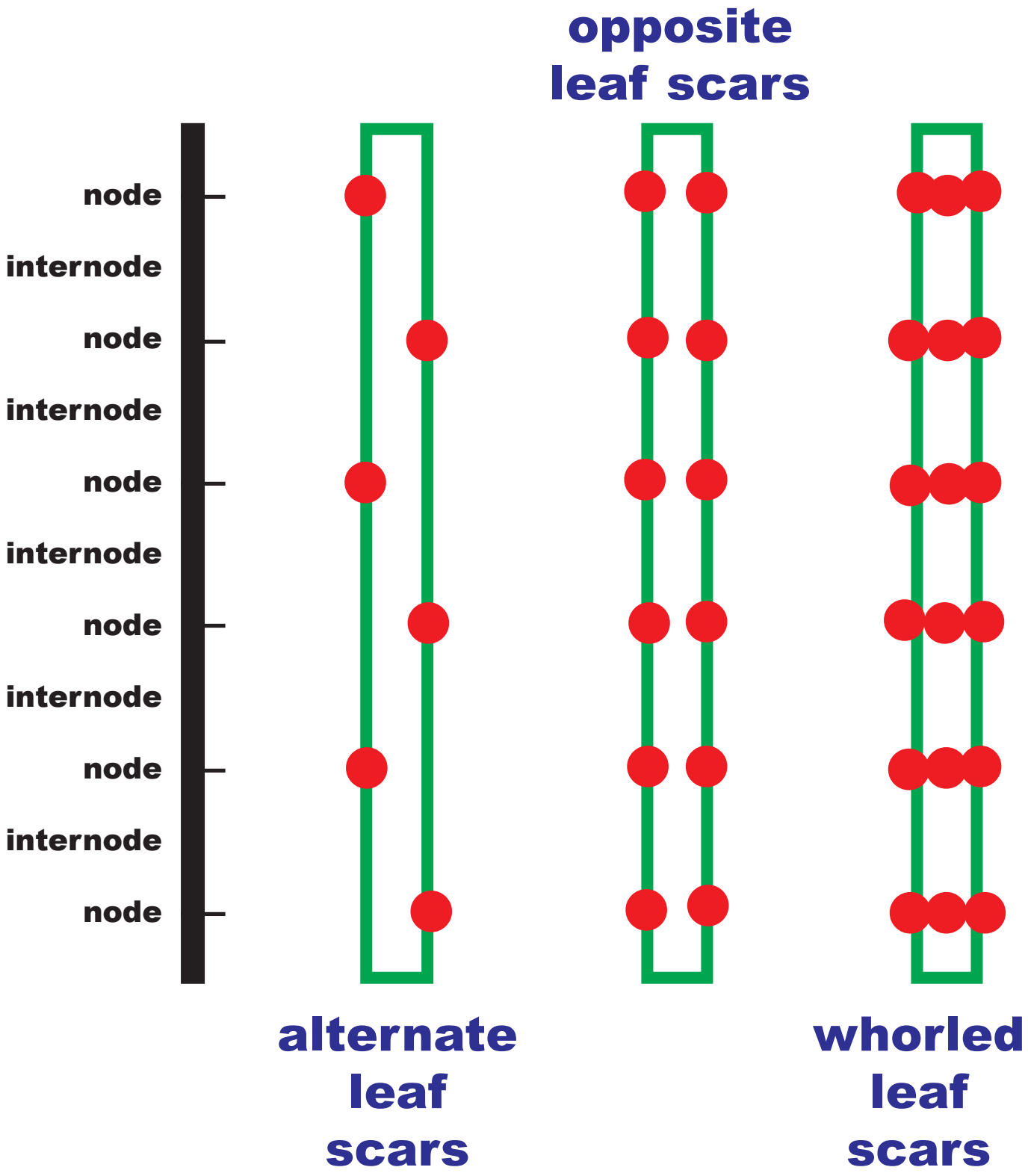


Figure 19: Primary twig leaf scar location forms.
(subopposite form not shown)

A) *alternate* - one leaf scar per node (nodal torus).

1) ***distichous alternate*** - leaf scars two-ranked.
2) ***helical alternate*** -
   a) ***dextrose*** - leaf scars right hand spiral to tip.
   b) ***sinistorse*** - leaf scars left hand spiral to tip.

B) *opposite* - two leaf scars per node (nodal torus).

1) ***decussate opposite*** - leaf scars perpendicular to previous & next pair.
2) ***distichous opposite*** - leaf scars alined with previous & next pair (two ranked).
3) ***spirodecussate opposite*** - leaf scars not perpendicular or in-line with previous & next pair.

C) *subopposite* - two leaf scars per node (nodal torus), but each scar not exactly opposite the other.

1) ***decussate subopposite*** - leaf scars perpendicular to previous & next pair of leaf scars.
2) ***distichous subopposite*** - leaf scars alined with previous & next pair of leaf scars (two ranked).
3) ***spirodecussate subopposite*** - leaf scars not perpendicular or in-line with previous & next pair.

D) *whorled* - three or more leaf scars per nodal torus. [called verticillate]

1) ***eucyclic whorled*** - same number of leaf scars in each nodal torus.

Figure 20: Leaf scar (leaf / petiole / rachis) position types.

2) helical alternate - leaf scars spiral around twig one per node
   a. dextrose - leaf scars in right hand spiral toward twig tip.
   b. sinistorse - leaf scars in left hand spiral toward twig tip.

B) opposite - two leaf scars per node (nodal torus).
   1) decussate opposite - two leaf scars per node placed perpendicular to previous and next pair of leaf scars.
   2) distichous opposite - two leaf scars per node alined with previous and next pair of leaf scars (two-ranked along twig).
   3) spirodecussate opposite - two leaf scars per node not perpendicular or in-line with the previous and next pair of leaf scars.

C) subopposite - two leaf scars per node (nodal torus) but each scar not exactly opposite from the other.
   1) decussate subopposite - two nearly opposite leaf scars per node placed perpendicular to previous and next pair of leaf scars.
   2) distichous subopposite - two nearly opposite leaf scars per node alined with the previous and next pair of leaf scars (two-ranked along twig).
   3) spirodecussate subopposite - two nearly opposite leaf scars per node not perpendicular or in-line with previous and next pair of leaf scars.

D) whorled - three or more leaf scars per node (nodal torus): [called verticillate]
   1) eucyclic whorled - same number of leaf scars in each nodal torus.

The arrangement of scars show growing season leaf arrangement (alternate, opposite, subopposite, or whorled) and leaf position (raised or protruding petiole base, normal, or sunken / crater). There are a host of leaf petiole scars which can be identified to genus or species, along with other scars. Leaf base / petiole / rachis scar shapes include thin crescent (falcate or sickle-shaped), broad crescent, shield, half round, circular, oval, triangular, 3-lobed, heart, V-shape, U-shape, and horseshoe. Figure 21.

Bundled

Within each leaf base / petiole / rachis cicatrix are bundle scars (also called leaf traces in newly removed leaves) These are remnants of broken lines of vascular tissue which served a leaf. Bundle scars can range from clearly visible, minute and not individually visible but can form visible lines, clumps or groups, or not visible. Some bundle scars can be highly informative as to tree species.

Tree twig bundle scars most commonly present include: not visible (most species); obscured by surrounding tissue; 1-5 individual bundle scars; many minute bundle scars appearing as one; and, a single U-shape. Figure 22.

Stipules

Some tree species have twigs with stipule scars. These cicatrices are visible periderm disruptions from where stipules fell. Stipules are paired or single fused growths on a twig from near the base of a leaf petiole, sessile leaf, or rachis. Stipules are modified leaves. Stipules vary in appearance by species, and can be small leaf-like blades, bud scale-like growths, or spine-like points. They leave either a thin

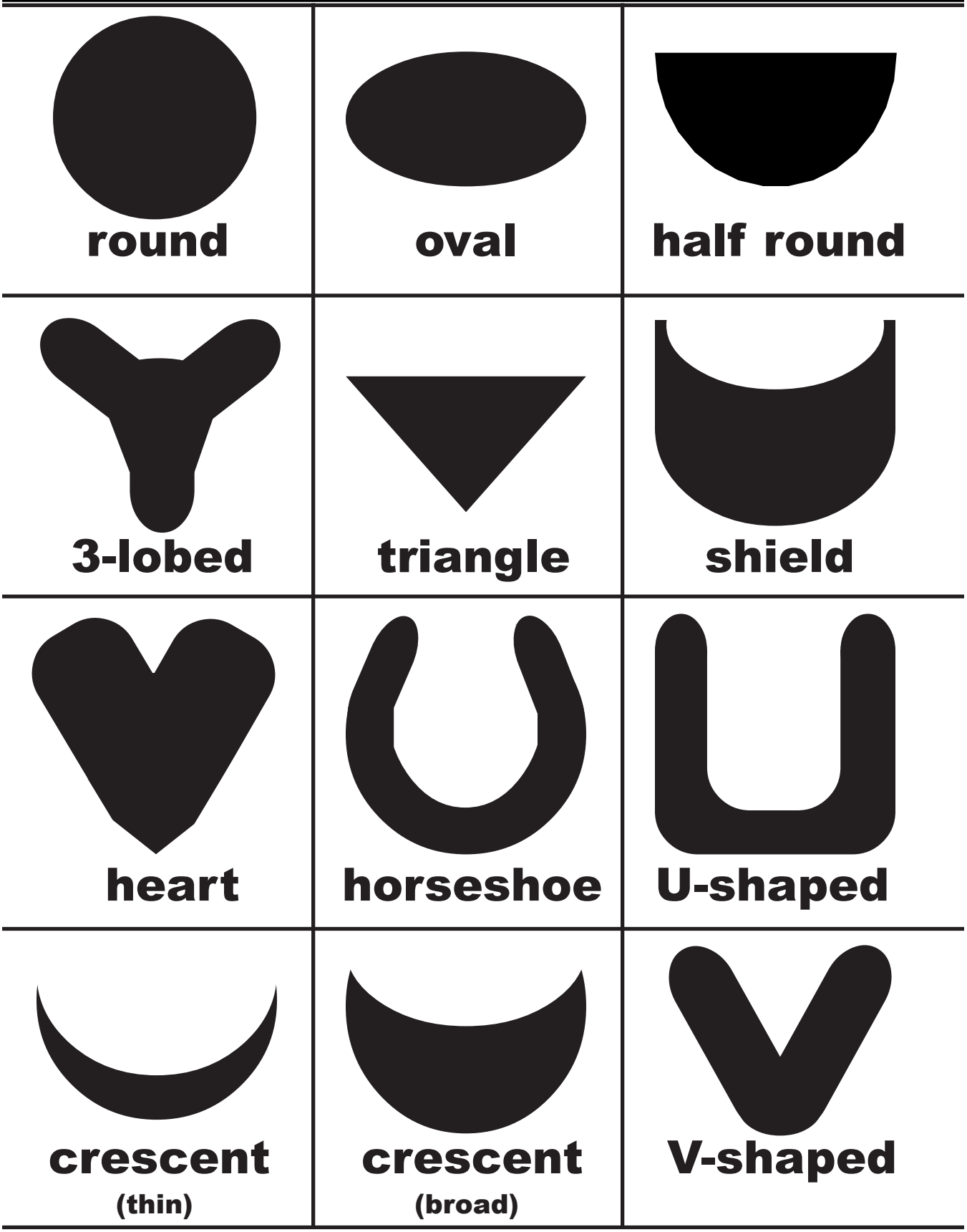


Figure 21: Twelve general tree twig leaf scar shapes.

