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Tree Anatomy: Defining Trees & Forms

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Tree anatomy and morphology represent how a tree stands against wind and gravity, (Figure 1) as well as how it functions and how it looks. Understanding trees requires the discipline of learning and using basic scientific and botanical terms.

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. A professional should be able to discuss tree life in a precise and accurate way using proper terms for field observed (macroscopic) items.

Tree anatomy is the study of structural components and their interactions. Tree morphology is the study of external shape, form, and structure. This work covers tree anatomy and morphology targeted at professional tree health care providers. Here, concentration on tree anatomy is focused upon macroscopic (as seen in the field) components.

A Tree

In general terms, a tree is a perennial woody plant with four main structural components – a stem, leaves, roots, and tricombes. Different terms for trees and tree-forms have included: dendron = a tree; diplocaulescent = a main axis with branches; dendroid = a plant with a tall erect main axis and many branches; arborescent = any tree-like form; phanerogamae = ancient term for *Gymnosperms* and *Angiosperms* (*Spermatophyta*) tree forms; and, phanerophyte = a tree form with its resting buds positioned well above the soil surface on a stem and branches which are open to the environment.

Phanerophytes are broken into three primary main axis height forms: Figure 2.

1) megaphanerophyte is a tree form over 99 feet (30m) tall;
2) mesophanerophyte is a tree form with height between 98feet (30m) and 26feet (8m); and,
3) microphanerophyte is a tree form with height between 25feet (8m) and 6.5feet (2m). This definition represents single stem and multistem shrubs, trees, and tree forms.

Defined Tree

To more accurately define a tree in the field, a number of definitions were polled from a variety of sources used by professionals and the public. Defining terms used here for trees were derived from multiple sources in the Eastern and South-central United States. Terms describing a tree were collected which included

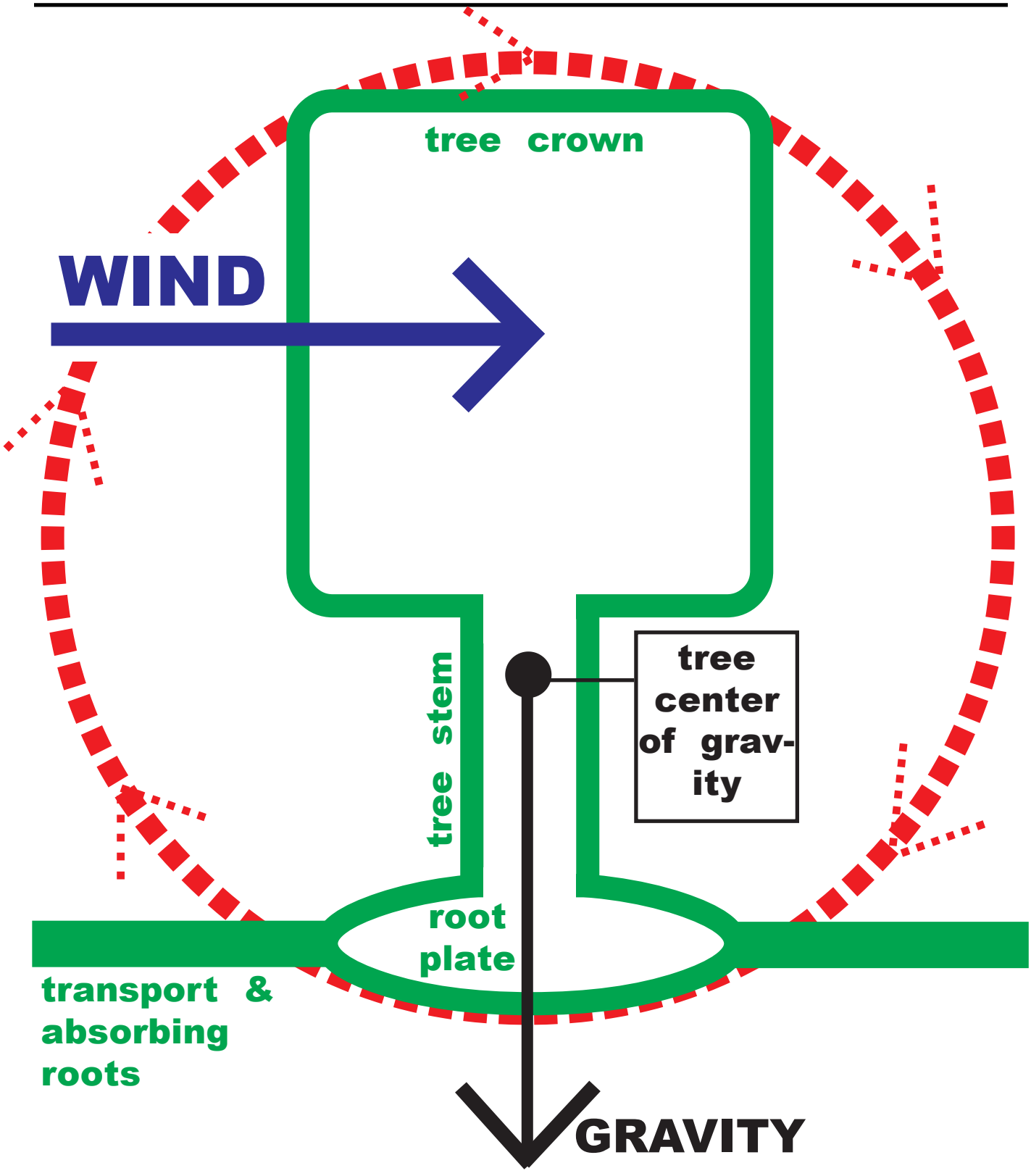

Figure 1: Simplified view of wind loading and gravity acting to rotate a tree out of a soil as a combined load wheel.

