Chapter 7

Stealth Learning: Acquiring Knowledge About Vascular Plant Structure While Using a Vegetative Key

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Introduction

Understanding the basic structure of the vegetative body of vascular plants and learning the terminology that is used to describe features of plants is an important component of any general botany course. This material could be taught in the lab, by getting students to observe various plant specimens and learn their characteristics. The problem is that many students will find this exercise tedious and boring. They will rapidly lose interest and fail to acquire the necessary knowledge. An alternative approach is to have them go outside and attempt to identify unknown plants, using a key based on their vegetative features. As they learn to use the key, the students gradually pick up the terminology and learn to understand the structure of plants in the process.

This exercise is most suitable for students in a freshman or sophomore level botany or plant biology course. It is designed to fit into a standard 3-hour lab period. Development of a key for your campus area will take between 2 days and a few weeks, depending on your knowledge of the flora and familiarity with the terminology. Once the key is ready, setup time for the lab is minimal. Allow enough time after the lab to go around and collect the labels that you attached to the plants.

Materials

- A selection of vascular plants around campus with a range of vegetative (non-reproductive) features
- Colored cardboard tags with large alphabetic letters or numbers
- Pins to attach tags to plants
- A clipboard for each student
- A small metric ruler for each student

Student Outline

Introduction

The vegetative or non-reproductive body of a vascular plant consists of a **root system** and **shoot system**. The root system is usually underground and its main functions are anchorage of the plant, absorption of water and minerals from the soil, and storage of food. In this lab, we concentrate on the shoot system, which is the part of the plant that we normally see growing above ground. The main business of the shoot system is food production, which usually occurs in flattened structures that are specialized to carry out photosynthesis: the **leaves**. These leaves are attached to **stems** that provide the necessary support to elevate the leaves into a position where they will be able to intercept enough light.

Vascular plant shoot systems display an amazing amount of variation in form. At first glance the shoots of a grass would appear to have little in common with those of a forest tree, and both of these seem completely different in structure from a cactus or a fern. Nevertheless, the shoots of all vascular plants are based on the same overall design (Figure 1).

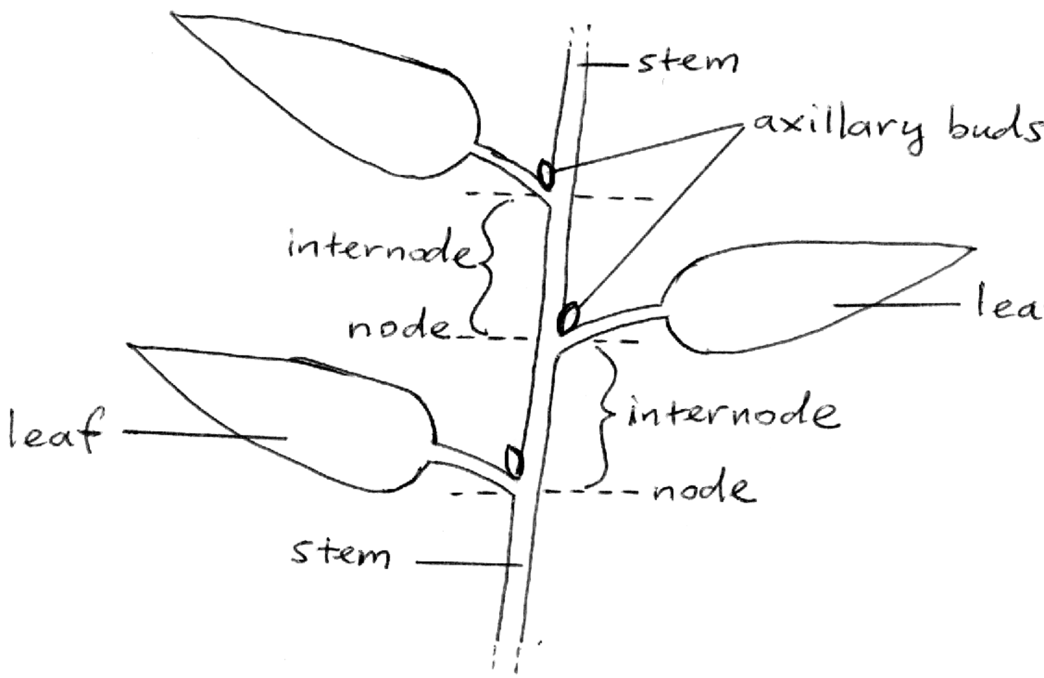

Figure 1: Structure of the vascular plant shoot system.

Leaves arise only from certain points on a stem, which are called **nodes**. The sections of stem in between the nodes are known as **internodes**. At each node, one or more leaves are attached to the stem. The number of leaves per node varies among different species of plants, but is usually constant within a species. The plant in Figure 1 has only one leaf per node.

Just above the point where a leaf is attached to the stem is a bud that is capable of developing into a branch. The V-shaped angle formed by the leaf and stem is called an **axil**. Because they are always located in an axil, the buds are known as **axillary buds**. Many of these buds remain dormant, but some of them may begin to expand and form a **branch** or lateral stem. Each lateral stem has all the same structures as the stem from which it diverged, with nodes, internodes, leaves and axillary buds.

To describe the diversity of vascular plant forms and accurately communicate it to others, botanists have developed a rich terminology. In this lab, you will learn the basics of this language. The following section explains, with the help of drawings, all of the terms that you will need to understand in order to use a vegetative key to identify unfamiliar plants. Read through this section, but don't be too concerned if you don't immediately absorb all of this information. You will gradually become familiar with the terminology as you apply it to keying out plants during the lab.