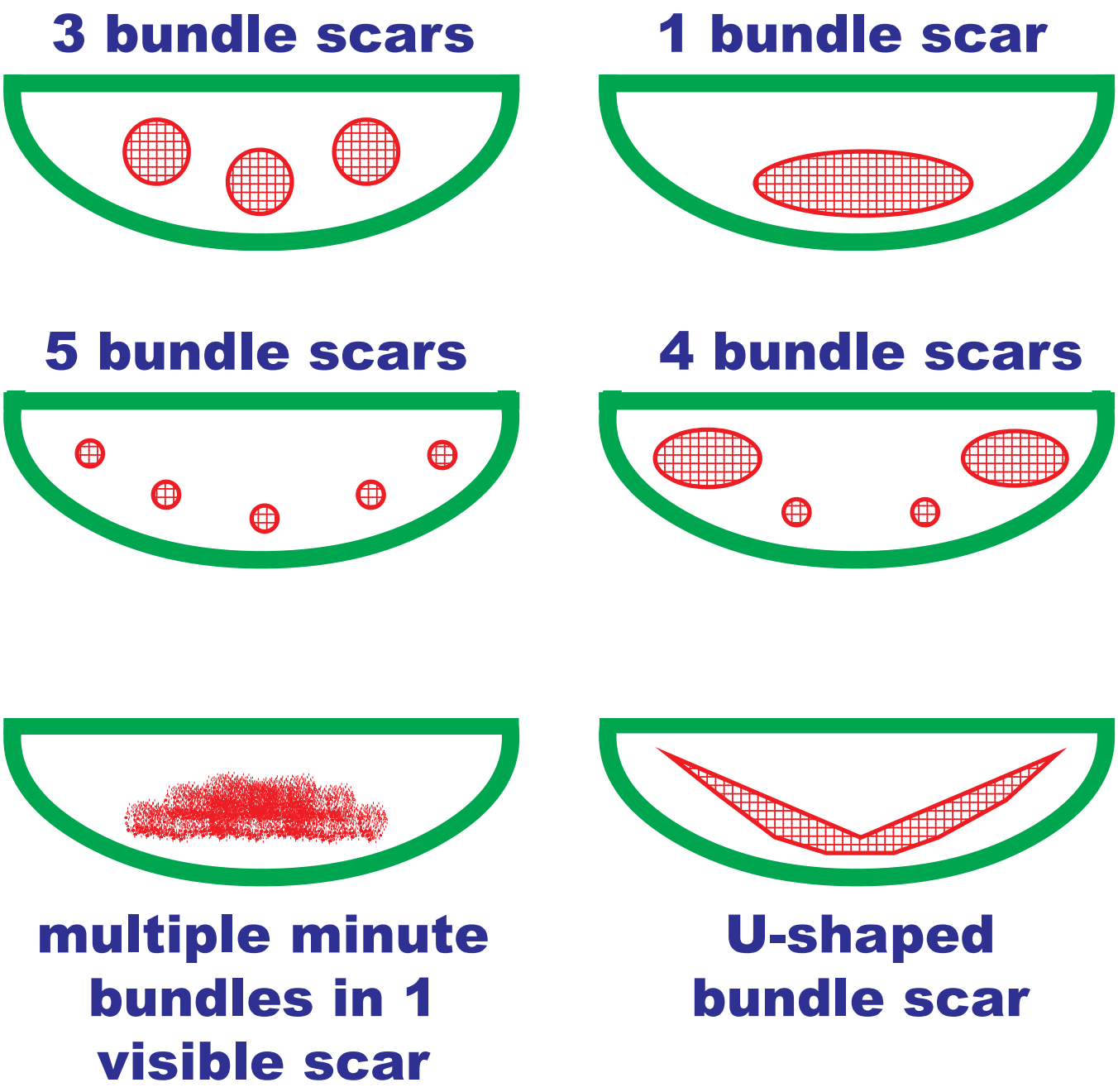


Figure 22: Half-round shaped leaf base / petiole / rachis twig scars showing various types of visible bundle scars within.

ring-like scar encircling (or partially encircling) a twig, or slit-like scars on the twig just above (more apical to) an axillary bud. Usually in temperate trees, stipular scars are visible by mid-Summer as slit-like or ring-like twig periderm disruptions. Figure 23.

Bud Scars

The past presence of a bud, and its associated bud scales, leave a number of periderm identification marks on twigs. Figure 24. Bud scars include terminal bud scale scars or false terminal bud scale scars, and axillary bud scars. A terminal bud scale scar shows the position of last year's terminal bud location when extension growth began. A false terminal or pseudoterminal bud scale scar shows the position, opposite of a false terminal bud, where last year's terminal twig shoot died. This is also called a terminal twig scar. Figure 25. An axillary bud scar shows the position of axil bud within confluence area of a leaf petiole / rachis and the twig axis).

A twig scar on a twig terminal (old term for this was branch scar) is a visible periderm disruption of where a terminal internode (shoot module) was shed opposite across a twig from a false terminal bud. An axillary bud cicatrix could be a single scar, or multiple scars from accessory buds either superposed above or below the axillary bud position (superposed accessory buds), or collateral to either side of the axillary bud position (collateral accessory buds).

Twigging

Looking carefully at twigs, and knowing what is being seen, is critical to understanding and applying proper tree health care and to tree identification. Figure 26. Looking at twigs is similar to a physician reading vital signs. For example, twig length can suggest growth rate while twig color can suggest health. Twigs allow a knowing person to read tree life and to make more accurate identifications.

The most critical four twig attributes used in tree genera (and species) identification are: 1) evergreen, persistent, OR deciduous leaf system; 2) leaf attachment scars opposite / whorled OR alternate / clustered; 3) twig tip with true terminal bud OR false terminal bud; and, 4) bundle scars visible within leaf scars OR no bundle scars clearly visible. Figure 27.

Presentation

Figure 28 provides a list of twig attributes for a few representative common tree genera. Figure 29 through Figure 42 show example tree species drawings representing listed genera attributes, with the first four identification characters given.

Conclusions

The first and newest above ground elongation growth of a new year is demonstrated by twigs. New growth is dependent upon the vulgarities of the past year's resource gathering, control, and efficient use, and this year's resource availability and environmental luck. Tree specialists can learn many things from twigs!

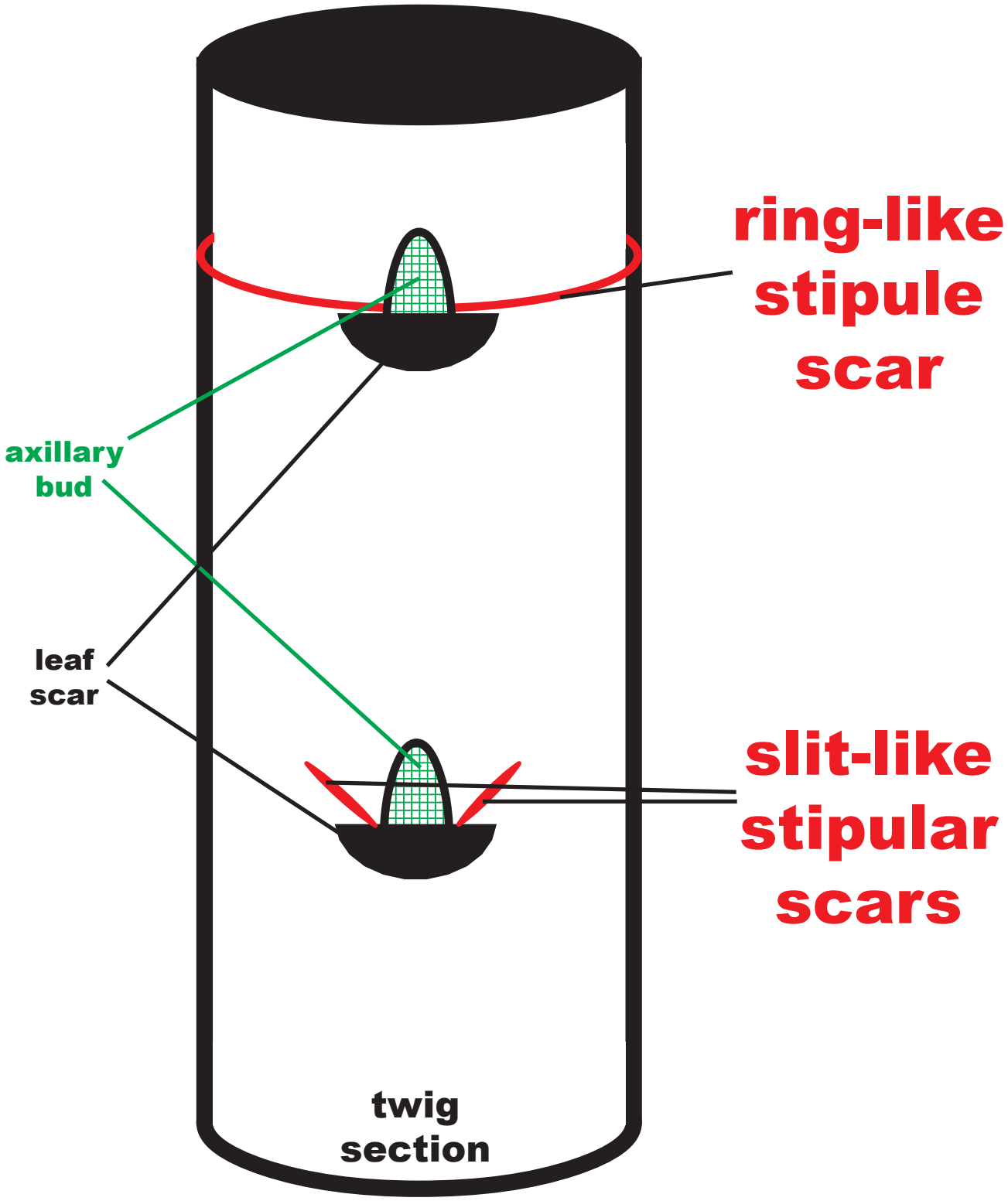


Figure 23: Two primary stipule scar types on tree twigs, if present.