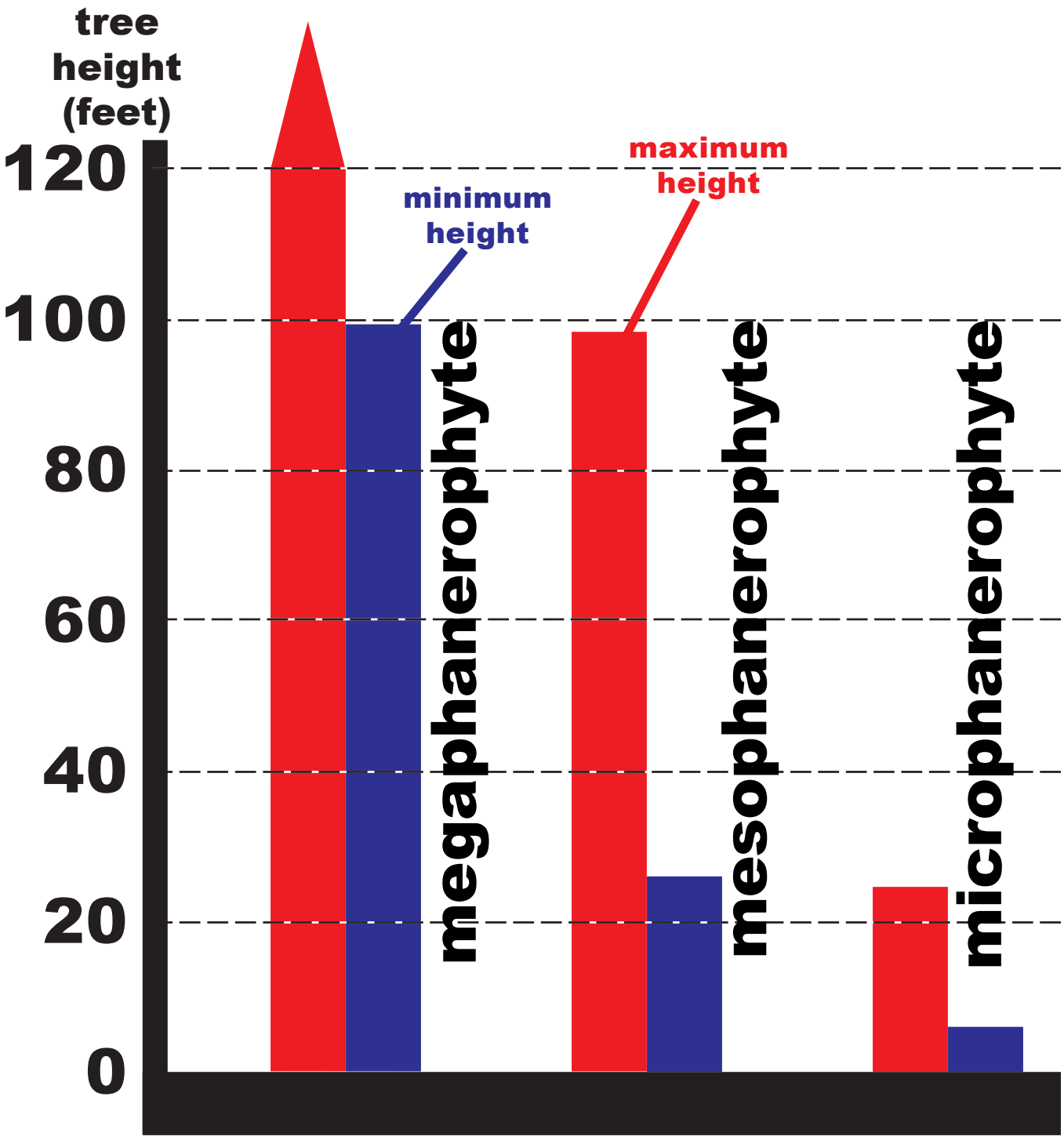

Figure 2: Height ranges of three main phanerophytes height forms. (mega-, meso-, & micro- phanerophytes)

155 unique descriptors within 45 different definitions. Definitions were taken from legal dictionaries and tree ordinances, botanical / ecological texts and glossaries, and general dictionaries. Figure 3 provides a summary.

The word "tree" is defined (accounting for 50% of all descriptors used) with three general terms – woody plant with a single stem. An additional three terms are used to further define and clarify a tree accounting for 30% of all descriptors. The most common six descriptors brings a total of 80% of all descriptors used for trees, including some height component, branching, and a perennial nature. Other terms were used less frequently to further define a tree. From all these descriptors, a master definition has been crafted:

> "A tree is a large, tall, woody, perennial plant with a single, unbranched, erect, self-supporting stem holding an elevated and distinct crown of branches with a total height greater than 10 feet and a diameter greater than 3 inches.""

Within this definition are height and diameter values used as minimum average values across multiple definitions, when specified at all.

Basic Forms

Beyond defining trees as a whole, there are many terms used by professionals and the public for primary tree parts above ground. For example, trunk, bole and stem tend to be used interchangeably by people discussing trees. There are some subtle professional differences among these concepts.

A tree trunk is considered the upright, massive main stem or main vertical axis of tree. A tree bole is a portion of the stem or trunk of a tree of such size from which lumber can be cut. A tree stem is the supporting axis bearing a living crown composed of tapering, overlapping columns of wood increments. Definition and word use varies by background of an observer and location across the continent.

Sub-Division

A technical term for branching is ramify, which means to subdivide (branch off of) an axis. The primary subdivisions of a stem which generate secondary growth (growth in girth or circumference) have been called by various names. A bough is any large division of the stem axis. A limb is a primary division of a stem or bough which bears foliage.

A branch is a large, medium, or small division of the main axis of the stem or another branch, equal to or greater than four (4) years (or full growing seasons) of age. As tree parts above ground are further divided, branchlets and twigs are defined. A branchlet is a small division of a branch equal to 2-3 years (or full growing seasons) of age. A twig is the current or most recent growing season's apical extension growth. Figure 4. A sprig is a portion of a twig.

Elongation Organization

Twigs, branchlets, and branches can be divided into two fundamental structural componenets – nodes and internodes. As with the children's building toy called TinkerToys (TM), there are elongated sticks (internodes) which separate round multi-connections (nodes). Figure 5. In trees, a node (a part of a circumferential nodal torus -- Figure 6) is a zone perpendicular to the long axis of a stem, branch, branchlet, or twig where vascular connections are diverted to support axillary buds, leaves, and elongating shoots / twigs (a vascular confluence zone). Figure 7. An internode is an elongated shoot segment between nodes.

descriptor	total	cumulative
plant	20%	20%
woody	16%	36%
single stem	14%	50%
tall / height	13%	63%
branched	9%	72%
perennial	8%	80%
girth / diameter	7%	87%
elevated crown	4%	91%
distinct crown	3%	94%
self-supporting stem & branches	3%	97%
lower stem without branches	2%	99%
erect / upright stem	1%	100%

Figure 3: Individual components of tree definitions taken from 45 individual definitions and 155 unique descriptors.