Vegetative features of vascular plants

Leaf arrangement (phyllotaxy)

Phyllotaxy is the pattern of leaf arrangement along a stem. Some plants have only one leaf arising from each node. This is known as **alternate** phyllotaxy (Figure 2a). More simply, you can say that this kind of plant has "alternate leaves." Another common arrangement is to have two leaves arising from each node, on opposite sides of the stem. Not surprisingly, this is called **opposite** phyllotaxy (Figure 2b). Some plants have more than two leaves attached at each node; that arrangement is called **whorled** phyllotaxy (Figure 2c).

When you are observing a plant's phyllotaxy, you have to be cautious, because new shoots may take a while to expand and most of the growth occurs in the internodes. As a result, the leaves in younger parts of a shoot (typically towards the ends of branches) may appear to be opposite or whorled, but as the shoots grow it becomes clear that they are really alternate.

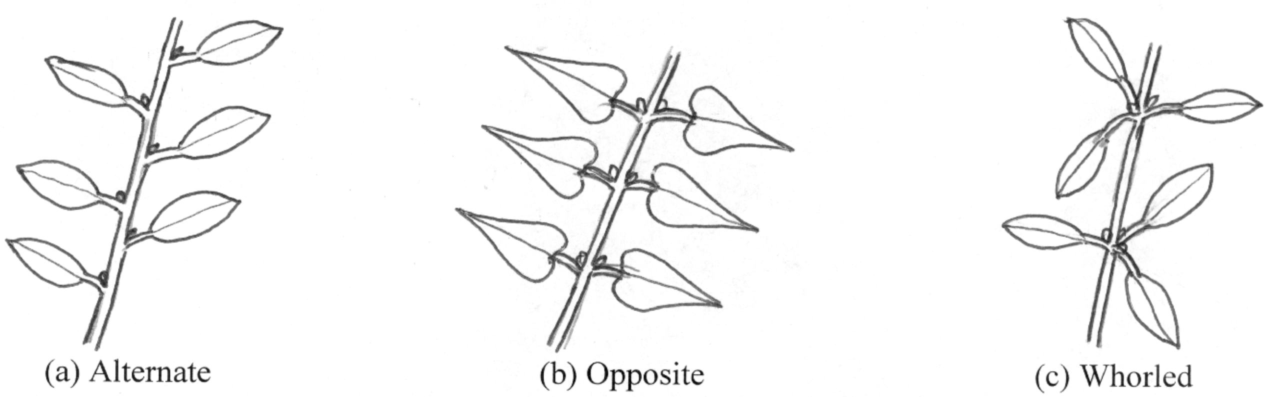

Figure 2: The three common types of leaf arrangement or phyllotaxy.

Leaf structure

A "typical" leaf has two main parts: the **petiole**, a stalk that attaches the leaf to the stem, and the flattened blade or **lamina** in which most of the photosynthesis goes on (Figure 3). The part of the lamina closest to the petiole is known as the **base** of the leaf, and the tip of the lamina is called the **apex**. The edge of the lamina is known as the **margin**. **Stipules** are a pair of appendages close to the point where the petiole joins the stem. They may be attached to the petiole or connected to the stem on either side of the petiole's point of attachment (Figure 3). Many species have no stipules.

In those that do have them, they may be small and scale-like or large and leaf-like. In some plants, the stipules are found only on new growth and they drop off as the shoots get older.

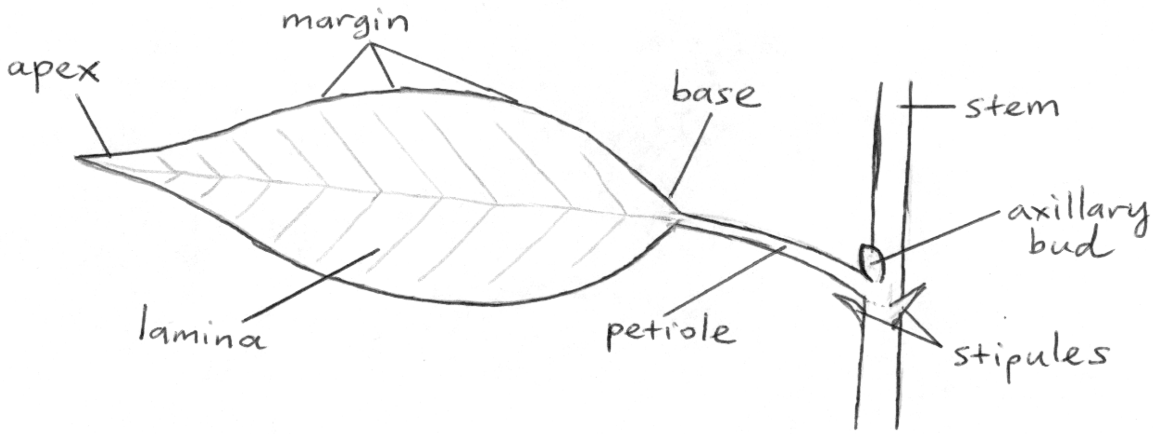

Figure 3: Structure of a typical leaf.

When the margin of the lamina forms a smooth curve it is said to be **entire** (Figure 4a). Some leaves have a **serrate** margin, with pointed "teeth" resembling the edge of a saw blade (Figure 4b), while others have rounded "teeth" and are described as **crenate** (Figure 4c). A **ciliate** margin is entire, but has a row of small hairs (Figure 4d).