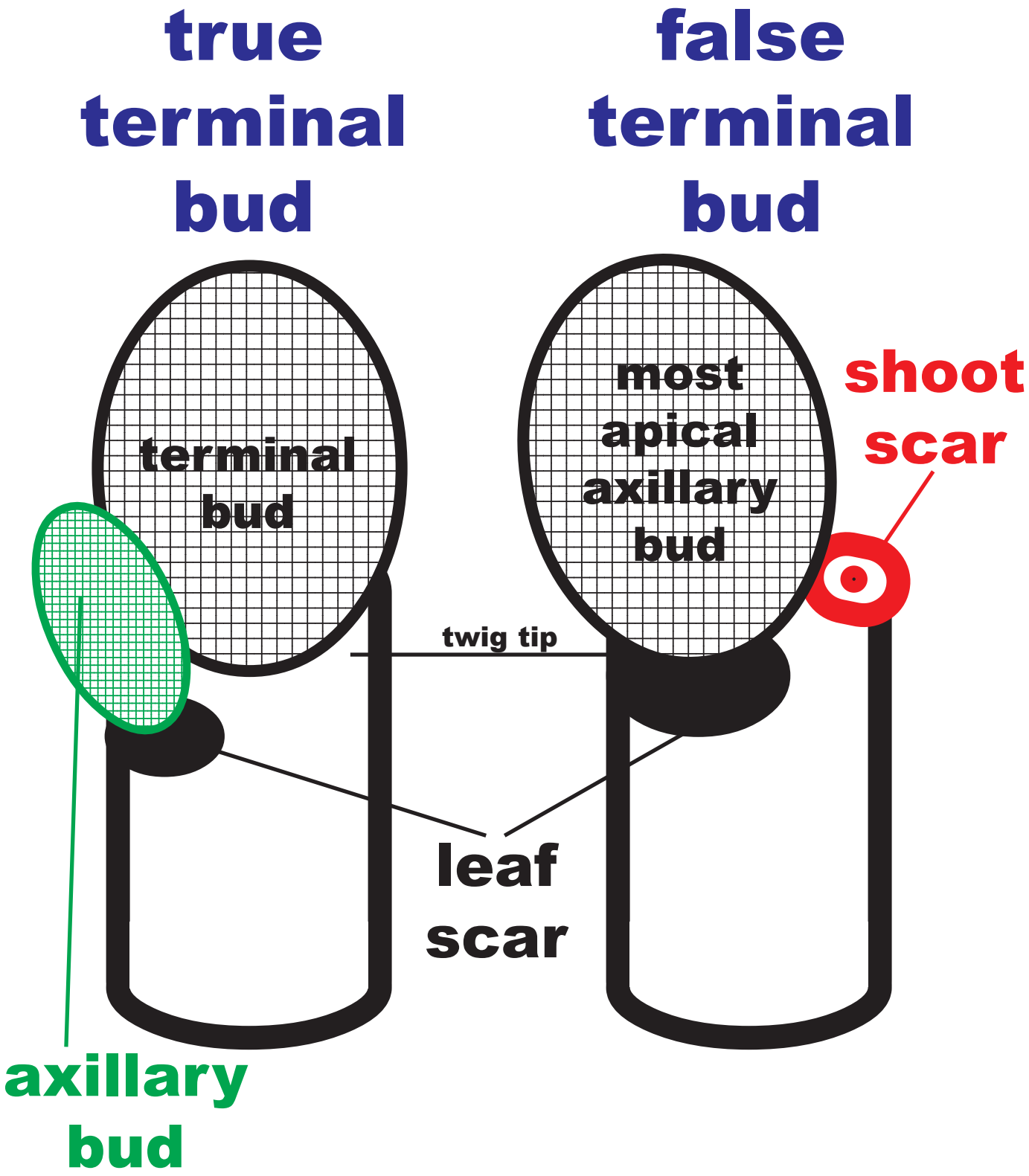


Figure 24: Generalized views of true terminal bud & false terminal bud (pseudoterminal).

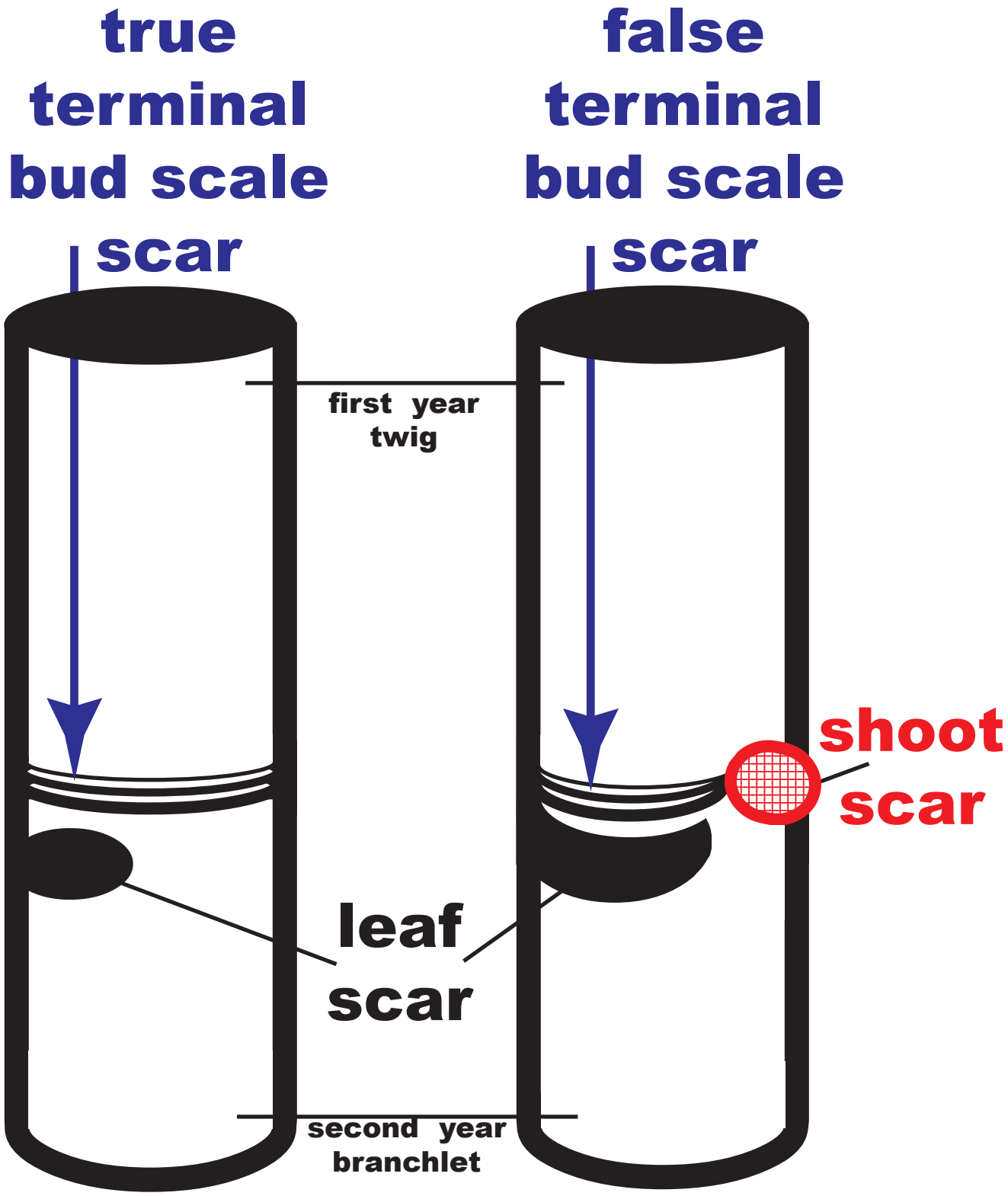


Figure 25: Generalized views of true terminal bud scale scars & false terminal (pseudoterminal) bud scale scars.

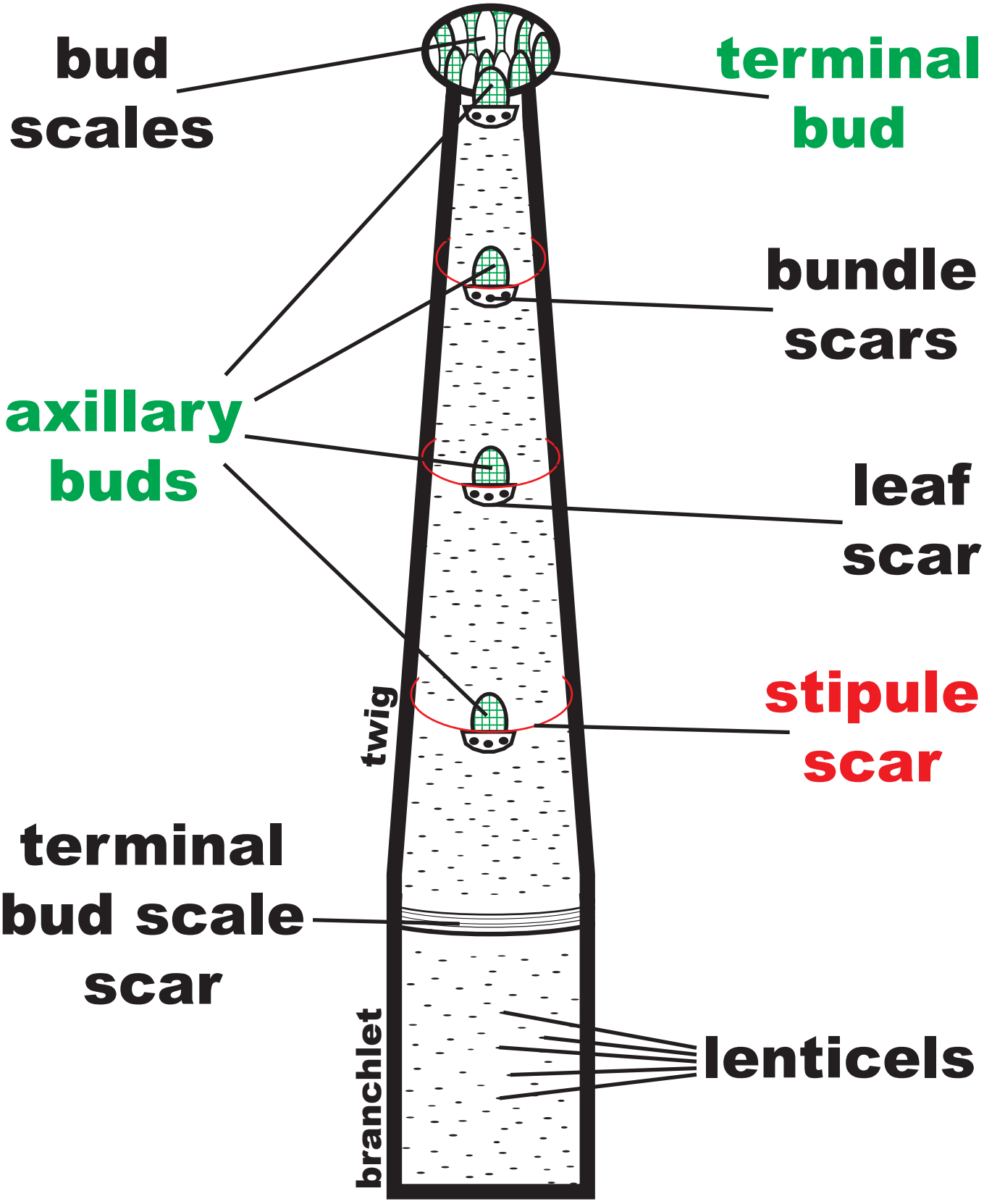


Figure 26: Key visible anatomy components on tree twig.