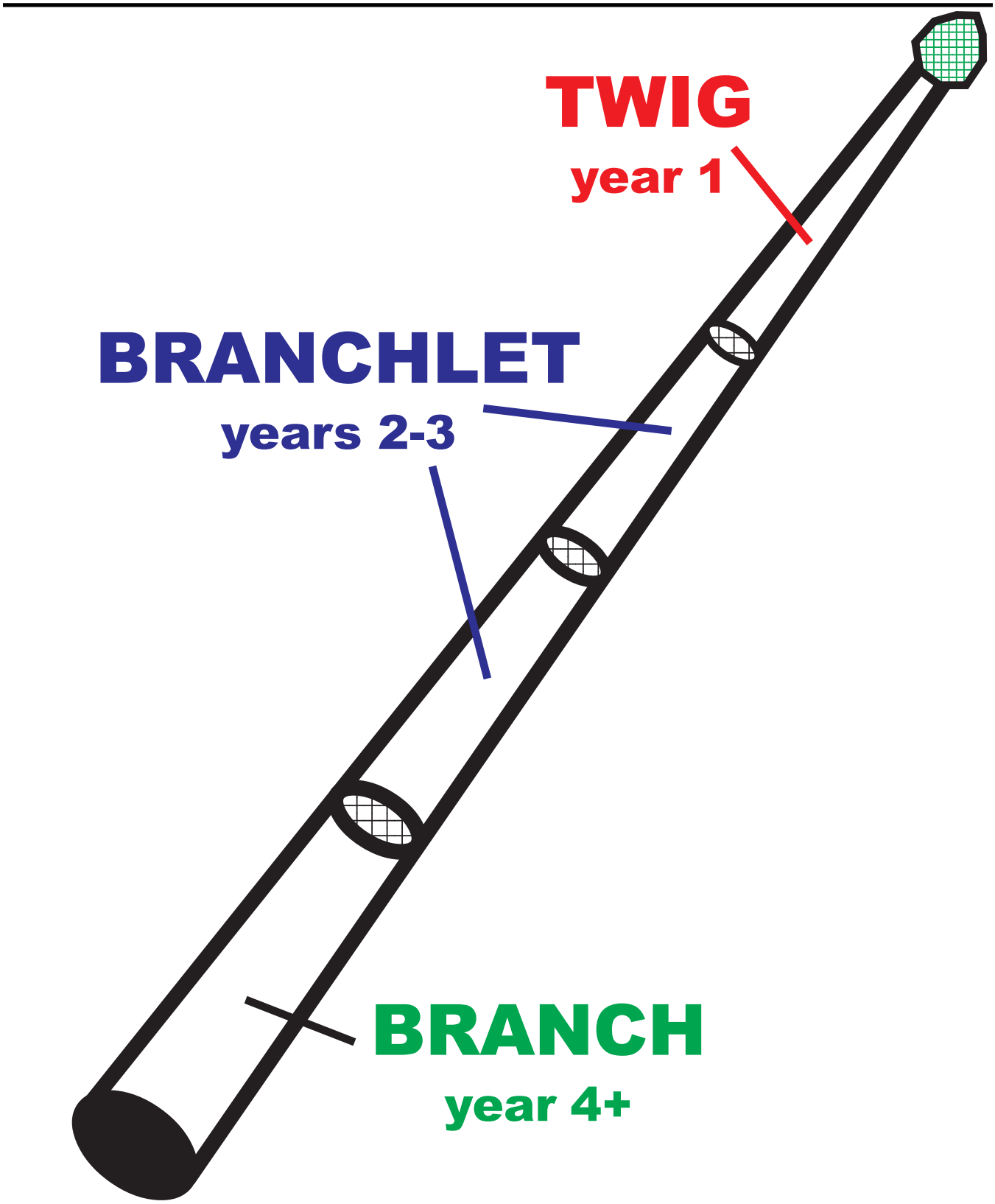

Figure 4: Defining twig, branchlet, branch by position & age.

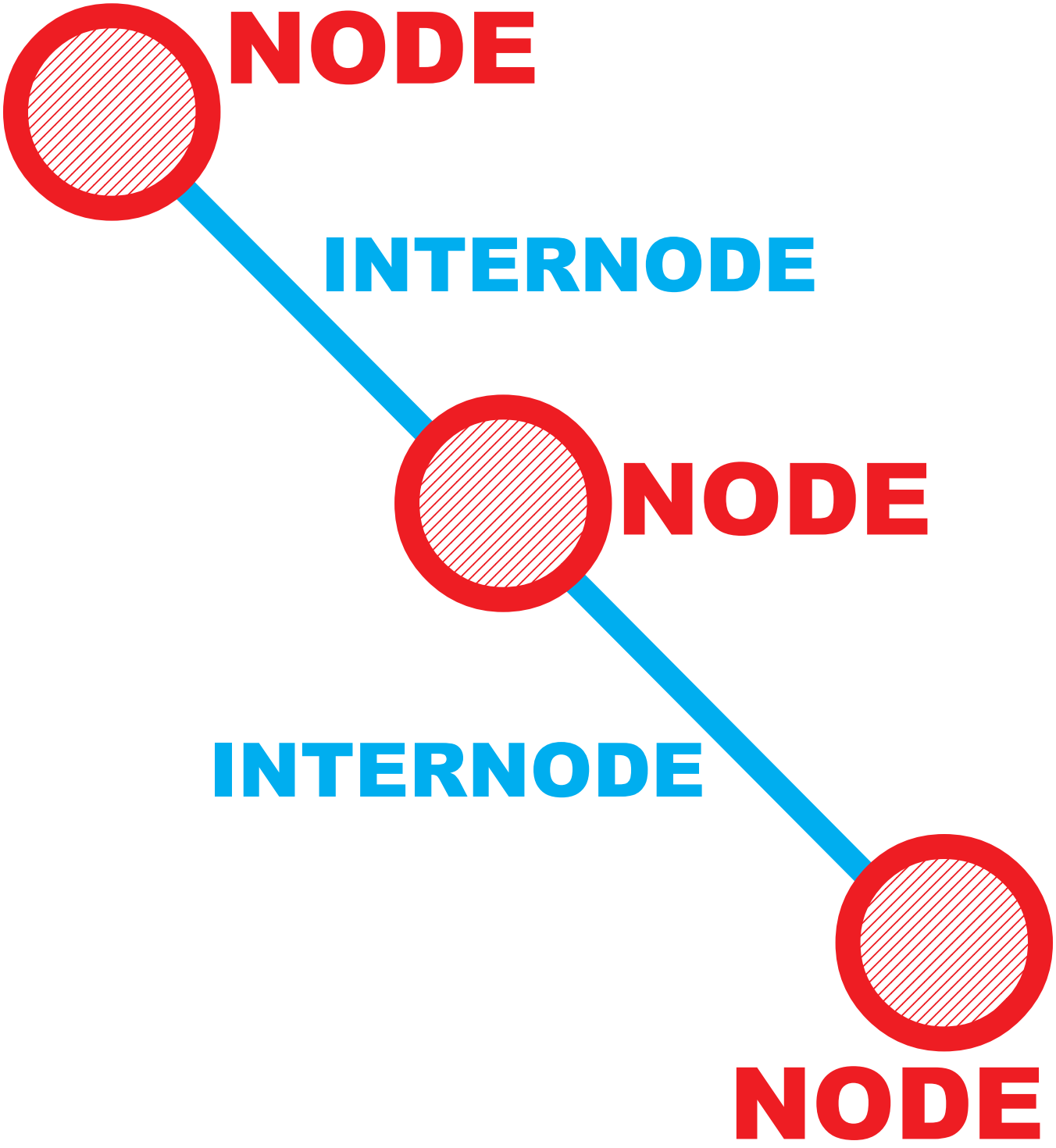

Figure 5: Modular growth system of nodes and internodes in trees.

