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## A KEY TO DICOTYLEDONOUS ROSETTES OF EASTERN NEBRASKA

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### ABSTRACT

This paper provides a key to the identification of rosettes of 113 species of 56 genera of dicotyledonous flowering plants in eastern Nebraska. The key is based on observations of fresh and dried specimens collected from 1977 to 1990. Rosettes were identified from personal experience, by growing seeds or transplanted rosettes in a greenhouse, or by comparison and association with mature plants found growing with the rosettes. Key characteristics taken from dried specimens included leaf shape, leaf size, marginal configuration, surface vestiture, venation pattern, and subterranean morphology while characteristics observed in the field included distribution, habitat, odor, and presence or absence of latex.

† † †

Many flowering plants spend a large portion of their life cycles at a juvenile or non-flowering stage of development. Most biennials, for example, form rosettes of leaves as the only above-ground structures during their first year of growth; this form often persists for much of the year. Many herbaceous perennials also restrict above-ground structures to leaves for the first year, or in some cases for several years. Some perennials, particularly scapose perennials, continue to form rosettes throughout their life cycles. Additionally, a few annuals form early-season rosettes; winter annuals, in particular, may form leaf rosettes in the fall and flowering stems in the spring.

Since angiosperms have been classified principally on the basis of floral or fruiting structures, vegetative characteristics are often neglected (Hickey and Wolfe 1975). When vegetative features are used in identification, the characteristics are those of plants in a flowering or fruiting stage; however other stages of development may also provide useful taxonomic information. For example, Frankton and Moore (1961) have pointed out that the best foliage differences between *Cirsium*

*flodmanii* (Rydb.) Arthur and *C. undulatum* (Nutt.) Spreng. are found in the rosettes and that reliance on characteristics of the stem leaves and on involucral size in taxonomic keys has led to frequent misidentifications of herbarium specimens.

Identification of flowering plants at non-flowering stages is not an easily-developed skill. Since few references are available, long-term familiarity with taxa at various stages is necessary. With some plants, the rosette leaves (or leaves similar to the rosette leaves) persist as basal leaves on the mature plants, making identification straightforward by allowing comparisons between these vegetative parts. With other plants, however, the rosette leaves are deciduous. For these species, a rosette may be difficult to identify, even by those who are thoroughly familiar with the flowering plant, since the adult plant may have no comparable vegetative parts.

Identification of immature plants is often important in various fields of science, including ecology and agronomy. For example, many rosette-forming plants are weedy species that can affect crop production. A key for identifying such plants before they produce flowers and seeds is potentially valuable. The purpose of this study was to supply such a key for the identification of rosettes for eastern Nebraska.

### METHODS AND MATERIALS

#### Rosettes

In this study, "rosette" is used to mean a herbaceous, terrestrial, acaulescent cluster of leaves. Plants with compound and strongly petiolate leaves are included here, even though clusters of these types of leaves are only occasionally called rosettes. Also included are a few caulescent plants that have leaf clusters that might be confused with rosettes because of

short internodes. Monocotyledonous rosettes and young seedlings are excluded, as are rosettes that were consistently associated with a stem.

### Collections

The area considered in this study was approximately the eastern third of Nebraska, from the Missouri River west to about 98° 43' west longitude, excluding Boyd and Holt counties. Taxa were included in this study based on their occurrence within this area whether determined by collections or by records previously published by the Great Plains Flora Association (1977, 1986).

Specimens were collected from October, 1988, through July, 1990, mostly from August through November 1989. Field study was done most intensively in Douglas County, Nebraska, but field observations and collections were also made in the following Nebraska counties: Burt, Cass, Colfax, Dodge, Greeley, Jefferson, Knox, Lancaster, Nemaha, Nuckolls, Pawnee, Platte, Richardson, Sarpy, Saunders, Seward, Webster, and Wheeler. Approximately 500 collections were made for this study, each collection consisting of one to about one dozen rosettes. In order to obtain representative specimens for taxa known to occur in eastern Nebraska but difficult to locate, a number of collections from outside this area were included. Most of these were collected by me in Brown and Cherry counties, Nebraska, in September and October, 1989; by David Sutherland in Keith County, Nebraska, in July and August, 1989; and by Barbara Wilson in Page, Montgomery, Taylor, and Dickinson counties, Iowa, from September, 1989, to August, 1990.