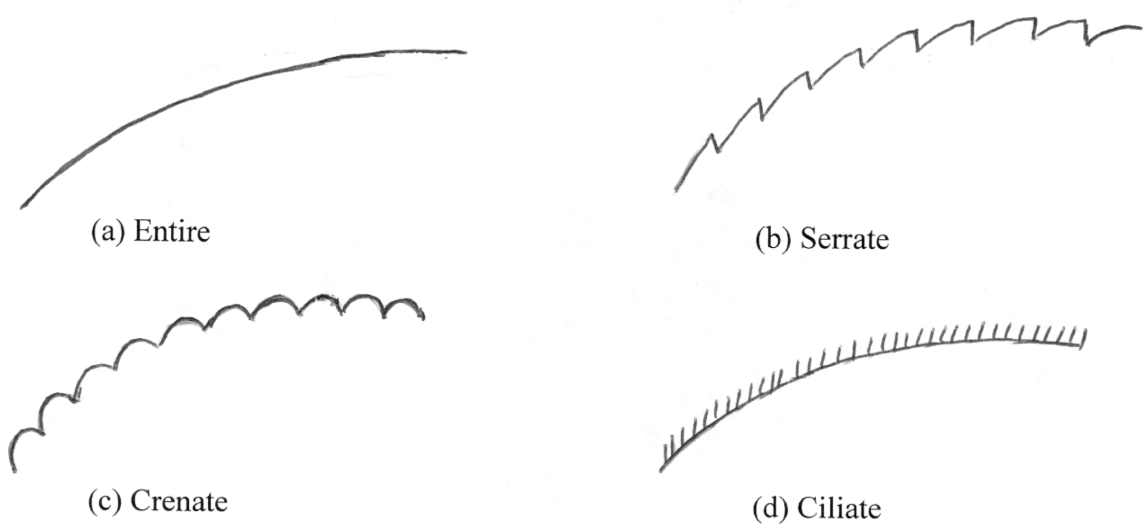

Figure 4: Types of leaf margins.

When you look at the lamina of a leaf, you can often see the main **veins** without magnification. These are part of the plant's transport system, made up of vascular tissues that move materials around its body. The arrangement of the major veins in a leaf is called **venation** and there are three main patterns. Grasses and most other monocots (lilies, orchids, sedges, *etc.*) have **parallel venation**, in which many veins run lengthwise along the lamina, roughly parallel to the margin (Figure 5a). Leaves with **pinnate venation** have a major vein, the **midrib**, running up the center of the lamina from the base to the apex, with smaller veins branching off either side (Figure 5b). Some leaves have **palmate venation**, where several major veins radiate out from the base of the leaf where the petiole joins the lamina (Figure 5c).

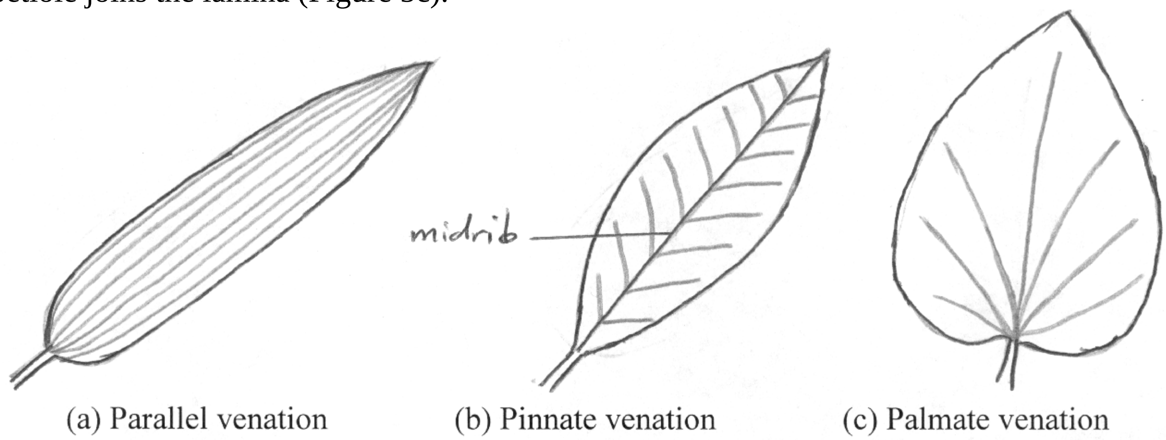

Figure 5: Patterns of leaf venation.

Simple and compound leaves

In a **simple leaf**, the lamina consists of one continuous sheet of tissues. Some examples of simple leaves are shown in Figure 6. The leaf margins of some plants have indentations that partially divide the lamina into lobes. The indentations in a **lobed** leaf can be deep, but as long as the lamina consists of only one piece it is still considered to be a simple leaf. Lobing patterns vary. If the lobes diverge from either side of the midrib, the leaf is said to be **pinnately lobed** (Figure 6b). In a **palmately lobed** leaf (Figure 6c), the lobes radiate from a single point near the base of the lamina.

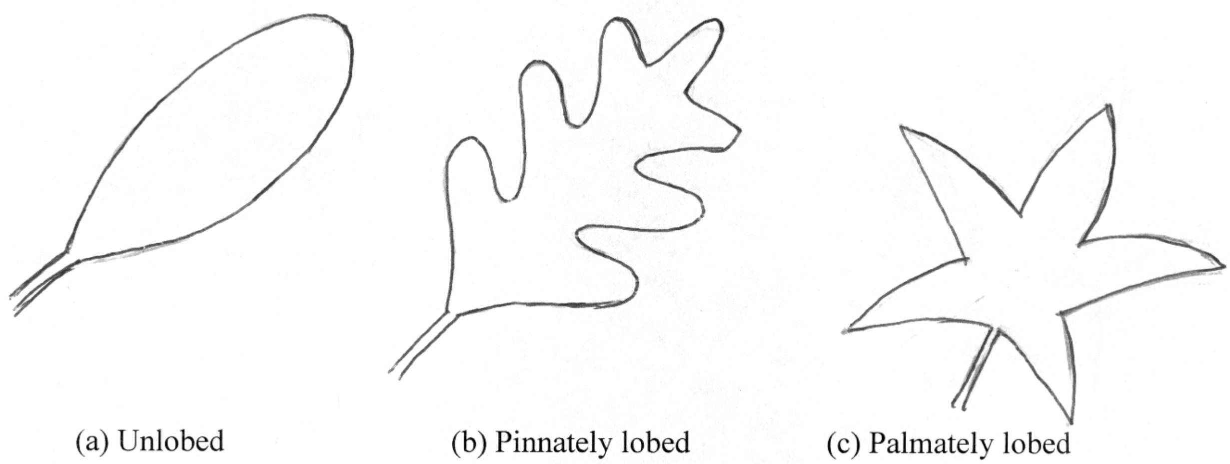

Figure 6: Examples of simple leaves.