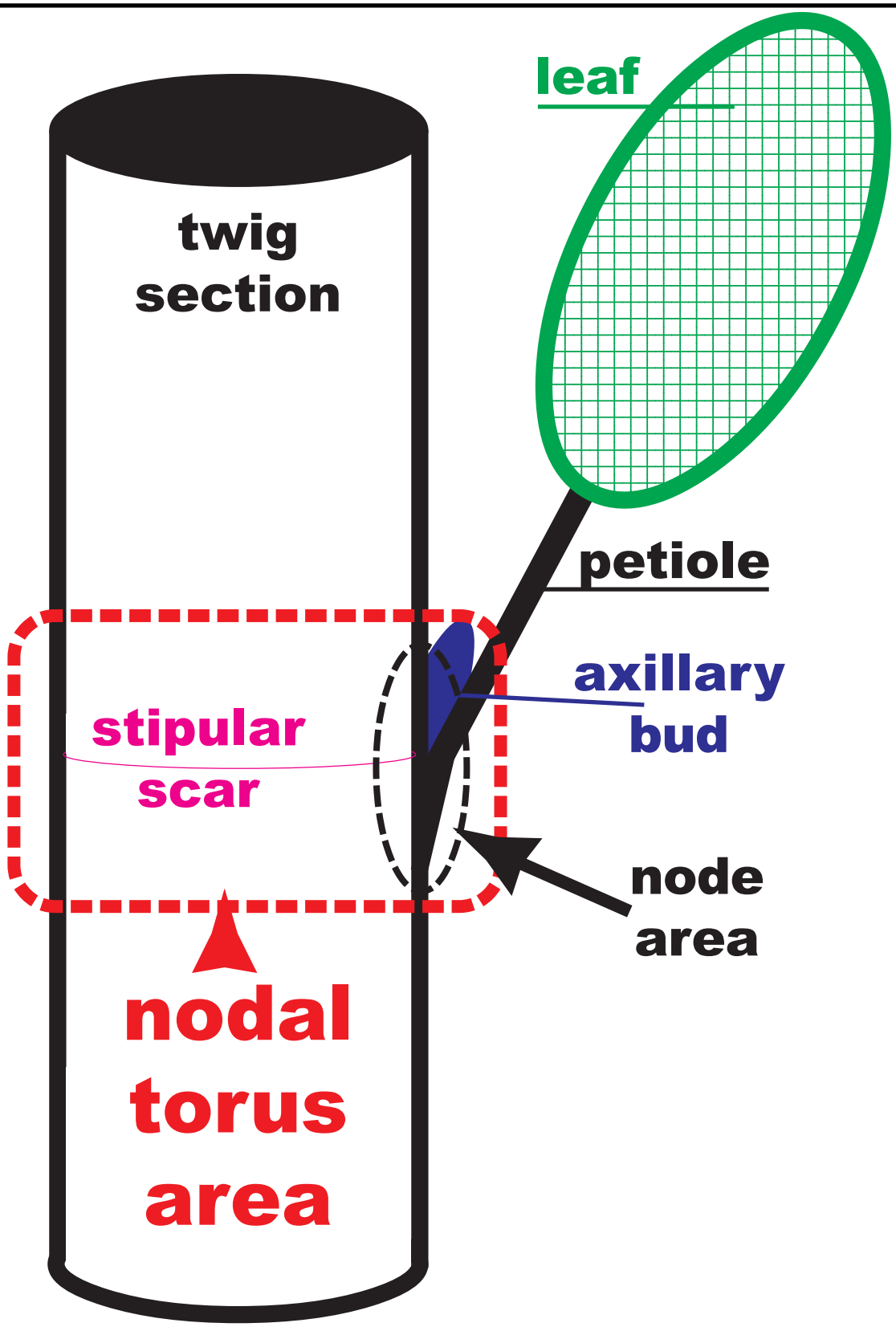

Figure 6: Node and nodal torus locations on twig.

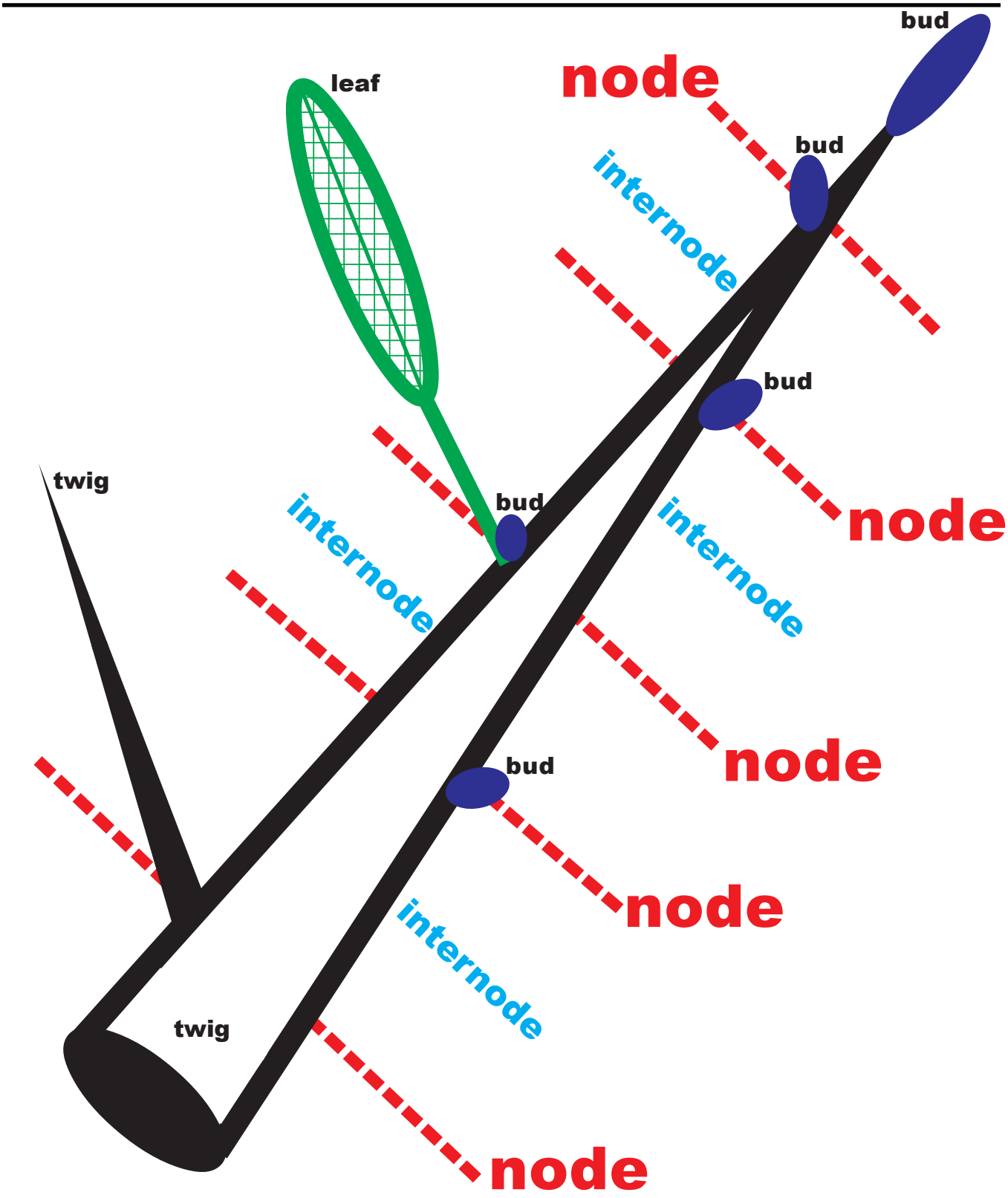

Figure 7: Diagram of twig with five nodes (dotted lines across twig) and four internode areas identified.

Trees are modular and segmented with an internode and node making one structural unit – sometime termed a shoot. Figure 8. Without nodes, internode elongation would stop, and without internodes, nodes would pile-up and smother each other. Defensive capabilities in above ground tree tissues are concentrated within nodes.

Tree Crowns

In defining trees and tree forms, total above ground size, stem and crown shape, and crown composition (number of branches, branchlets, and twigs, and their relative positions) are key. A few terms help better define crown components. A leader is the upper-most portion of the main axis of a tree. Polycormic describes a tree with several strong vertical axises.

The crown of a tree is the upper portion of main axis (stem) bearing live branches and foliage. The shape of a crown is fashioned by branch growth rates. The terms for branch elongation setting crown shape are: acrotony where upper branches elongate most; mesotony where the middle branches elongate most; and, basitony where lower branches elongate most. Figure 9

The elongation of twigs is usually generically divided into long shoots where internode growth is allowed to elongate; short shoots where internode growth is constrained (but not completely stopped) in elongation; and, spur shoots where internodes elongate only slightly. Orientation of twig, branchlet, and branch growth is divided between orthotropic shoots which have a vertical growth habit and plagiotrophic shoots which approach a horizontal growth habit. Figure 10.

Tree Forms & Shapes

Tree form plants can be divided into five general shapes based upon where the crown is located above the ground. Figure 11.

— Abcurrent tree forms have an aerial terminal bud and leaves (palm-like).

— Adcurrent tree forms have basal buds and leaves (ground hugging yucca-like).

— Bicurrent tree forms have irregular forked branching usually with thick green stems (catus-like).