Observe Full Mature Twig

STEP 1 =

evergreen OR deciduous

STEP 2 =

opposite / whorled OR alternate / clustered leaf scars

STEP 3 =

true terminal bud OR no terminal bud / false terminal bud

STEP 4 =

individual bundle scars visible OR no bundle scars visible

Figure 27: Four simple first key steps in identifying tree twigs.

Figure 28: Example Twig Features For Select Tree Genera

(twigs from mature trees only)

opposite leaf scars with terminal bud

Acer = visible lenticels, 3 bundle scars

Cornus = raised darkened leaf scars, leaf scars joined by fine lines, 3 bundle scars

Fraxinus = bud scales imbricate, bundle scars U-shaped

opposite leaf scars with no terminal bud

Paulownia = pith chambered or excavated with solid pith at nodes, lenticellate, twigs stout, very small lateral buds, large leaf scars, circular bundle scar

Catalpa = pith entire, small lateral buds, leaf scar 3 per node (whorled), stout twigs, crater-like leaf scars, circular bundle scars

alternate leaf scars with no clear bundle scars

Robinia = no terminal bud, sunken lateral buds under leaf scars, paired spines, 3 part leaf scars

Maclura = no terminal bud, single unbranched slightly curved thorns, stipular scars, spur shoots

alternate leaf scars with terminal bud

Ilex = 1 bundle scar, minute black stipular scars, lenticels visible, lateral buds often superposed, pith soild or spongy, 3-4 lateral bud scales, (very difficult to identify to species using twigs alone)

(continued)

Figure 28: Example Twig Features For Select Tree Genera (continued)

(twigs from mature trees only)

alternate leaf scars with no terminal bud

Celtis = 1 bundle scar, closely appressed lateral buds, zig-zag form twig, pith chambered or diaphragmed in branchlets, single bud over single leaf scar

Diospyros = 1 bundle scar, lateral buds closely appressed, laterals usually with 2 bud scales, buds solitary, pith diaphragmed, twig cross section round (terete), twig stiff

alternate leaf scars with 3 bundle scars

Gleditsia = no terminal bud, forked thorns directly above node, raised lenticels, lateral buds partially sunken, lateral bud scales minute

Juglans = terminal bud partially valvate, laterals superposed, twigs robust, pith cambered

alternate leaf scars with >4 bundle scars

Quercus = terminal bud, pith angular in cross-section, accessory buds clustered around terminal bud, lateral buds imbricate

Carya = terminal buds much larger than lateral buds, no stipular scars, pith angular in cross-section, pith solid or diaphramed

Platanus = no terminal bud, one wrinkled lateral bud scale, leaf scar surrounds bud (horseshoe shaped leaf scar), ring stipular scar around twig, zig-zag form

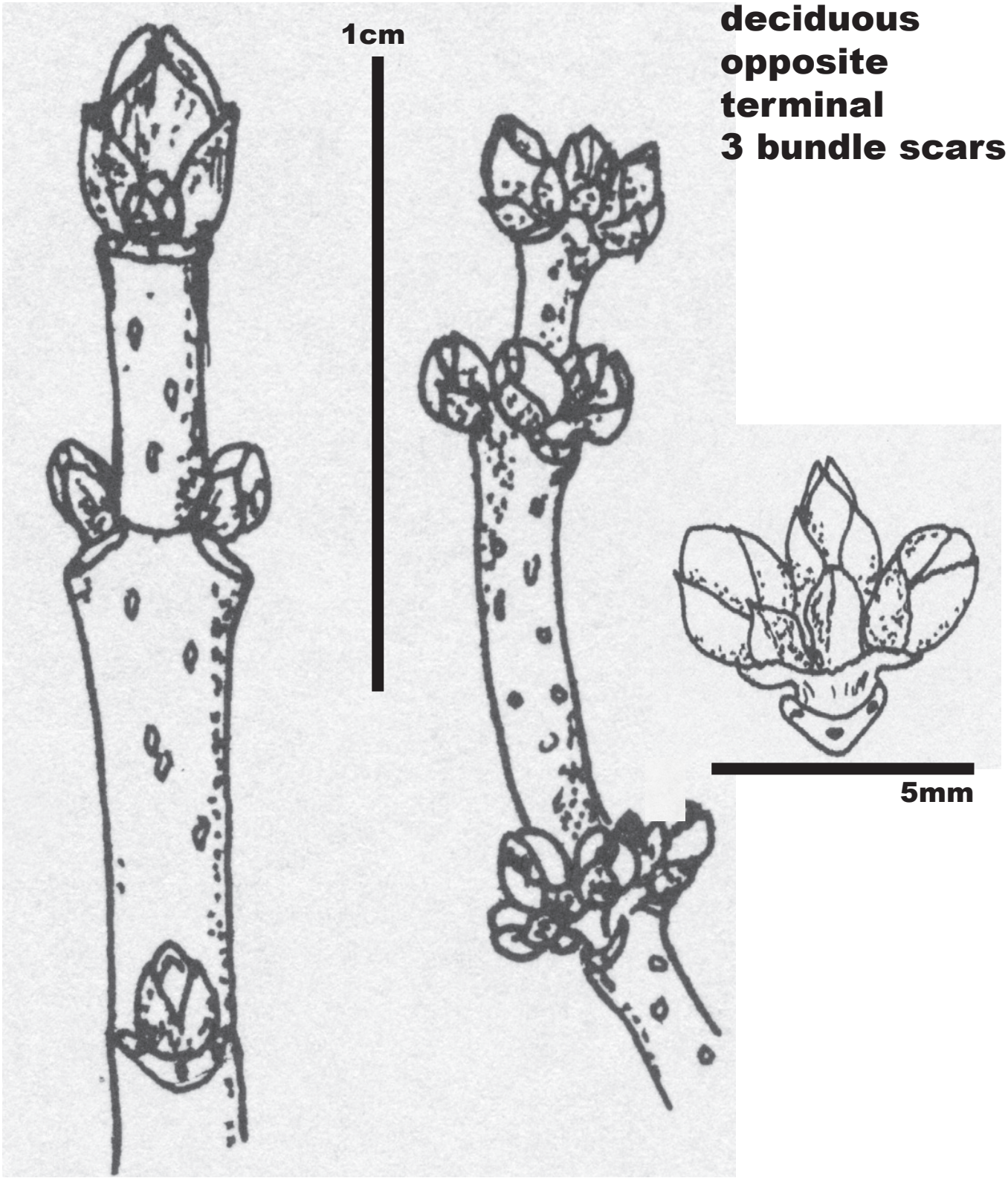


Figure 29: *Acer rubrum* red maple twig tips and axillary / assessory buds with leaf scar.

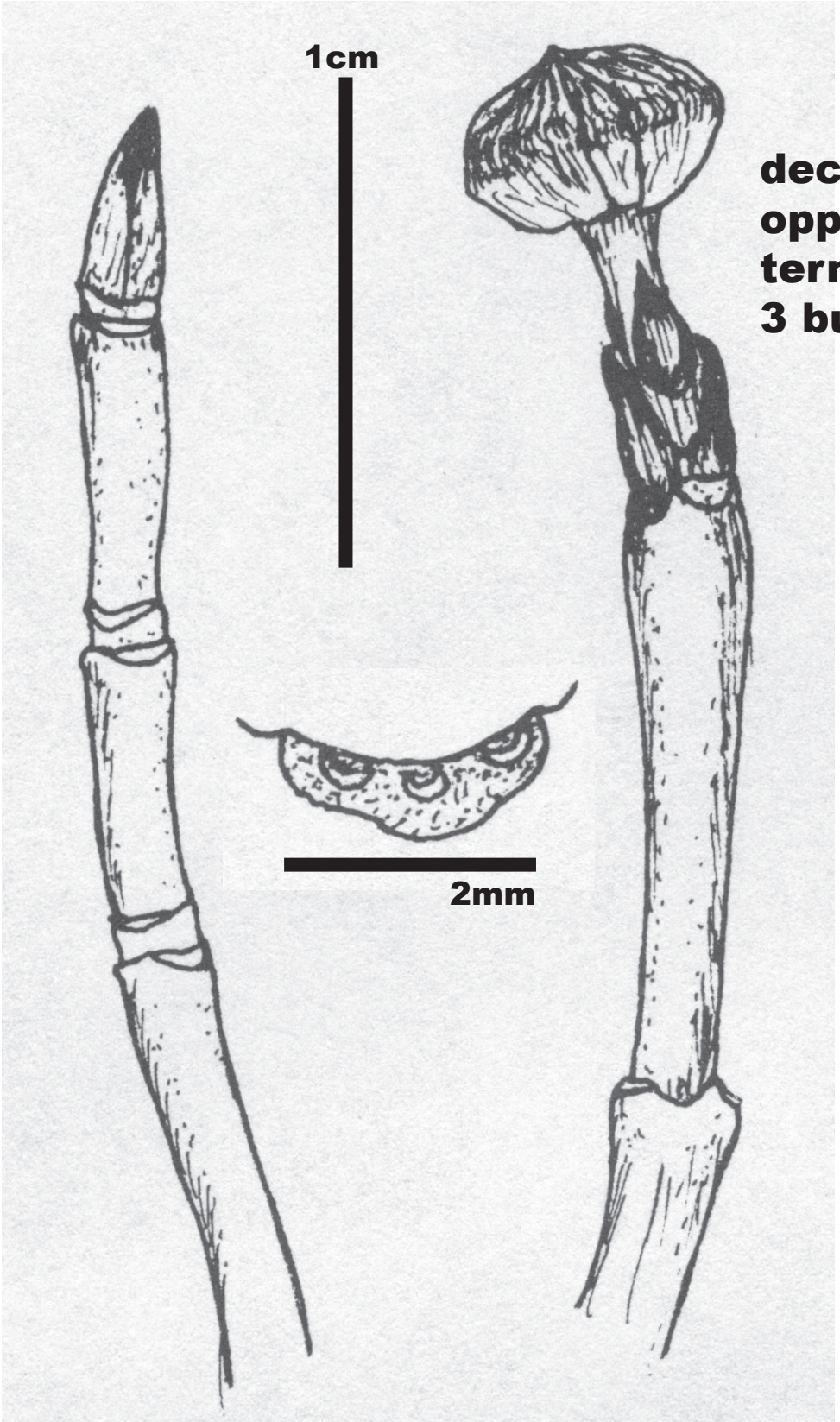


Figure 30: *Cornus florida* flowering dogwood twig tips (one with terminal flower bud), and leaf scar.