Compound leaves have a lamina made up of several distinct parts, each of which looks superficially like a separate leaf. These parts are known as **leaflets,** and the stalks that attach them to the axes of the compound leaf are called **petiolules**. A compound leaf that has only three leaflets is called a **trifoliolate leaf** (Figure 7a). Probably the most famous plants with trifoliolate leaves are the clovers. The so-called "four-leaved clover" that is reputed to bring good luck is a mutant that has four leaflets per leaf instead of the usual three. A **pinnate leaf** is a compound leaf with leaflets attached to opposite sides of a central axis, known as a rachis (Figure 7b). In a **bipinnate leaf**, the leaflets attached to the rachis are themselves further divided into smaller leaflets (Figure 7c). Another kind of compound leaf is the **palmate leaf**, in which the leaflets radiate from the tip of the petiole (Figure 7d). To avoid confusing a pinnate leaf with a pinnately lobed simple leaf or a palmate leaf with a palmately lobed simple leaf, compare Figures 7b and 7d with Figures 6b and 6c. For leaf to be regarded as a compound leaf, the lamina must be divided into completely separate leaflets, not just deeply lobed.

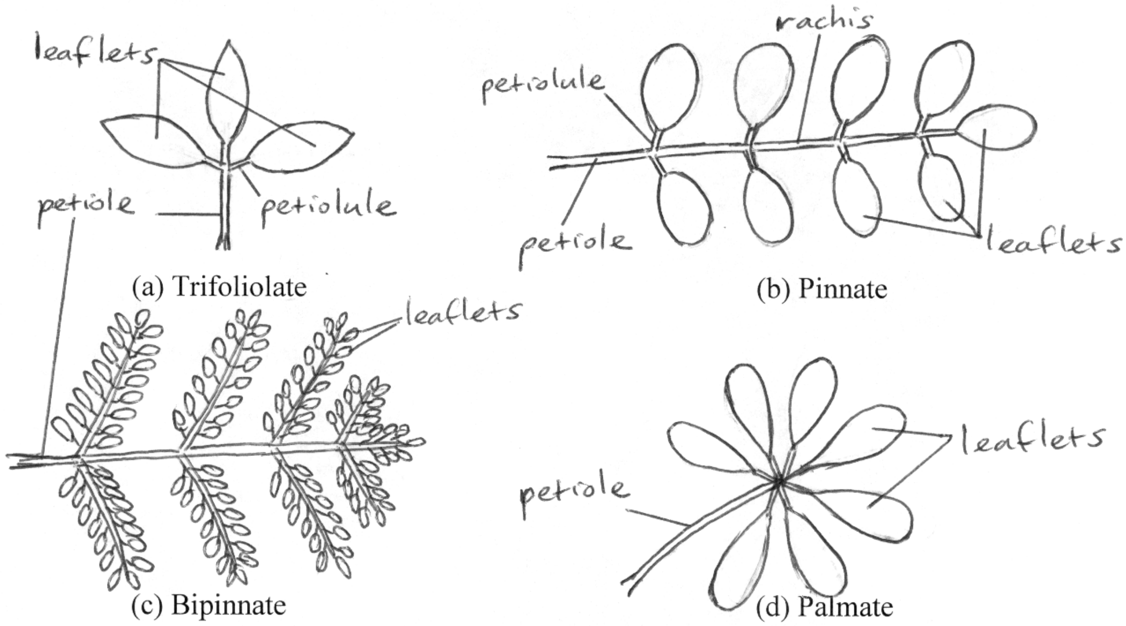

Figure 7: Examples of compound leaves.

How to distinguish simple and compound leaves

When examining the foliage of an unfamiliar plant, there are several clues that will help you to work out whether the flattened structures you are observing are the laminae of simple leaves or the leaflets of compound leaves. Firstly, look for axillary buds. Buds always occur in the axil of a leaf, so if you find a bud, you can be sure that the axis on one side of it is a stem and the stalk on the other side is the petiole of a leaf. The leaflets in a compound leaf will never have buds in their axils. In some plants, buds are deeply embedded or else very small and therefore difficult to see. Branches develop from axillary buds, so sometimes a branch may help you identify a leaf axil. Stipules are another clue that you are looking at the base of the petiole of a leaf, rather than the petiolule of a leaflet in a compound leaf. Finally, the flat surfaces of the leaflets in a compound leaf are usually aligned so that they all fall roughly into a single flat surface or plane. The laminae of simple leaves have this arrangement in some plants, however, so you will need additional evidence (*e.g.*, location of buds) before you conclude that a plant has compound leaves.

Leaf shape

Leaves come in an enormous variety of shapes, a selection of which is illustrated in Figure 8. In an **elliptic** leaf (Figure 8a), the widest part of the lamina is about halfway between the apex and the base (elliptic means “shaped like an ellipse”). **Linear** leaves (Figure 8b) and **broadly elliptic** leaves (Figure 8c) are narrower or wider variants of this basic elliptic shape.