— Decurrent (deliquescent) tree forms have many dominant branches with a spreading crown form caused by lateral branches growing at similar rates as the main axis terminal (leader), or the terminal continues to die with lateral branches rebranching continuously (so no one central axis develops, but many spreading branches).

— Excurrent tree form has a single dominant axis (leader) and forms a conical shaped crown as the terminal elongates more annually than lateral branches (a distinct main axis and many short secondary branches.

Tree crown shape have been described in many ways and represent many shapes. Crown shape descriptions represent both an outward crown appearance and an internal branching form. Figure 12. Some generic side-view shapes are given in Figure 13. Another way to describe tree crown shape, lateral area, wind drag, and volume is by using solid geometric shape descriptors. Figure 14 provides the 10 general crown shape forms with relative side area, crown volume, and drag for each. Figure 15 shows the shape outlines of these crown forms from the side.

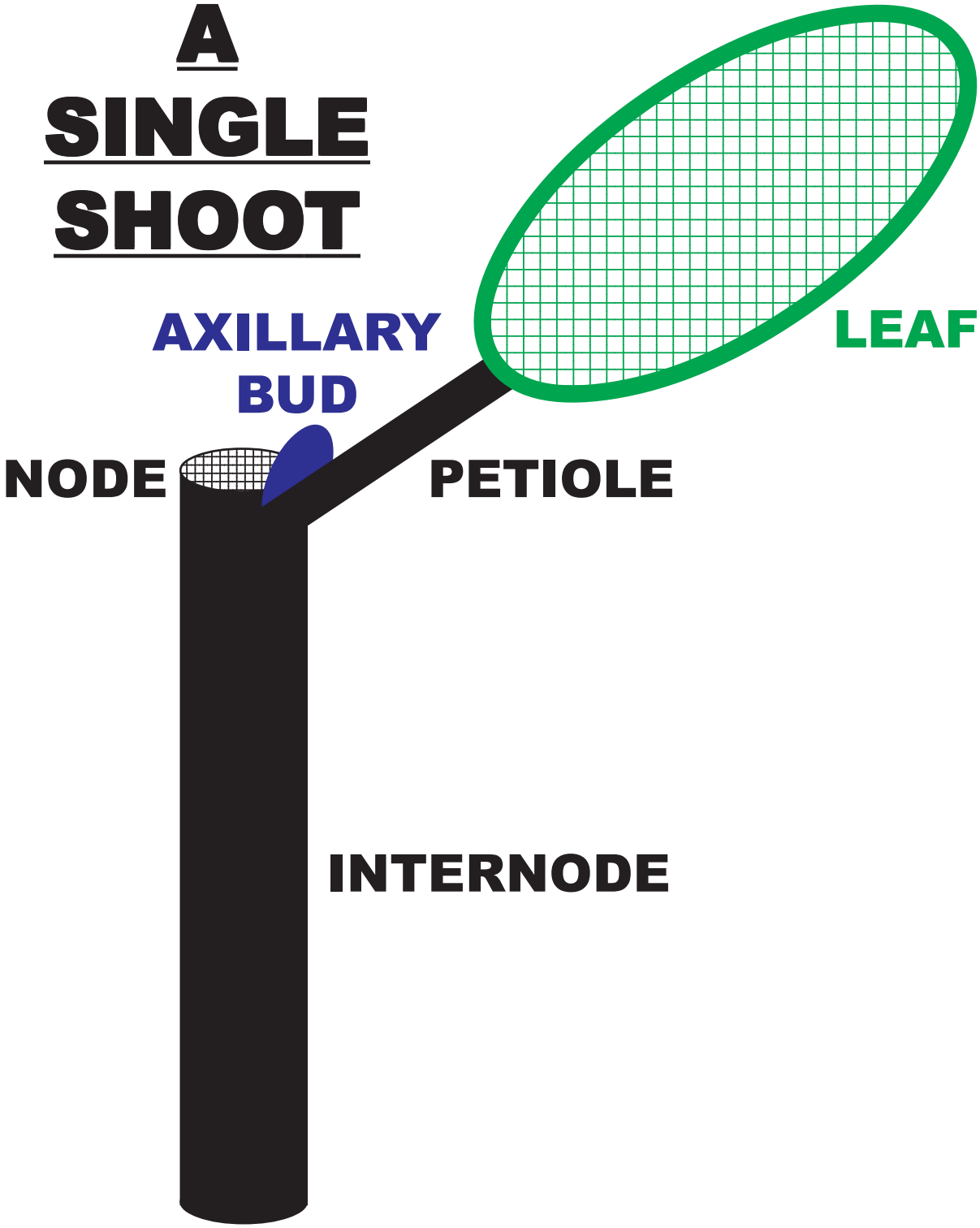

Figure 8: Defining a non-terminal shoot, module, phytomer, or metamer (one modular twig segement). A terminal shoot would also contain an apical growing point.