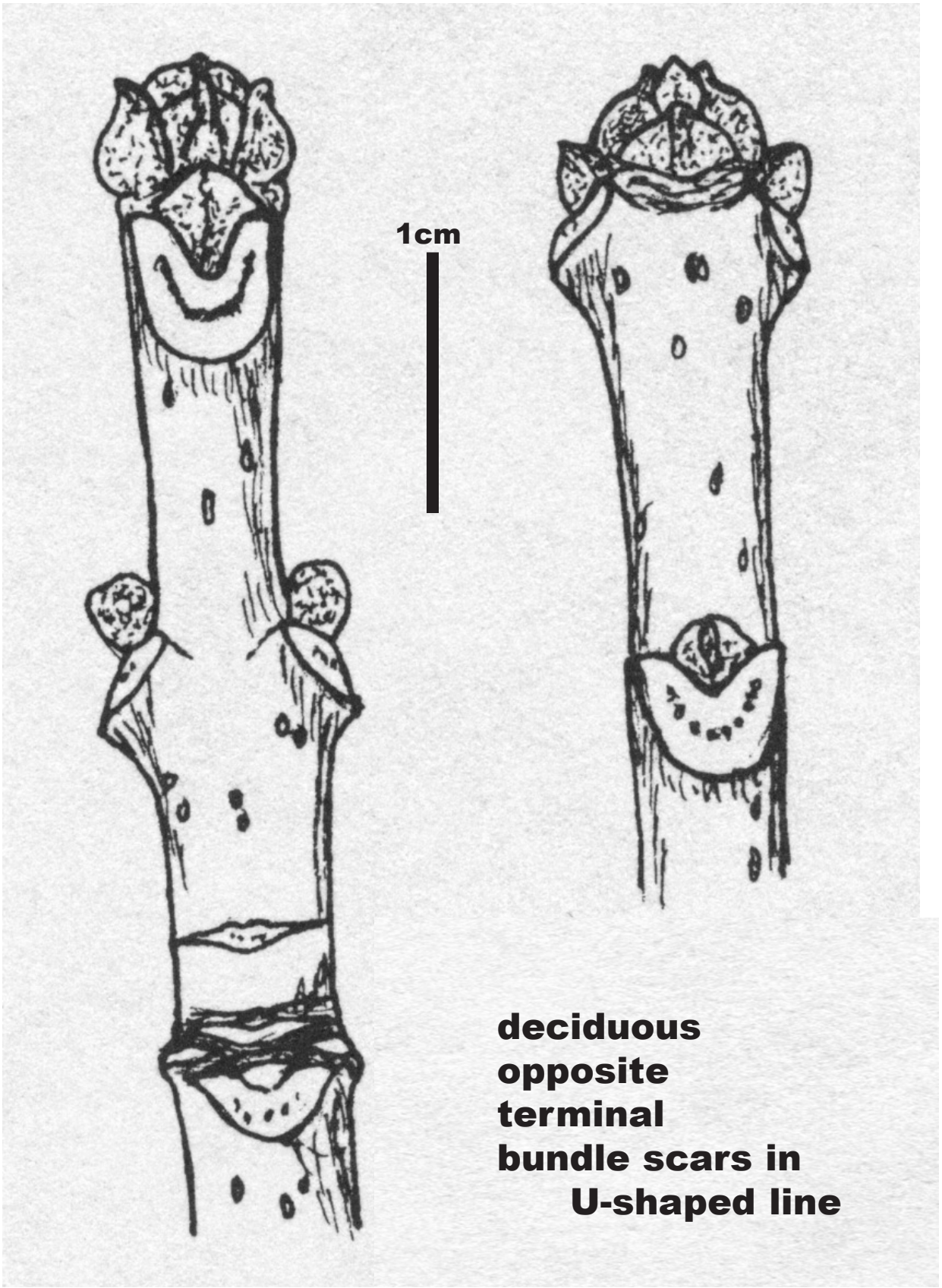


Figure 31: *Fraxinus americana* white ash twig tips.

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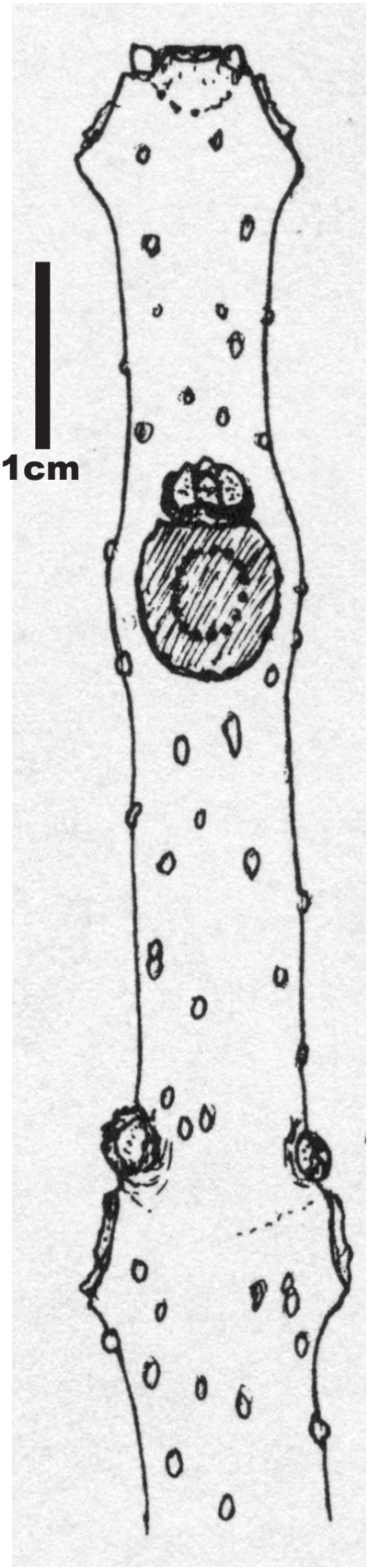


Figure 32: *Paulownia tomentosa* twig tip.

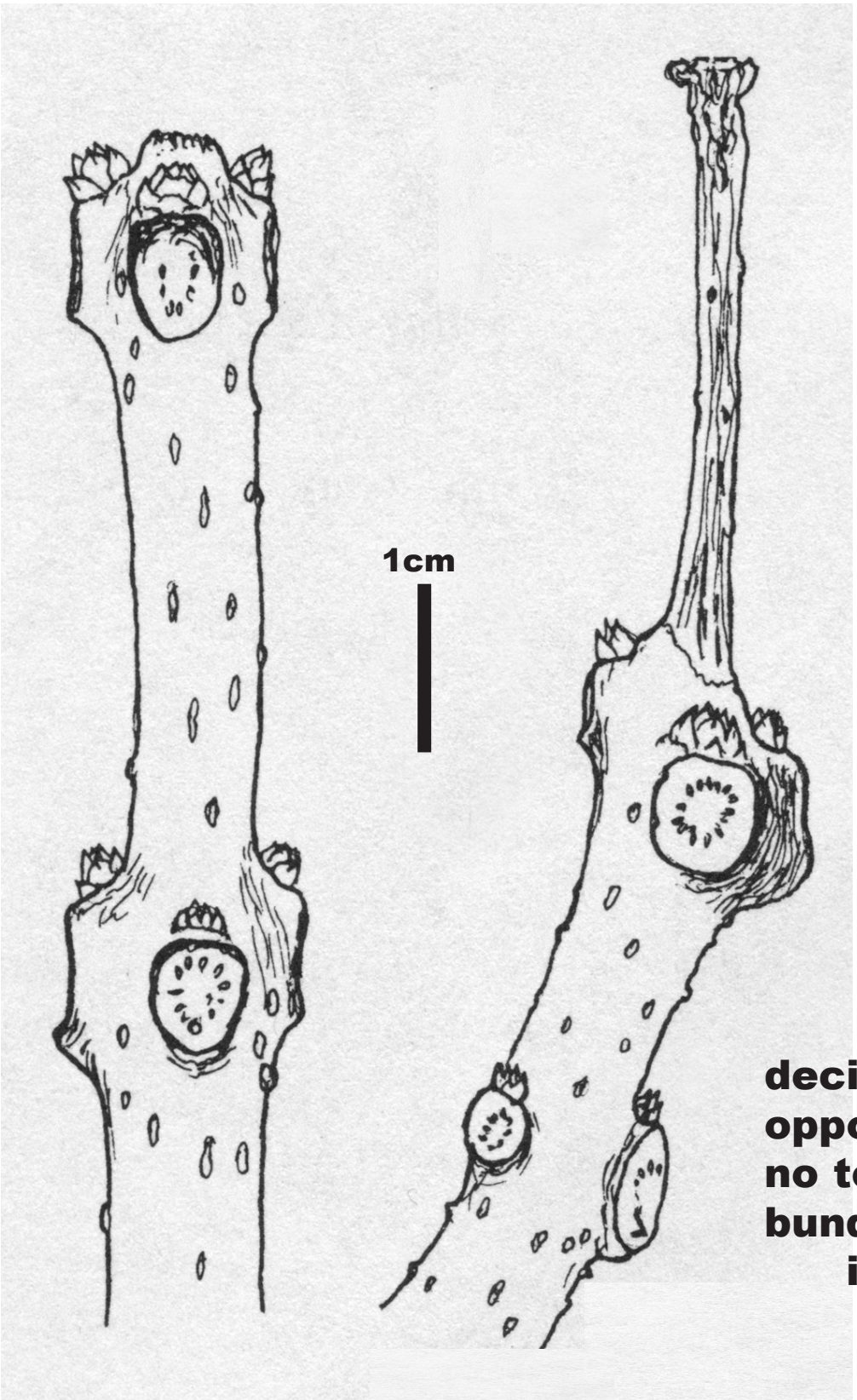


Figure 33: *Catalpa* ssp. twig tips (one with aborted terminal shoot still attached).