If the widest point is closer to the base, the leaf is said to be **lanceolate** (Figure 8d), which means “shaped like the head of a lance”. **Ovate** leaves are a broader variant of this shape (Figure 8e). A leaf that has the same basic proportions as a lanceolate leaf, but is curved to one side like the blade of a sickle, is said to be **falcate** (Figure 8f). When the widest point is towards the apex of the lamina, the shape is called **oblanceolate** (Figure 8g), or **obovate** if the leaf is broader relative to its length (Figure 8h). An extreme form of an oblanceolate shape, where the widest point is right at the apex and the lamina is shaped like a wedge, is known as **cuneate** (Figure 8i).

All of the above terms may be applied either to the lamina of a simple leaf, or to the leaflets of a compound leaf. The overall outline of a lobed simple leaf may also be described using one of these basic shapes. For example, the pinnately lobed leaf in Figure 6b is ovate in shape. An **acicular** leaf (Figure 8j) has a very narrow, needle-shaped lamina that is rounded in cross-section. Some plants have tiny, **scale-like** leaves (Figure 8k), which are usually folded in against the stem and may overlap each other like roofing tiles.

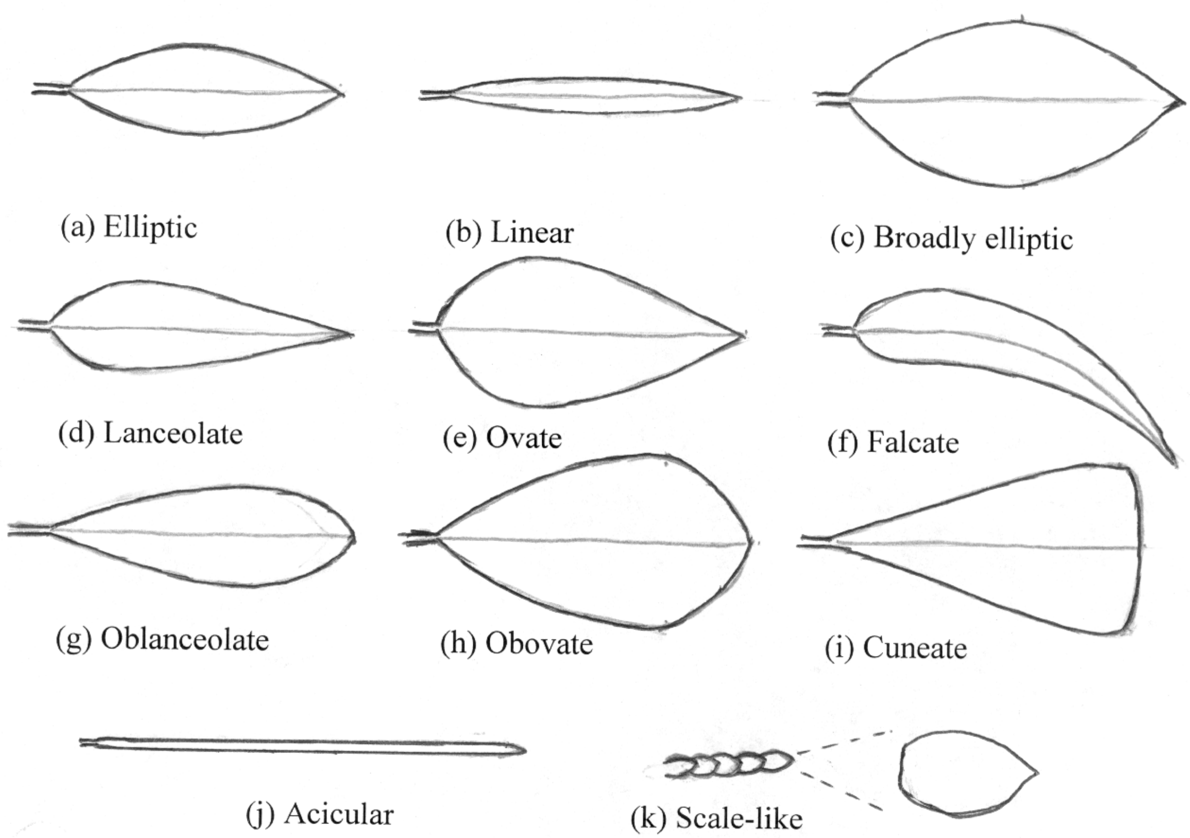

Figure 8: Some common leaf shapes.

Special terms are used to describe the base and apex of a leaf. When the margins of the lamina make an angle less than 90° where they meet at the base of the leaf, the leaf base is said to be **acute** (Figure 9a). If the angle is greater than 90°, the leaf base is **obtuse** (Figure 9b). The term **cordate** ("heart-shaped") is used when the margins curve around and form a notch at the base of the leaf (Figure 9c), giving the lamina the overall form of an upside-down heart. Leaves with a cordate base or often loosely termed "cordate leaves," irrespective of the overall shape of the lamina.