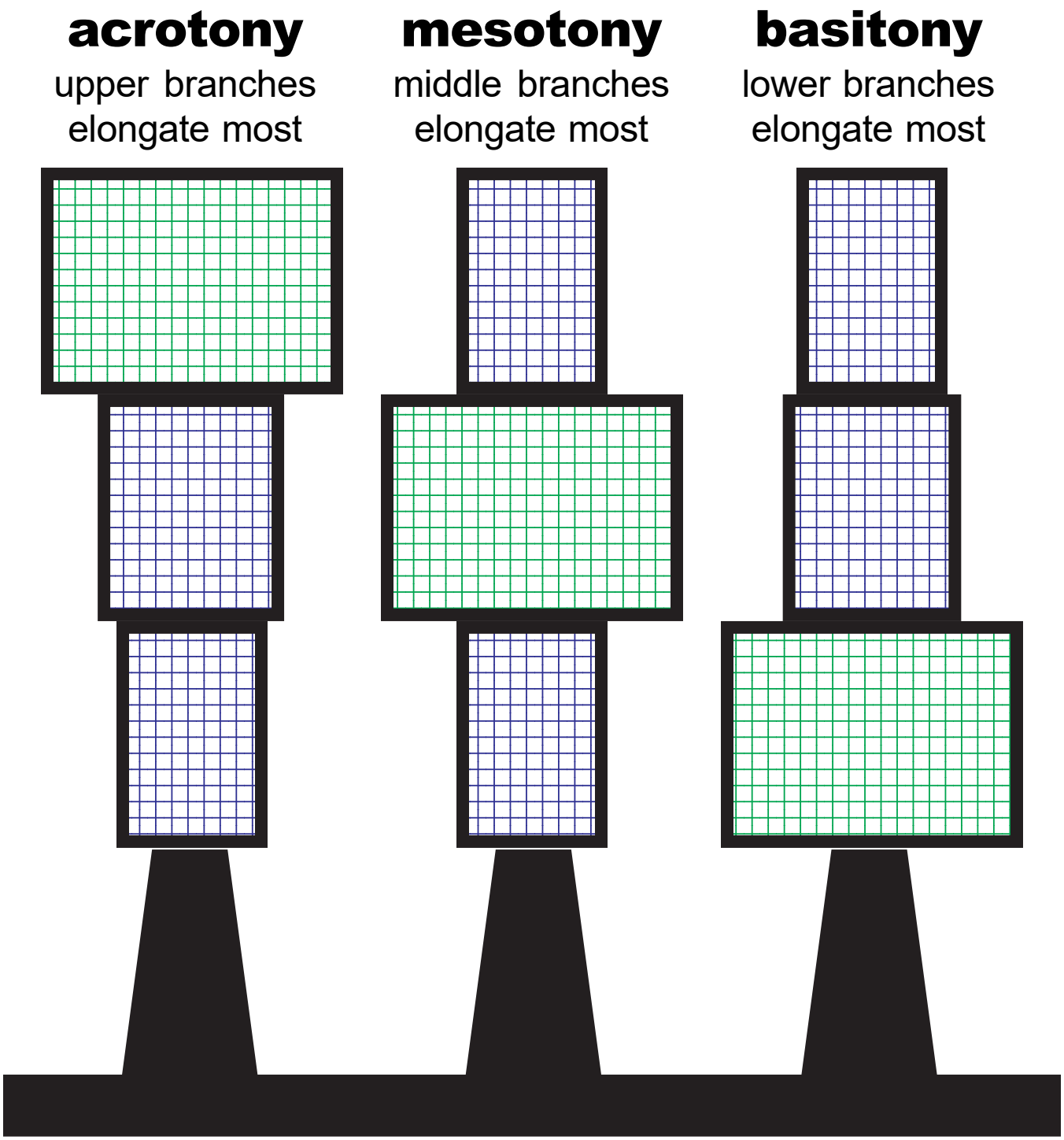

Figure 9: Branch elongation forms which determine crown shape.

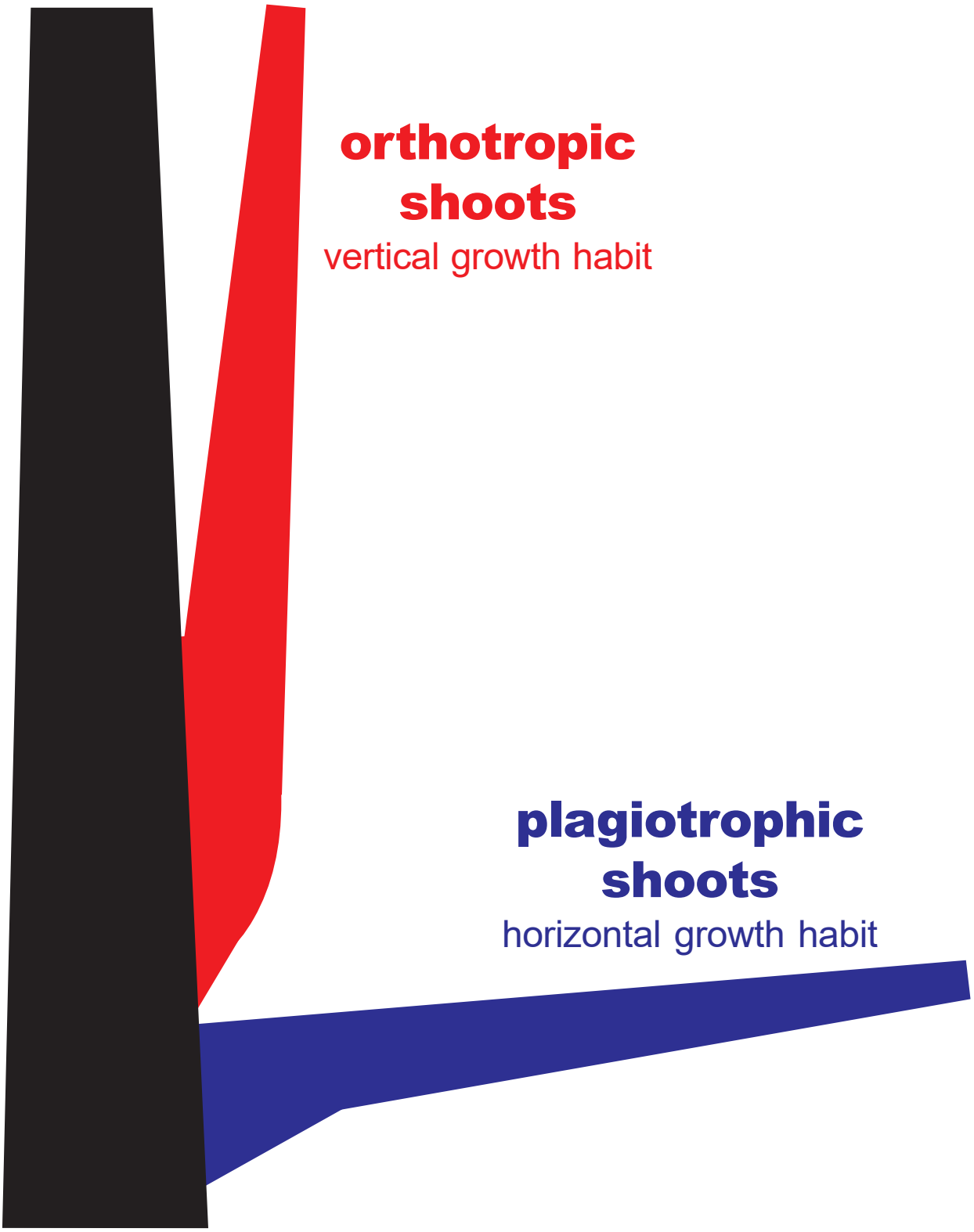

Figure 10: Orientation of twig, branchlet, and branch growth.