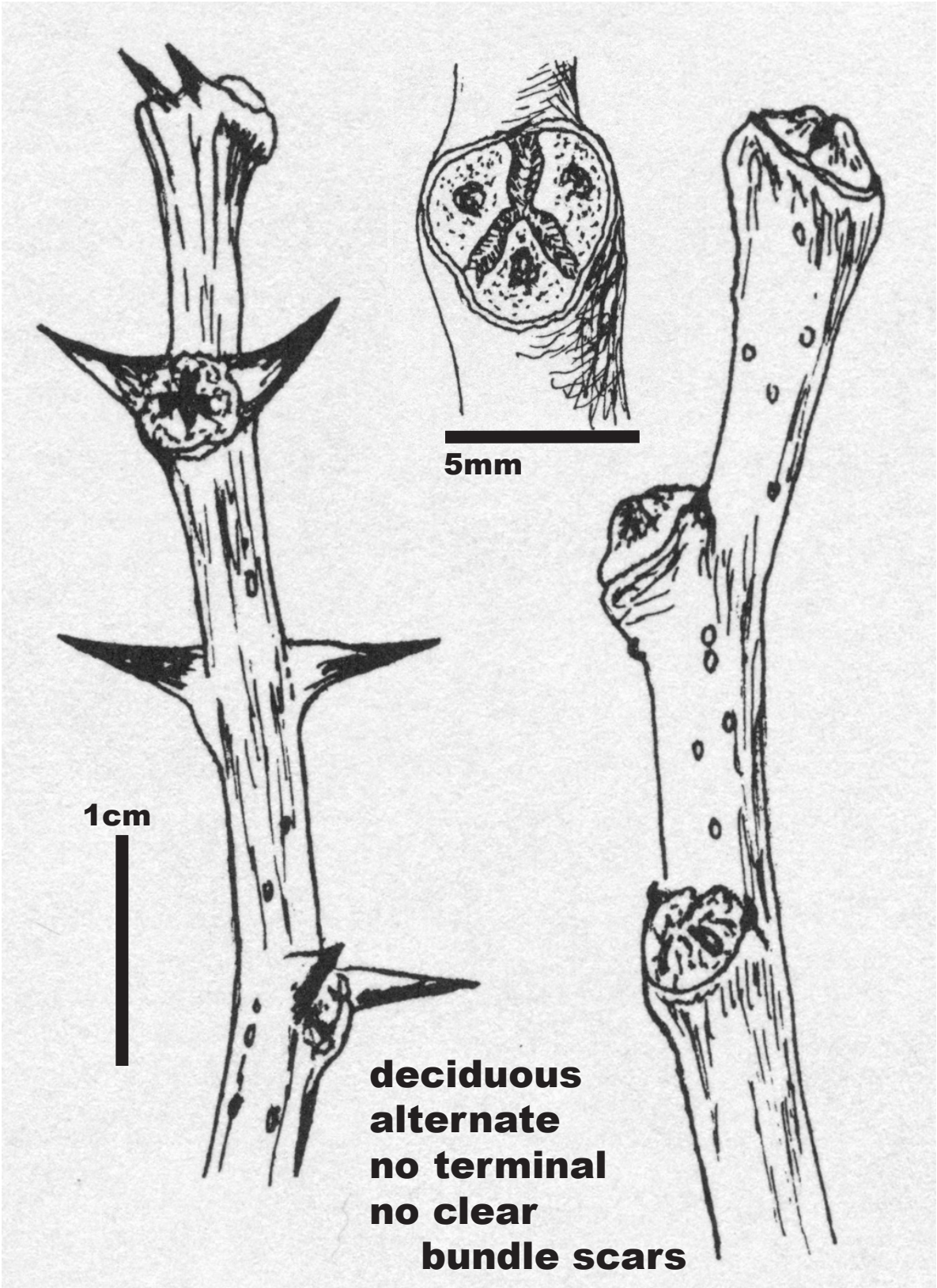


Figure 34: *Robinia pseudoacacia* black locust twig tips with and without paired spines, and a leaf scar.

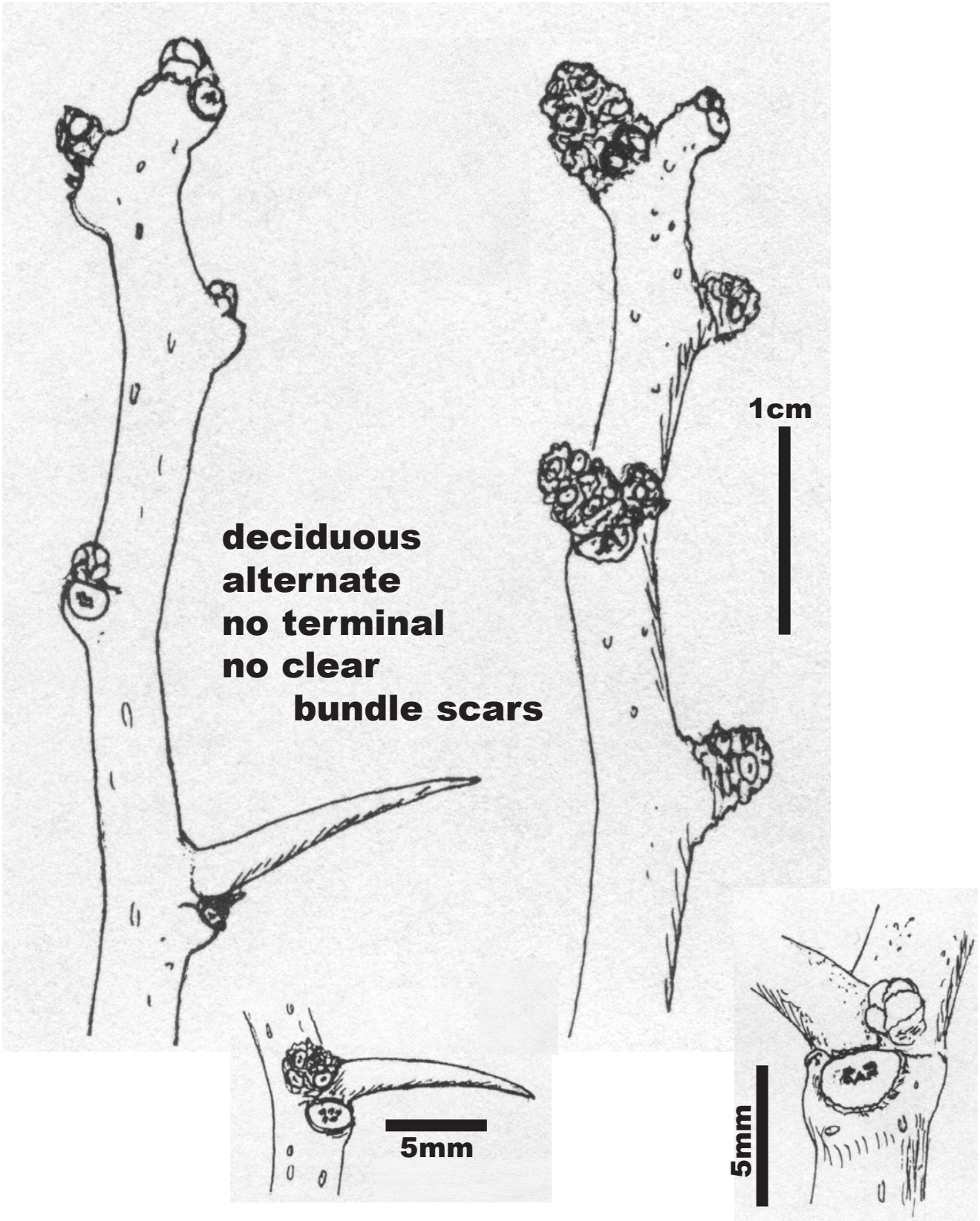


Figure 35**:** *Maclura pomifera* Osage orange twig tips with axillary buds & spur shoots, leaf scar, and thorn.