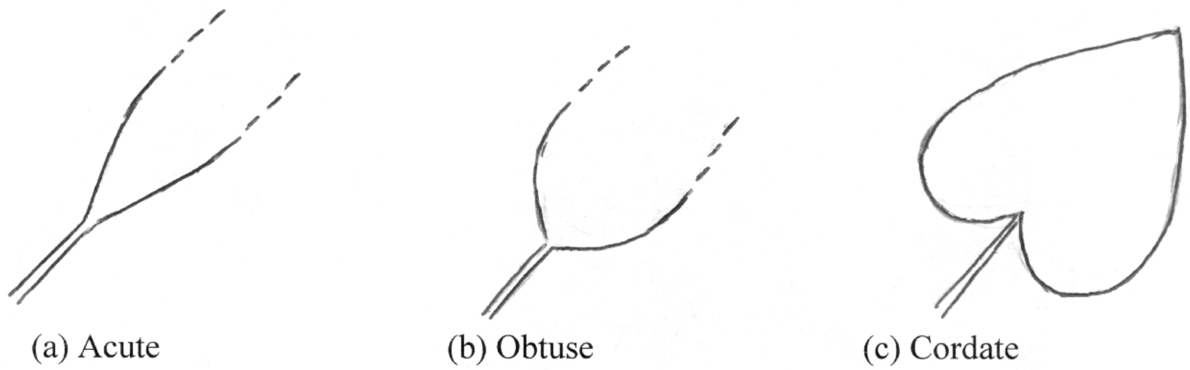

Figure 9: Leaf bases.

The terms **acute** and obtuse may also be applied to the apex of a leaf (Figures 10a,b). If the apex is formed into a short point it is said to be **apiculate** (Figure 10c), while an apex with a long, tapered point is called **acuminate** (Figure 10d).

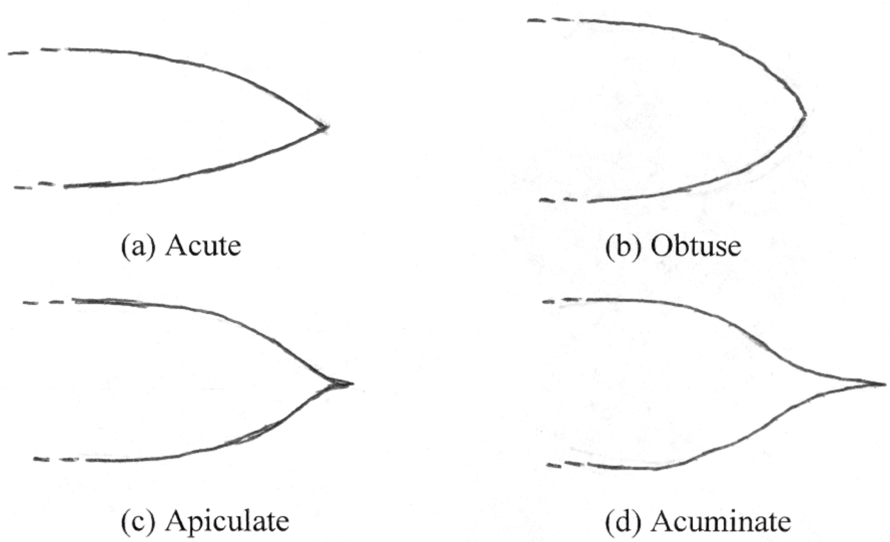

Figure 10: Leaf apices.

Taxonomic keys

A taxonomic key is a method for efficiently identifying an unknown species. The key is made up of a series of choices, based on observed features of the specimen. If you make the correct choice at each step in the key, you will eventually arrive at the name of the species (provided, of course, that the designer of the key included that species).

Keys in which each choice involves only two alternatives are called **dichotomous keys** and that's the type we will be using in this lab. Driving a dichotomous key is like traveling a roadway that forks repeatedly. If you take the correct fork each time, you will ultimately arrive at the correct destination. Here are some tips that will help you to use the key successfully.

- Always start at the top of the key (step 1).
- Before you make your decision about which way to go at each step, read both of the alternatives carefully. Sometimes the first alternative may seem to be correct, but the second one turns out to be even better for your specimen.
- If you are unsure about the meaning of any terms used in the key, check back over the preceding section on vegetative features of vascular plants.
- When measurements are needed, use a ruler. Do not "guestimate."
- Plants, like all living organisms, are variable. Leaves can vary in shape or arrangement between plants of the same species, or even within an individual plant, so always examine a number of examples before making your decision.

Use the key on the following pages to identify each of the plants pointed out by the instructor. Once you have arrived at a name, check it with the instructor. If your identification was incorrect, check back carefully over the key to see where you went astray.

A vegetative key to woody plants of the LSU campus

1.	Leaves acicular, scale-like or linear (go to step 2)	
	Leaves otherwise (go to step 6)	
2.	Leaves acicular, arranged in bundles at the tip of short branches (go to step 3)	
	Leaves scale-like or linear (go to step 4)	
3.	Leaves 4-10 cm long, 2 leaves per bundle	*Pinus glabra* (spruce pine)
	Leaves 15-25 cm long, 2 or 3 leaves per bundle	*Pinus eliottii* (slash pine)
4.	Leaves scale-like or linear with a sharp point, <1 cm long	*Juniperus virginiana* (Eastern red cedar)
	Leaves linear, not sharply pointed, >1cm long (go to step 5)	
5.	Leaves 1-2 cm long, thin	*Taxodium distichum* (baldcypress)
	Leaves 7-10 cm long, thick and leathery	*Podocarpus macrophylla* (Japanese plum pine)
6.	Leaves compound (go to step 7)	
	Leaves simple, though the lamina may be deeply lobed (go to step 18)	
7.	Leaves trifoliolate or palmate (go to step 8)	
	Leaves pinnate, bipinnate or 3-4 times pinnate (go to step 10)	
8.	Leaves palmate, margins of leaflets serrate	*Parthenocissus quiquefolia* (Virginia creeper)
	Leaves trifoliolate, margins of leaflets entire (go to step 9)	
9.	Phyllotaxy opposite	*Jasminum mesnyi* (primrose jasmine)
	Phyllotaxy alternate	*Ptelea trifoliata* (wafer ash)
10.	Leaves bipinnate or 3-4 times pinnate (go to step 11)	
	Leaves pinnate (go to step 14)	
11.	Stipules broad and membranous, plant prostrate, leaflets fold rapidly if touched	*Mimosa strigillosa* (sensitive plant)
	Stipules absent, plant not as above (go to step 12)	
12.	Leaves 3-4 times pinnate	*Nandina domestica* (heavenly bamboo)
	Leaves bipinnate (go to step 13)	
13.	Margins of leaflets entire, plant is a tree	*Albizia julibrissin* (mimosa or silk tree)
	Margins of leaflets serrate, plant is a vine	*Ampelopsis arborea* (pepper vine)
14.	Phyllotaxy opposite (go to step 15)	
	Phyllotaxy alternate (go to step 16)	
15.	Petioles reddish, plant is a tree	*Acer negundo* (boxelder)
	Petioles green, plant is a vine	*Campsis radicans* (trumpet vine)
16.	Leaflets elliptic, stipules modified into sharp thorns	*Robinia pseudoacacia* (black locust)
	Leaflets lanceolate or falcate, stipules absent (go to step 17)	
17.	Margins of leaflets entire, base acute	*Sapindus drummondii* (Western soapberry)
	Margins of leaflets serrate, base obtuse	*Carya illinoiensis* (pecan)