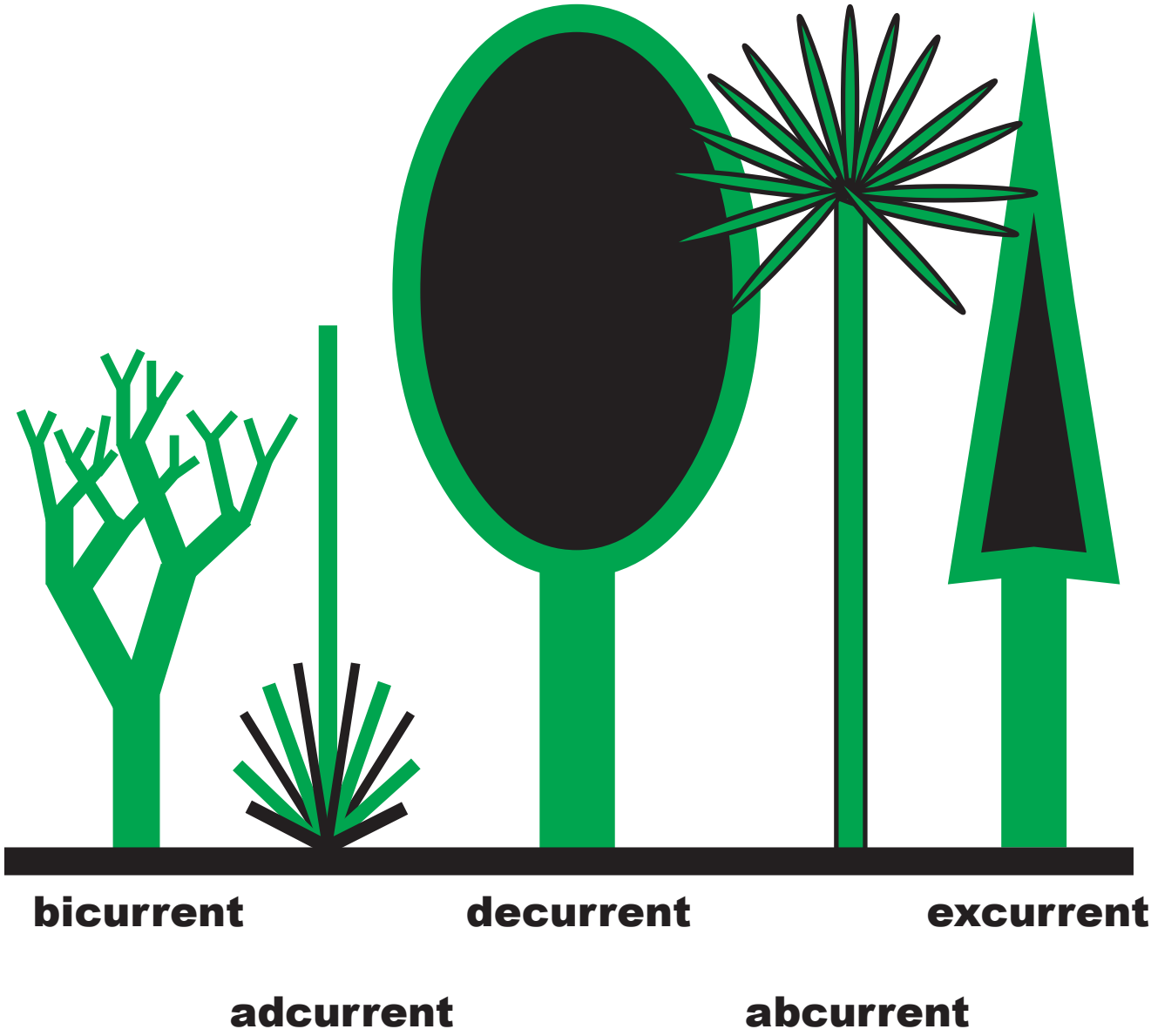

Figure 11: Five primary crown architectures found in tree-form plants.

Bicurrent = irregular, forked, thick green stems (cactus-like);
Adcurrent = basal buds & leaves (ground yucca types);
Decurrent or deliquescent = many dominant branches, spreading form;
Abcurrent = aerial terminal bud & leaves (palm-like);
Excurrent = single dominant leader, conical form.

Figure 12: Terms describing common tree crown shapes and branching habits.

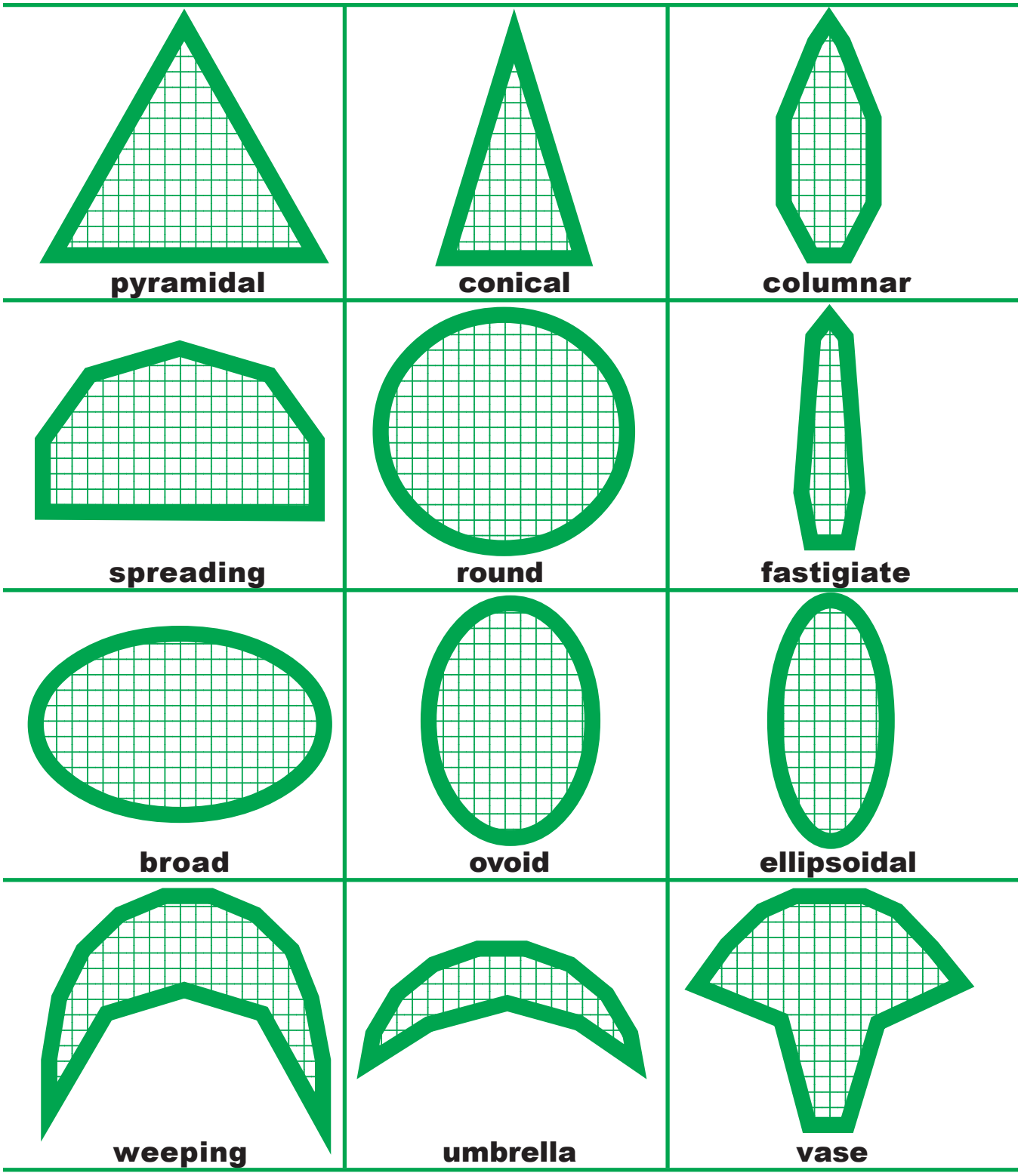

Figure 13: Common tree crown shape descriptions.

geometric shape	relative / proportional		
	lateral area	crown volume	drag
square / cylinder	1.0	0.8	1.0
round edge cylinder	0.9	0.7	0.84
elongated spheroid	0.8	0.6	0.68
spheroid	0.7	0.5	0.53
expanded paraboid	0.6	0.5	0.54
paraboloid	0.5	0.4	0.42
fat cone	0.4	0.3	0.29
cone	0.3	0.25	0.17
neiloid	0.2	0.2	0.08
thin neiloid	0.1	0.1	0.01

Figure 14: Tree crown geometric shape descriptors and relative or proportional lateral (frontal) view area, crown volume, and solid shape drag.
(drag value based upon drag of a solid cube = 1.27).