Specimens were pressed and dried and deposited in the herbarium of the University of Nebraska at Omaha (OMA). Where practical, about half of the rosettes collected from each population were transplanted to the greenhouse at the University of Nebraska at Omaha and allowed to mature so that they could be identified with certainty.

### Identification

Initial identifications of rosettes were based on my personal experience or that of David Sutherland, Thomas Bragg, or Barbara Wilson. Rosettes identified in this manner were compared with vegetative character-

istics of specimens from the OMA herbarium. In the event that identification was not certain, one or more of the three following methods were used to identify rosettes: 1. Rosettes transferred to the greenhouse were identified as they flowered. 2. Morphological features of rosettes were compared to flowering or fruiting plants found in the same area or to herbarium specimens with the same kinds of dried fruits and stems as those found in the same area. 3. Rosettes were grown in the greenhouse from seed gathered from mature fruiting plants and compared with unknown rosettes. Nomenclature and taxonomic interpretations throughout this study follow the Great Plains Flora Association (1986).

### Observations and measurements

Characters obtained from field notes included distribution, habitat, odor, and presence or absence of latex. Characters obtained from direct observation included leaf organization, shape, marginal configurations, venation patterns, surface vestiture, and subterranean morphology. Terms used in the following key are derived from Hickey (1973, 1979), Hickey and Wolfe (1975), Lawrence (1951), Paine (1978), Radford et al. (1974), and Theobald et al. (1979).

### KEY TO THE ROSETTES

In the following key, all characteristics are those of the rosettes. Seedlings and basal rosettes of mature plants may not key to the correct name. A number of characteristics should be noted in the field before a specimen is pressed and dried. These include the habitat, the odor, the presence of milky juice, and the morphology of subterranean parts, particularly if these are not included in the collection. Trichomes need to be viewed with a magnification of at least 10 power. When a characteristic requires magnification higher than 10 power, or when a characteristic other than those referring to trichomes requires magnification, a suggested minimum magnification is indicated parenthetically (e.g. 30×). Nomenclatural citations are not given in the key but may be sought in Great Plains Flora Association (1986). Detailed descriptions of the rosettes may be found in Moore (1990). Terms used in the following key are defined in the glossary that follows it. Because of morphological variation, some species key in more than one group.

### Key to the Groups

- 1 All leaves simple, sometimes deeply lobed but never compound, decomposed or more than once dissected.
- 2 Margins with stout spines, the plants somewhat difficult to handle ..... **GROUP 1, p. 25**
- 2 Margins without stout spines, spinulose at most, the plants not difficult to handle.
  - 3 Plants with milky juice ..... **GROUP 2, p. 26**
  - 3 Plants without milky juice, or apparently so.

- 4 Lower surface of blade densely white-tomentose, the tomentum obvious and immediately apparent ..... **GROUP 3, p. 27**
- 4 Lower surface of blade glabrous or hairy but not densely white-tomentose, or not obviously so.
  - 5 Leaves with branched or dolabriform hairs; these may be mixed with other types of hairs, very small, or somewhat difficult to locate (check the leaf margins and petiolar portions) ..... **GROUP 4, p. 27**
  - 5 Leaves glabrous or with simple (unbranched) hairs.
    - 6 Upper surface of blade distinctly rough-scabrous or rough-hairy (try rubbing from apex to base since the hairs may be antrorsely bent) ..... **GROUP 5, p. 27**
    - 6 Upper surface of blade not rough, or not distinctly so.
      - 7 Leaves with a mustard-oil odor (crush some of the foliage and/or split open the midvein) ..... **GROUP 6, p. 28**
      - 7 Leaves without a mustard odor.
        - 8 Venation parallelodromous or perfect acrodromous, with primary or strong secondary veins converging toward the apex, and the leaves not lobed or divided .. ..... **GROUP 7, p. 29**
        - 8 Venation various but not as above, or some leaves lobed to divided.
          - 9 Margins of all leaves entire ..... **GROUP 8, p. 30**
          - 9 Margins of some leaves toothed or cut.
            - 10 Some or all leaves palmately or ternately cut ..... **GROUP 9, p. 31**
            - 10 Leaves not palmately cut.
              - 11 Base cordate or truncate, and leaves not pinnately cut ..... **GROUP 10, p. 31**
              - 11 Base tapering, or some leaves pinnately cut.
                - 12 Petioles distinct, usually more than half as long as the blade ..... **GROUP 11, p. 31**
                - 12 Petioles strongly winged, or short, less than half as long as the blade ..... **GROUP 12, p. 32**
  - 1 At least one leaf compound, decomposed, or dissected.
    - 13 Leaves not strongly organized into distinct leaflets, dissected, the ultimate divisions mostly less than 1 cm wide, often with a lacy appearance ..... **GROUP 13, p. 33**
    - 13 Leaves with distinct leaflets, the divisions broad, usually more than 2 cm wide.
      - 14 Leaves pinnately compound, or ternately decomposed, if trifoliolate then the leaflets deeply lobed to divided so that the overall appearance of the leaf is pinnate ..... **GROUP 14, p. 34**
      - 14 Leaves palmately compound or trifoliolate ..... **GROUP 15, p. 34**