18. Phyllotaxy opposite (go to step 19)
Phyllotaxy alternate (go to step 24)

19. Leaf margin entire, lamina not lobed (go to step 20)
Leaf margin serrate, lamina may be 3-lobed (go to step 22)

20. Lamina 1-2 cm long, stems square in section — *Buxus microphylla* (littleleaf boxwood)
Lamina >2 cm long, stems round in section (go to step 21)

21. Leaf apex apiculate to acuminate, twining undershrub — *Trachelospermum jasminoides* (star jasmine)
Leaf apex obtuse to acute, shrub or small tree — *Ligustrum lucidum* (Chinese privet)

22. Lamina 3-lobed, base cordate — *Acer rubrum* (red maple)
Lamina not lobed, base obtuse or acute (go to step 23)

23. Lamina glabrous (hairless), base obtuse — *Acuba japonica* (Japanese laurel)
Lamina hairy, base acute — *Callicarpa americana* (American beautyberry)

24. Lamina cordate at base, may be deeply lobed (go to step 25)
Lamina obtuse or acute at base (go to step 29)

25. Leaf margin entire, stipules absent (go to step 26)
Leaf margin serrate, stipules present (go to step 27)

26. Lamina 3- or 5-lobed, petiole longer than lamina — *Firmiana simplex* (Chinese parasol tree)
Lamina not lobed, petiole shorter than lamina — *Cercis canadensis* (Eastern redbud)

27. Lamina asymmetric, not lobed — *Tilia americana* (American basswood)
Lamina symmetric, deeply lobed (go to step 28)

28. Leaf venation and lobing palmate — *Liquidambar styraciflua* (sweetgum)
Leaf venation and lobing pinnate — *Crataegus marshallii* (parsley hawthorn)

29. Leaf margin entire (go to step 30)
Leaf margin serrate or crenate (go to step 39)

30. Leaves obovate or cuneate (go to step 31)
Leaves elliptic, ovate or falcate (go to step 34)

31. Lamina cuneate, 3-lobed near apex — *Quercus nigra* (water oak)
Lamina neither cuneate nor 3-lobed (go to step 32)

32. Leaf apex acuminate — *Magnolia acuminata* (cucumber tree)
Leaf apex obtuse (go to step 33)

33. Petioles reddish-brown, 1-2 mm long — *Lagerstroemia indica* (crape myrtle)
Petioles yellowish-green, 6-10 mm long — *Pittosporum tobira* (Japanese mockorange)

34. Leaves ovate to falcate, base obtuse — *Maclura pomifera* (osage orange)
Leaves elliptic, base acute (go to step 35)

35. Leaves hairy on both surfaces, margin ciliate — *Rhododendron indica* (azalea)
Leaves glabrous (hairless) on upper surface (go to step 36)

36. Lamina 15-20 cm long — *Magnolia grandiflora* (Southern magnolia)
Lamina <10 cm long (go to step 37)

37. Leaf apex obtuse, petioles reddish-brown — *Lagerstroemia indica* (crape myrtle)
Leaf apex acute, apiculate or acuminate, petioles green (go to step 38)

38. Leaves with aromatic odor when crushed — *Cinnamomum camphora* (camphor laurel)
Leaves without aromatic odor — *Quercus virginiana* (live oak)

39. Lamina with three or more lobes (go to step 40)
Lamina not lobed (go to step 41)

40. Lamina pinnately lobed, with pinnate venation — *Quercus shumardii* (Shumard oak)
Lamina 3-lobed, with palmate venation — *Malvaviscus arboreus* (Turk's cap or wax mallow)

41. Leaf margin crenate — *Quercus michauxii* (cow oak)
Leaf margin serrate (go to step 42)

42. Lamina asymmetric — *Ulmus rubra* (slippery elm)
Lamina symmetric (go to step 43)

43. Petioles reddish (go to step 44)
Petioles green (go to step 45)

44. Lamina 2-3.5 cm long, margin evenly serrated — *Ilex vomitoria* (yaupon holly)
Lamina 5-7 cm long, margin serrated near apex — *Ilex cassine* (Dahoon holly)

45. Lamina 5-7 cm long, petiole 1-5mm long — *Camellia japonica* (camellia)
Lamina 7-10 cm long, petiole 8-12mm long — *Quercus virginiana* (live oak)

Notes for the Instructor

Preparing for the Lab

I generally conduct this lab outside and use trees, shrubs and woody vines growing around the campus. Students seem to like being outdoors for a change. I lead the class around from plant to plant and attach large colored letter labels. Students key out the plant and write the letter next to the species name. I ask them to check each identification with me. If they get one wrong, I suggest that they go back over the key with me and see where the error occurred.