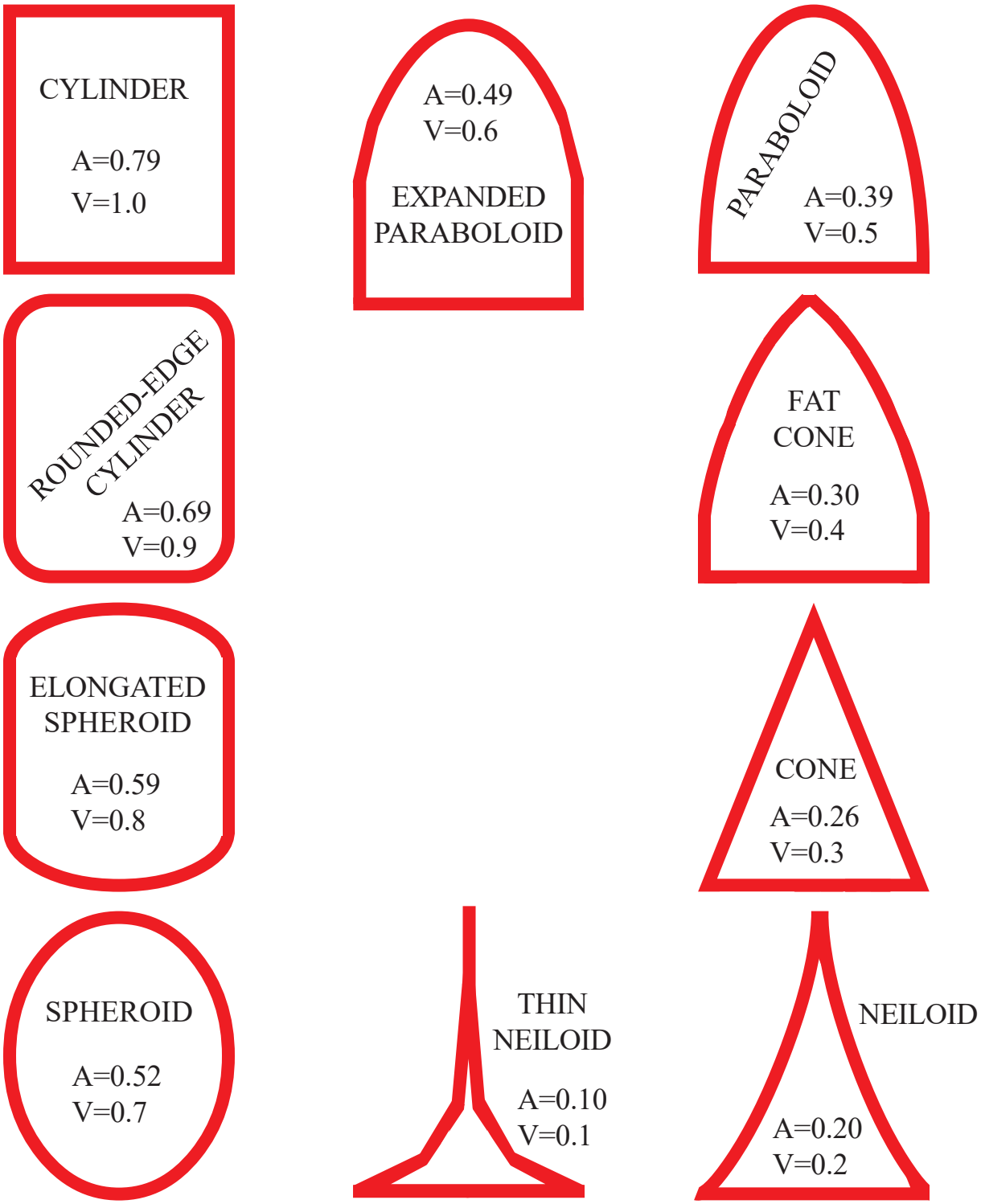

Figure 15: Idealized side view of different tree crown shapes.
All shapes have circular cross-sections, or are round when viewed from above. Shape names, relative crown area (A), and crown volume (V) values provided.

Crown Ratios

The size of a tree crown can be estimated using linear, area, or volume measures. One simple measure commonly used to describe tree crowns, and tree health and structural attributes, is live crown ratio. Live crown ratio is the proportion of total tree height along the main axis which carries living branches with foliage. Stem and basal sprouts are not included in this measure. The total vertical linear height of the live branch area along the main stem is divided by total tree height. The result is a decimal percentage which is live crown ratio. Figure 16.

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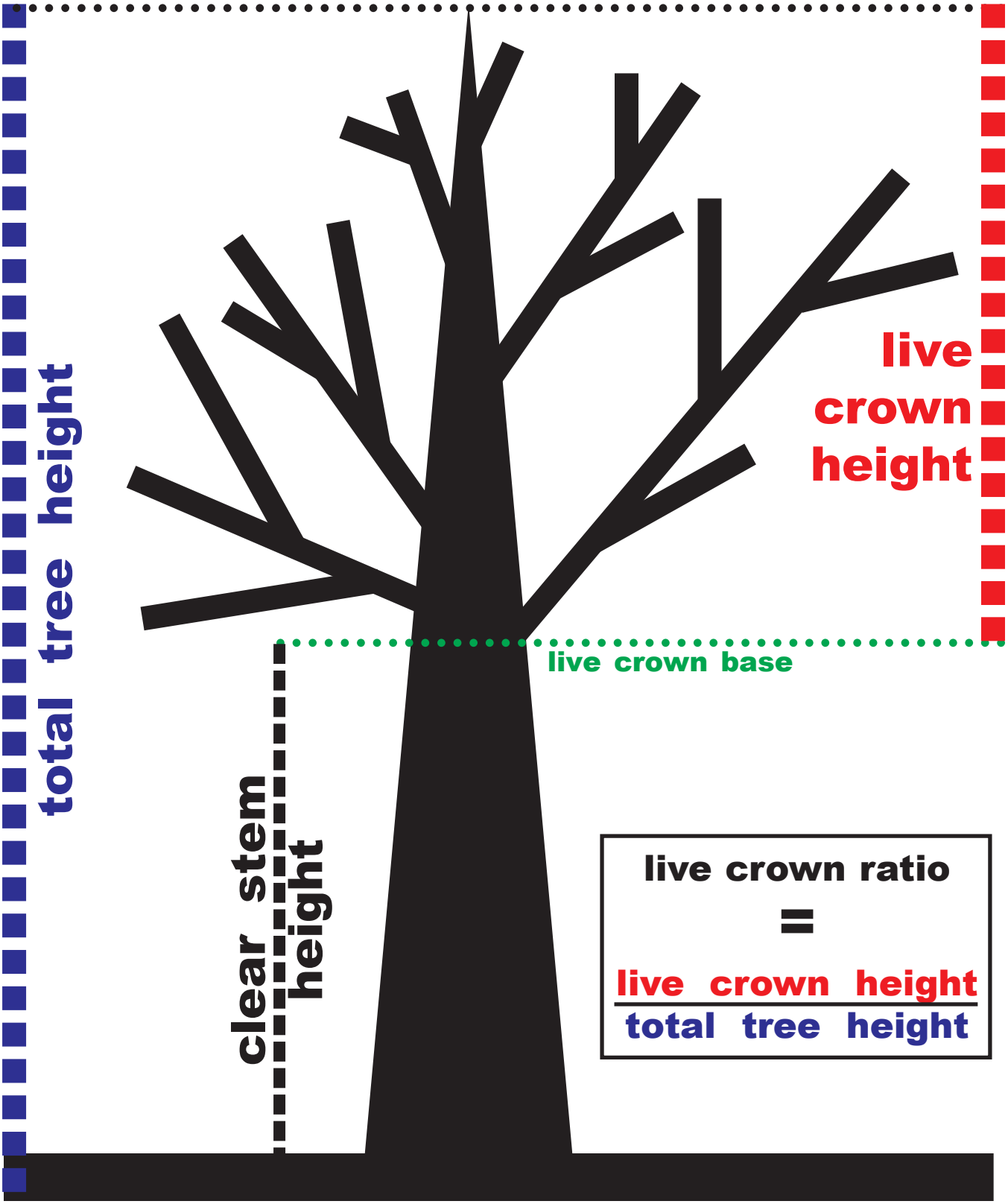

Figure 16: Diagram of various height measures in a tree and the formula for determining live crown ratio.