#### **GROUP 1: Leaf margins with stout spines.**

- 1 Plants with bright yellow juice; lower blade surface spiny ..... ***Argemone polyanthemus***
- 1 Plants without yellow juice; lower surface not spiny.
  - 2 Upper blade surface prickly; some marginal spines very long, often longer than 5 mm, to about 10 mm .... ***Cirsium vulgare***
  - 2 Upper surface not prickly; marginal spines to about 5 mm long.
    - 3 Rosettes not taprooted, arising from creeping roots ..... ***Cirsium arvense***
    - 3 Rosettes taprooted (sometimes also arising from creeping roots).
      - 4 Leaves not tomentose; plants introduced ruderals.
        - 5 Lower surface of blade glabrous or glabrate ..... ***Carduus nutans***
        - 5 Lower surface, or at least the midvein, villous ..... ***Carduus acanthoides***
      - 4 Leaves densely white-tomentose, at least on the lower surface; plants native.
        - 6 Upper surface of blade green, glabrate or deciduously floccose-tomentose, much less hairy than the lower surface; margin often unlobed or remotely lobed, if lobed the segments usually somewhat flat, sometimes strongly undulate-lobed.
          - 7 Upper surface glabrate to thinly pubescent, usually puberulent with short multicellular hairs, dull green; rosettes taprooted or forming tubers in late fall ... ***Cirsium altissimum***
          - 7 Upper surface deciduously floccose-tomentose to arachnoid, or glabrous, but not puberulent, usually shiny green but becoming dull green with age; rosettes often arising from creeping roots, but individual rosettes taprooted ..... ***Cirsium flodmanii***

- 6 Upper surface grayish, densely and persistently tomentose, almost as hairy as the lower surface; margins strongly undulate-lobed, unlobed only on young plants.
- 8 Segments narrow, oblong, longer than broad, somewhat remote; unlobed leaves 1-nerved or camptodromous ..... *Cirsium canescens*
- 8 Segments broad, irregular, usually deltoid, mostly crowded; unlobed leaves strongly pinnately veined, craspedodromous ..... *Cirsium undulatum*