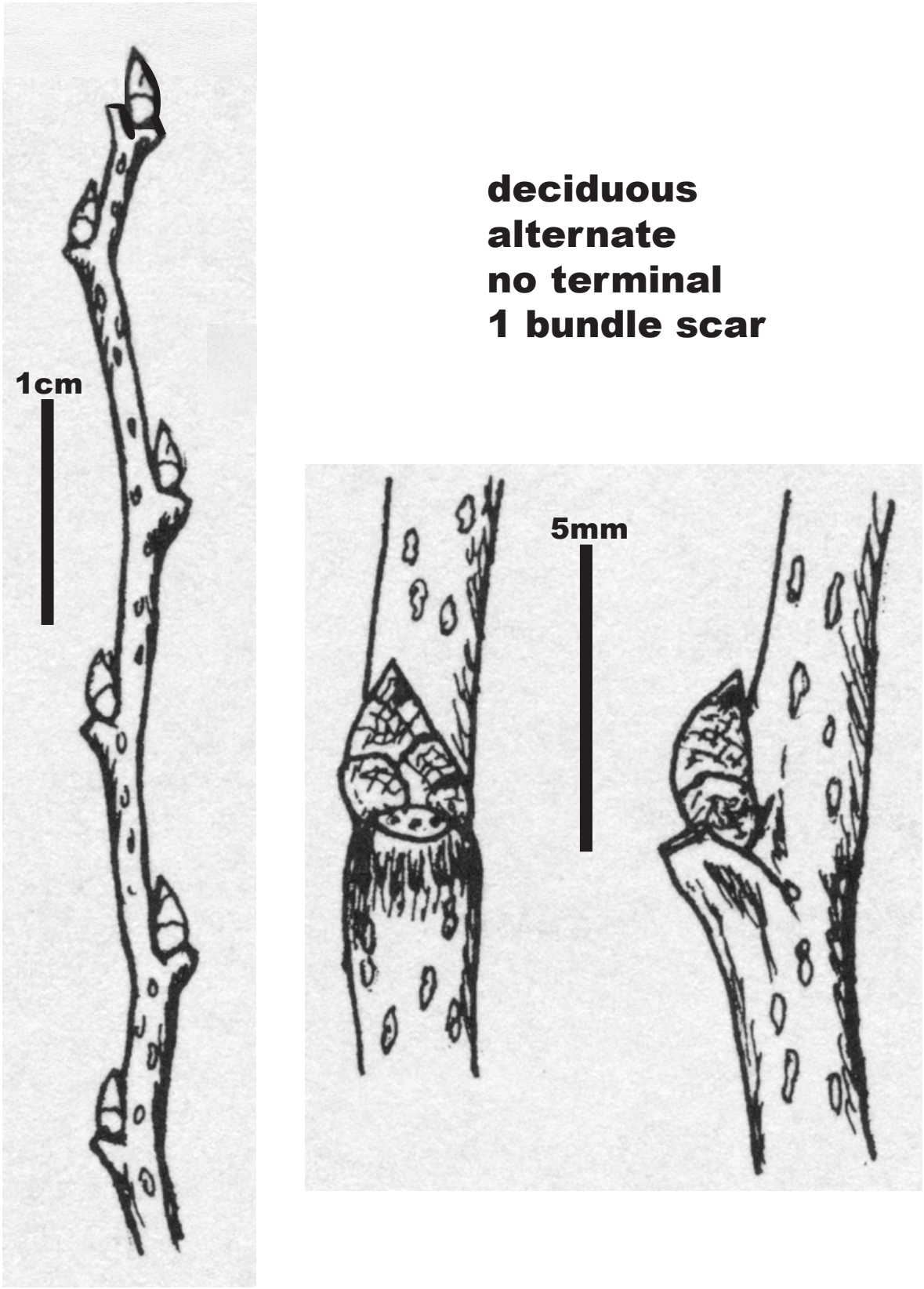
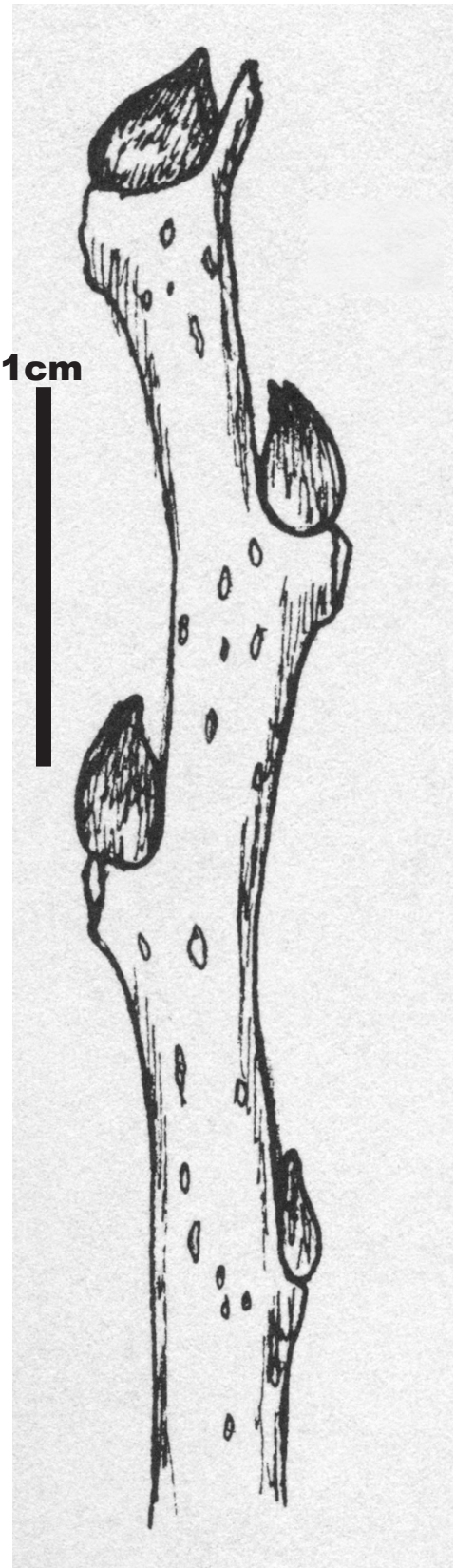


Figure 36: *Celtis* ssp. hackberry
twig tip, axillary buds, and leaf scars.



deciduous
alternate
no terminal
1 bundle scar

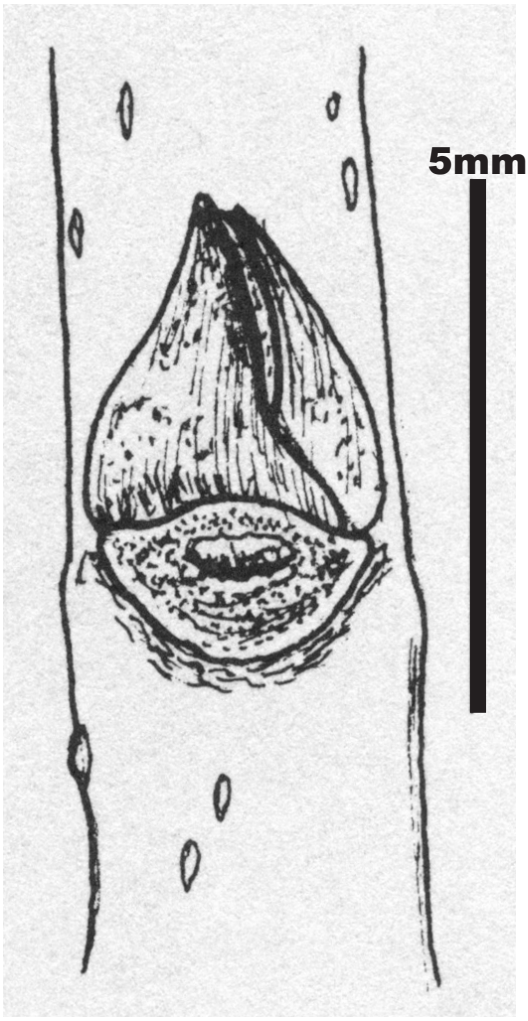


Figure 37: *Diospyros virginiana* persimmon twig tip & leaf scar.

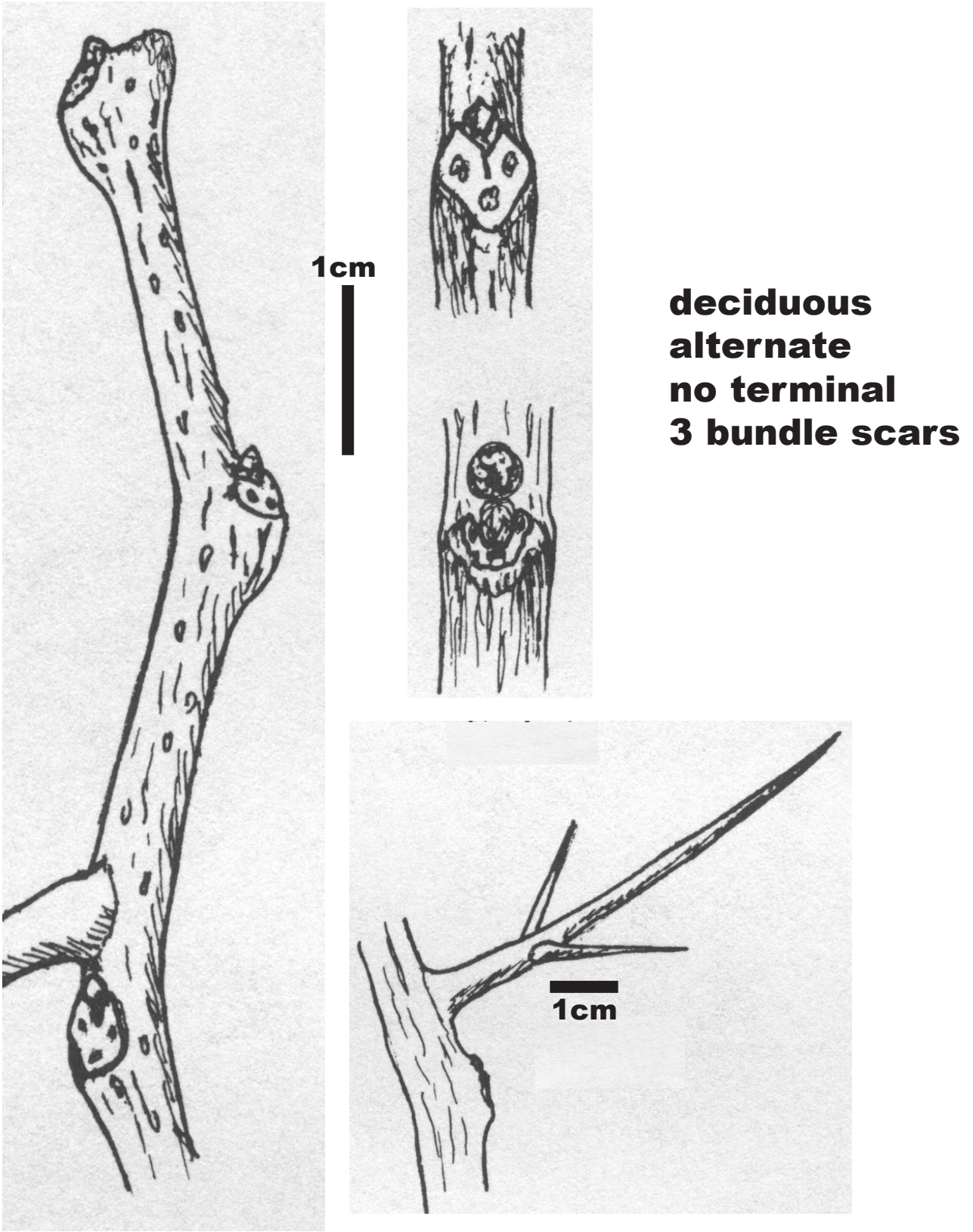


Figure 38: *Gleditsia triacanthos* honeylocust twig, leaf scar, and thorn.