In the weather is inclement, the lab could be held in a laboratory, with specimens of each plant in large jars. Care would be needed to ensure that each specimen was large enough to adequately display such features as phyllotaxy. You might want to collect specimens from several different plants in order to display natural variability. In climatic zones where deciduous species are leafless during the part of the teaching semester when the lab occurs, you could either restrict the exercise to evergreen species or use dried, pressed specimens in the laboratory.

The most challenging part of the lab preparation is developing the key the first time you run it. If you find a good vegetative key to the plants in your area, you may want to use it directly or modify it for use in this lab. If so, make sure that all the terms used in the key are explained in the student lab manual. I developed the key for this workshop exercise from scratch. Here is how I did it.

First I set up a spreadsheet with species name in column A and columns for each vegetative feature that I might include in the key. The features I included were Phyllotaxy, Leaf Type (simple, pinnate, palmate etc), Leaf(let) Shape, Leaf Lobing, Leaf Venation, Leaf Margin, Leaf Apex, Leaf Base, Leaf Symmetry, Upper Leaf Color, Lower Leaf Color, Lamina Length, Lamina Width, Petiole Length, Stipules, Petiole Color, Twig Color, Bark Type and Other Special Features (odors, thorns, *etc.*). I then did a tour of the parts of the campus within easy walking distance of the lab and recorded the features of a selection of plants on a printout of the spreadsheet. I used identification books and taxonomic experts in the department to determine any unfamiliar species.

Having obtained the data, I entered it into the spreadsheet. I then used the sorting function in the spreadsheet to sort the species on various combinations of features, in order to identify features that would make good dichotomies in a key. To construct an efficient key, in which the number of steps required to identify species is minimized, it is best to find features that separate the remaining species at each step into two groups of roughly equal size. This will not always be possible, of course. Another point to remember when developing the key is that it should include as key features all of the terms that you would like the students to learn. *If you would like a copy of the Excel spreadsheet containing the data on which the key in this exercise is based, please email me.*

It is usually best to separate out species that have very distinctive or unusual features at the start of the key. For example, in my key I isolated the gymnosperms, which have either acicular leaves (needles), scale-like leaves, or linear leaves, at the start.

For species that are variable on certain key features, it is often necessary to have more than one pathway to that species in the key. Note that I have included both *Lagerstroemia indica* (crape myrtle) and *Quercus virginiana* (live oak) twice in my key. Crape myrtle has leaves that vary in shape from elliptic to obovate and live oak has leaves that sometimes have entire and sometimes serrate margins.

There is, of course, no single “correct” key for a group of species. By trial and error, you will eventually obtain one that works. As students use the key, you will probably find that some of your choices are either misleading or you may even discover errors in the key. This will allow you to refine the key for the following semester.

If you are conducting the lab outdoors, work out a suitable circuit along which you will encounter a selection of the species. To make sure that the route will fit into the available time, walk it slowly and allow about five minutes keying-out time per plant. Then add on an additional fifteen minutes because students will take longer over the first few species, until they start to get familiar with the process. In a 3-hour lab session, allowing about 30 minutes for the introduction, I typically find time to include about 20 to 25 species.

Running the Lab

Have the students read over the exercise before coming to the lab. Remind them the week before to wear suitable footwear and other outdoor clothing appropriate to the season and local conditions (*e.g.,* hat, long-sleeved shirt, *etc.*). They may also need to bring sunscreen and/or insect repellant.

At the start of the lab, give a brief introduction to the structure of vascular plant shoot systems (stem, node, internode, leaf, axillary bud, lateral branch). Explain the difference between simple and compound leaves and go over the clues they will need to look for in order to correctly identify what constitutes a leaf (axillary buds, branches, stipules). There is no need to run through all of the features of leaves, but tell them they should refer back to those sections of the manual as they use the key.

Next, explain what a taxonomic key is and how you use one. Go over the tips on using a key. A common mistake that students will make the first time they use a key is not starting at step 1. They will observe some feature of their specimen (*e.g.*, it has pinnate leaves) and then hunt through the key for a step that asks about pinnate leaves.

Lead the students around the planned circuit, stopping at each plant you want them to key out. Attach a piece of paper or cardboard with a letter label (A-Z) or number to each plant. Keep your own species list in which you write down the letter corresponding to each species as you go. Have the students key out the plant, write the label next to the name and then check it with you. If incorrect, get them to go back over the key to find out where they went wrong. You may need to help them with this.

If you have a group of species close together, you can label all of them at once, so the faster students don't have to wait before moving on to the next. In fact, you could go around the whole circuit in advance and attach the labels.

Less motivated students may stand back and wait for others to identify the species, and then just write down the identification. Tactfully point out to them that they should make their own observations of each plant, otherwise they will not learn the features and will be unlikely to perform well in practical exams. The lab is not about knowing and memorizing the names of the plants, it is about becoming familiar with the terms used to describe the features of plants and being able to observe their features.

As for practical exams, there are two types of practical questions that I use to test material from this lab. One would involve questions about the features of a specimen. For example, "What term describes the leaf shape of this plant?" or "What kind of phyllotaxy does this plant have?" The second would be a station with one or more specimens and a miniature key, so the student has to key out each species. For this, I would use plants that were not in the original lab, to foil students who simply memorized the names. In fact, there is no need to use the correct names of the plants in the exam key: you could simply denote them as "species A", "species B" etc.

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I would like to thank Dr. Roland Roberts for the idea on which this lab is based. While Roland was a graduate student, he taught plant biology labs with me. For one of the labs, Roland developed a taxonomic key to a smaller set of plants on the LSU campus, which was the inspiration for this workshop exercise.