### GROUP 2: Plants with milky juice.

- 1 Margins prickly, spinulose-toothed.
  - 2 Margins weakly spinulose-toothed; plants not ruderal, usually in prairie; midvein usually somewhat pubescent; if pinnately lobed or parted then the margin of the sinuses usually rounded and entire; leaves somewhat leathery and firm ..... *Lactuca ludoviciana*
  - 2 Margins strongly spinulose-toothed; plants ruderal, usually in disturbed, cultivated, or moist places; midvein glabrous, or weakly puberulent; if pinnately lobed or parted then the margin of the sinuses often spinulose-toothed; leaves thin.
    - 3 Perennials with deep, creeping roots; leaves often lyrate-pinnatifid, the terminal lobes more or less narrowly oblong with a rounded apex, leaves sometimes oblanceolate, but not generally spatulate ..... *Sonchus arvensis*
    - 3 Annuals with a taproot; leaves oblanceolate-spatulate to lyrate-pinnatifid, the terminal lobes not narrowly oblong, mostly deltoid or suborbiculate, apex rounded or pointed. [NOTE: The following species are often difficult to separate with confidence; leaves of *Sonchus asper* are sometimes lyrate-pinnatifid with a deltoid terminal lobe, but the margins are usually more densely and strongly spined.]
      - 4 Leaves frequently oblanceolate-spatulate, apices often rounded; when lyrate-pinnatifid, the terminal lobes often suborbiculate or elliptic, sometimes deltoid; projections mostly 4–6 per cm, 0.5–2.0 mm long ..... *Sonchus asper*
      - 4 Leaves usually lyrate-pinnatifid, the terminal lobes mostly deltoid with a pointed apex; projections mostly 3–5 per cm, to 1.5 mm long ..... *Sonchus oleraceus*
- 1 Margins not at all spiny.
  - 5 Leaves linear, more than 20 times longer than broad ..... *Tragopogon dubius*
  - 5 Leaves not linear, less than 20 times longer than broad.
    - 6 Blades less than 3 times longer than broad; petiole long, more than ½ times the length of the blade; base cordate or truncate ..... *Lactuca floridana*
    - 6 Blades mostly more than 3 times longer than broad; petiole winged, short, or lacking, seldom more than ½ times the length of the blade; base not cordate.
      - 7 Midvein rounded, without a prominent ridge; juice white; blades often distinctly runcinate, lobes often directed basally, teeth directed basally or spreading; if blades pinnatifid the sinuses between larger segments more or less sharply toothed; introduced ruderals of lawns, roadsides, and waste ground, occasionally in disturbed woodlands or prairies.
        - 8 Mature leaves glabrous to hirsute below; blades only moderately thin; leaves oblanceolate to variously pinnately cut, but often lyrate-runcinate, sometimes complex-lobed with prominent secondary lobes on larger segments; teeth mostly spreading (rosettes commonly confused with *Taraxacum*, especially when the blades are glabrous and oblanceolate or runcinate) ..... *Cichorium intybus*
        - 8 Mature leaves glabrous or sparsely hairy, never hirsute; blades very thin; leaves oblanceolate to pinnately cut, but frequently runcinate-pinnatifid, only occasionally lyrate, never distinctly complex-lobed; teeth often directed basally ..... *Taraxacum officinale*
      - 7 Midvein more or less triangular in cross section, with a single prominent ridge below; juice white or brownish; most teeth or lobes usually spreading, not distinctly runcinate; if pinnatifid the margins of the sinuses between larger segments mostly broadly rounded and more or less entire; native plants of prairies or woodlands, or introduced ruderals of waste places.
        - 9 Juice white; lower midvein glabrous or with stiff bristles, never hirsute; annuals or winter annuals with short-lived rosettes; introduced ruderals of waste places ..... *Lactuca serriola*
        - 9 Juice brownish; lower midvein glabrous to hirsute, never with stiff bristles; biennials with first-year rosettes; native plants of woodlands, woodland edge, or prairies. [NOTE: Although vegetative characteristics of the following species of *Lactuca* overlap, many plants may be recognized with some degree of confidence.]

- 10 Plants usually in woodlands or edge, sometimes in disturbed prairies; blades thin, weakly leathery at most; teeth not spinulose, calloused at most .....*Lactuca canadensis*  
 10 Plants in prairies; blades somewhat leathery; teeth weakly spinulose or merely calloused .....*Lactuca ludoviciana*