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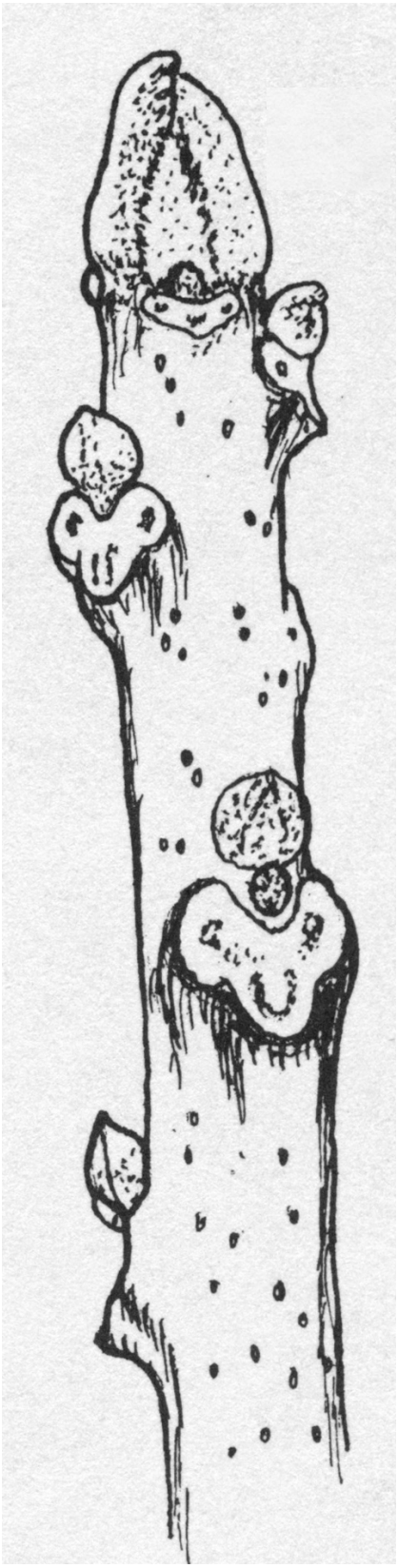


deciduous
alternate
terminal
3 bundle scars

1cm

Figure 39: *Juglans nigra* black walnut
twig tip & leaf scar.

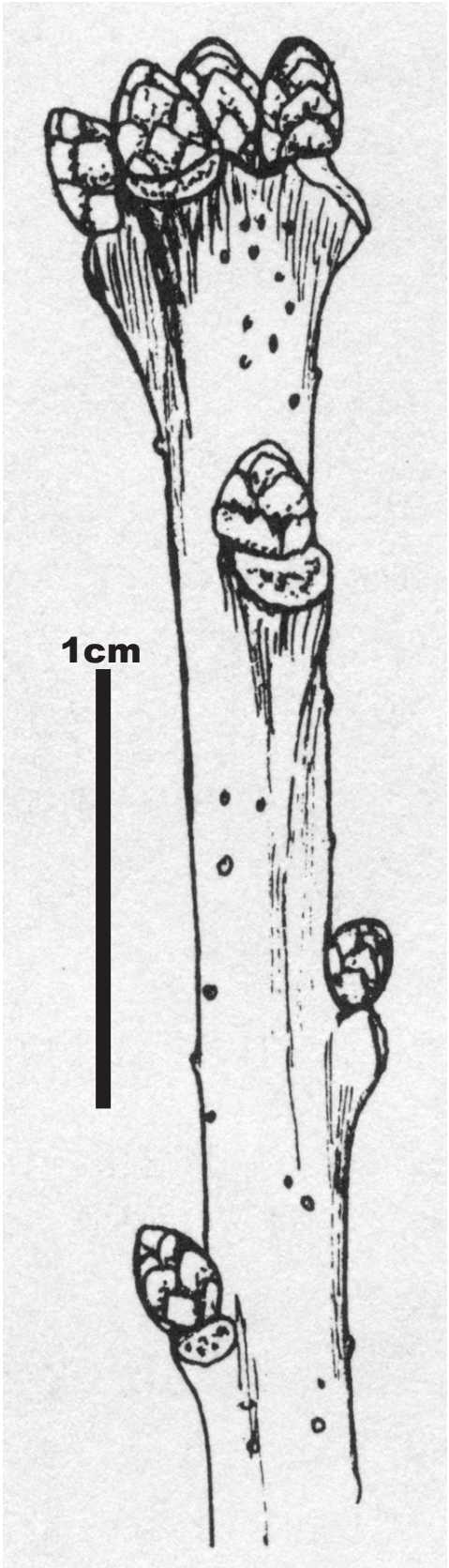
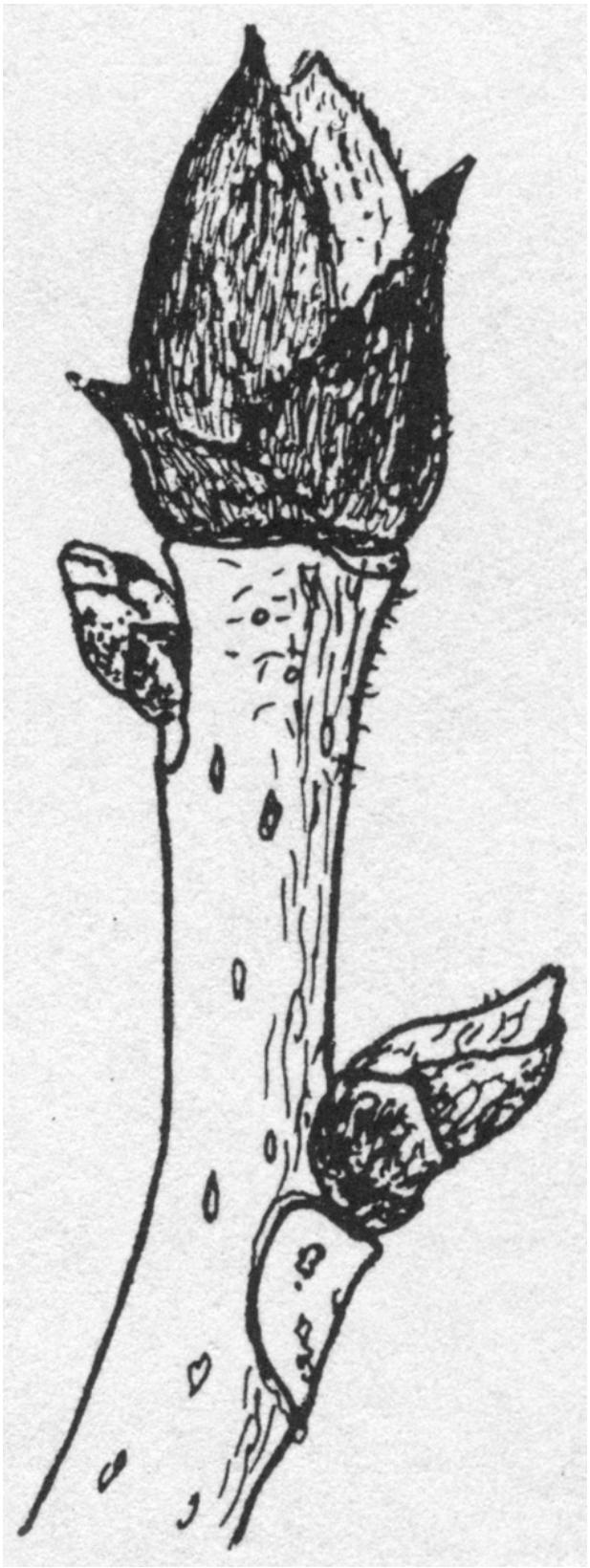


Figure 40: *Quercus alba* white oak twig tip.



deciduous
alternate
terminal
>4 bundle scars

1cm

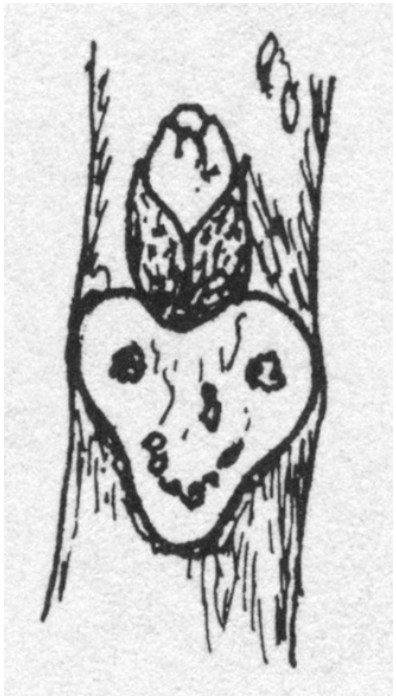
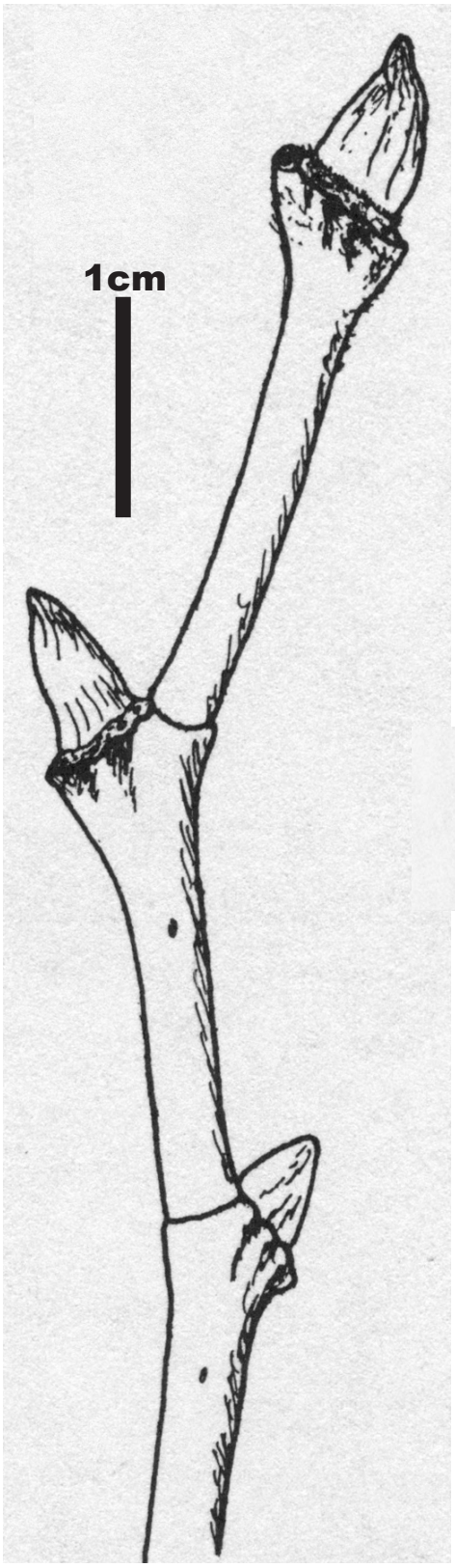


Figure 41: *Carya ovata* shagbark hickory twig tip & leaf scar.

Figures source: **Woody Plants of the Southeastern United States: A Winter Guide**, by Ron Lance, published by the University of Georgia Press, Athens, Georgia, USA.



deciduous
alternate
no terminal
>4 bundle scars

1cm

Figure 42: *Platanus occidentalis* sycamore twig tip & leaf scar.

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