**GROUP 3: Lower leaf surface white-tomentose**

- 1 Leaves pinnately lobed to pinnatifid .....*Hymenopappus scabiosaeus*  
 1 Leaves not pinnately cut.  
 2 Base cordate or truncate .....*Arctium minus*  
 2 Base tapering.  
 3 Leaves more than 5 times longer than broad, including the petiole .....*Hymenopappus scabiosaeus*  
 3 Leaves less than 5 times longer than broad (stoloniferous except *Eriogonum*).  
 4 Leaves distinctly 3–5 nerved, often more than 2 cm wide .....*Antennaria parlinii*  
 4 Leaves 1-nerved or obscurely 3-nerved, less than 2 cm wide.  
 5 Upper surface of larger leaves glabrate or glabrescent, clearly less hairy than the lower .....  
 .....*Antennaria neglecta*  
 5 Upper surface arachnoid-floccose, nearly as hairy as the lower.  
 6 Leaves spatulate; plants stoloniferous and mat forming, not taprooted .....  
 .....*Antennaria parvifolia*  
 6 Leaves oblong or elliptic; plants not stoloniferous, taprooted .....*Eriogonum annuum*

**GROUP 4: Plants with branched or dolabriform hairs.**

- 1 At least some leaves palmately cut; venation palmate; plant with a fleshy, napiform taproot.  
 2 Blades glabrous, or with a few stellate hairs towards the base of the blade .....*Callirhoe alcaeoides*  
 2 Blades densely stellate .....*Callirhoe involucrata*  
 1 Leaves not palmately cut; venation pinnate or 1-nerved; if taprooted then not napiform.  
 3 All hairs dolabriform; margins remotely but evenly retrorsely serrate; blades 1-nerved .....  
 .....*Erysimum asperum*  
 3 Stellate or Y-shaped hairs present; margins various but not retrorsely serrate; venation mostly pinnate.  
 4 Most hairs Y-shaped .....*Hesperis matronalis*  
 4 Most hairs not Y-shaped.  
 5 Blades often pinnately cut, strongly to weakly serrate, or some leaves entire; foliage sparsely to densely hairy, with stellate hairs and often with various types of simple hairs .....  
 .....*Capsella bursa-pastoris*  
 5 Blades entire, finely crenate, or sinuate-dentate, never pinnately cut; foliage densely hairy, with stellate, candelabrate, or dolabriform hairs.  
 6 Leaves often much larger than 2 dm, densely woolly with candelabrate hairs; margins entire or finely crenate .....*Verbascum thapsus*  
 6 Leaves never larger than 2 dm; hairs not candelabrate; margins entire or sinuate-dentate.  
 7 Margins clearly sinuate-dentate above and below the middle of the blade; leaves small, to about 7 cm long; hairs 2–4 armed, mostly rotate-stellate, with 3–4 rays, or densely dolabriform on the petiole .....*Erysimum inconspicuum*  
 7 Margins entire, or sinuate-dentate mainly on the lower half of the blade; leaves often much longer than 7 cm, to about 18 cm; hairs pedate-stellate, mostly with more than 4 rays .....*Berteroa incana*

**GROUP 5: Upper leaf surface rough.**

- 1 Base of the blade cordate to rounded.  
 2 Blades palmately lobed; venation somewhat palmate, with two pairs of actinodromous lateral veins .....  
 .....*Hydrophyllum appendiculatum*  
 2 Blades not palmately lobed; venation pinnate or acrodromous.  
 3 Venation acrodromous, with two or more pairs of lateral veins converging toward the apex; petiole hairs clearly retrorse .....*Hackelia virginiana*

- 3 Venation pinnate, the lateral veins not strongly converging towards the apex; petiole hairs spreading or appressed, but not strongly retrorse.
  - 4 Leaves ovate-deltate, the base truncate ..... *Silphium perfoliatum*
  - 4 Leaves ovate-cordate ..... *Aster oolentangiensis*
- 1 Base of the blade tapering.
  - 5 Plants strongly taprooted.
    - 6 Petioles short; hairs glochidiate with numerous minute barbs (20×); leaves pinnatifid, to about 2 dm long ..... *Mentzelia decapetala*
    - 6 Petioles long; hairs not barbed; leaves entire to pinnatifid, if pinnatifid then often much larger than 2 dm, to about 6 dm long ..... *Silphium laciniatum*
  - 5 Plants not taprooted, or weakly so.
    - 7 Petioles short, seldom more than ½ times as long as the blade; leaves entire or toothed, but never lobed or parted.
      - 8 Lower surface of blade with distinct areolae; leaves large, to 3 dm ..... *Silphium integrifolium*
      - 8 Lower surface not distinctly areolate; leaves not large, to 1.5 dm ..... *Solidago nemoralis*
    - 7 Petioles long, often more than ½ times as long as the blade; leaves entire, toothed, lobed, or divided.
      - 9 Leaves deeply lobed to divided ..... *Ratibida pinnata*
      - 9 Leaves entire or toothed but not deeply cut, at most with a few lobes towards the base.
        - 10 Margins entire.
          - 11 Blades 3-nerved ..... *Echinacea angustifolia*
          - 11 Blades not 3-nerved ..... *Solidago rigida*
        - 10 Margins toothed.
          - 12 Margins coarsely crenate-serrate, mucronulate; leaves sometimes lobed toward the base.
            - 13 Leaves large, sometimes more than 21 cm long, or the blades more than 12 cm long or 7 cm wide ..... *Erigeron annuus*
            - 13 Leaves not large, to about 21 cm long, the blades to about 12 cm long and 7 cm wide ..  
..... *Erigeron annuus* or *strigosus*
          - 12 Margins remotely toothed, crenulate-serrulate, or sharply serrate; leaves not lobed at the base.
            - 14 Venation somewhat acrodromous.
              - 15 Margins remotely toothed ..... *Erigeron strigosus*
              - 15 Margins strongly toothed ..... *Ratibida pinnata*
            - 14 Venation clearly camptodromous.
              - 16 Plants of open areas or prairies; leaf-margins mostly crenulate-serrulate; apices mostly obtuse; leaves firm ..... *Solidago rigida*
              - 16 Plants of woodlands; leaf-margins usually sharply serrate or doubly serrate, occasionally crenulate-serrulate; apices acute; leaves thin .... *Solidago ulmifolia*

#### GROUP 6: Foliage with a mustard odor.

- 1 Lower surface of blades hirsute ..... *Sisymbrium loeselii*
- 1 Lower surface glabrous or weakly hairy but not hirsute.
  - 2 Petioles long, often more than half as long as the blade.
    - 3 Leaves reniform to rotund-cordate, not lobed or divided.
      - 4 Margins crenate ..... *Alliaria petiolata*
      - 4 Margins entire ..... *Barbarea vulgaris*
    - 3 Leaves lobed to divided.
      - 5 Blades sinuate-lobed or irregularly lobed; base usually long tapering ..... *Thlaspi arvense*
      - 5 Blades mostly lyrate-lyrate parted or divided with one or more pairs of lateral segments that are much smaller than the terminal portion, the margins otherwise entire; base not long tapering ....  
..... *Barbarea vulgaris*
  - 2 Petioles short or lacking, rarely more than half as long as the blade.
    - 6 Blades sinuate-lobed to lyrate with rounded lobes, the apex rounded and margins otherwise entire; lowest pair of lateral veins diverging at a steeper angle than other pairs; leaves glabrous .....  
..... *Thlaspi arvense*
    - 6 Blades mostly pinnately or lyrate-lyrate lobed to divided, the margins irregular or toothed; lowest pair of lateral veins not diverging at a steeper angle than other pairs; leaves glabrous or with short hairs.

- 7 Rosettes superficial, arising from slender rhizomes, a stem apparent, on close examination, in the center of the rosette, the leaves cauline; some hairs, if present, vesiculate or clavate (50×) ..... *Rorippa sinuata*
- 7 Rosettes persisting, taprooted, the leaves not cauline; hairs, if present, not vesiculate or clavate.
- 8 Leaves small, to about 7 cm long; apical margin of larger lateral segments usually more lobed or toothed than the basal side, or the basal side entire; segments tending to be directed toward the apex of the blade; hairs, if present, falcate or conical, not flattened (50×) ..... *Lepidium densiflorum*
- 8 Leaves often longer than 7 cm; apical margin of lateral segments not noticeably more lobed or toothed than the basal side; segments tending to be directed toward the base of the blade; hairs, if present, subulate-lorate ..... *Rorippa palustris*

**GROUP 7: Leaf venation acrodromous or paralleldromous.**

- 1 Blades linear, grass-like, more than 20 times longer than broad.
- 2 Leaves large, to 6 dm long and 10 mm wide ..... *Liatris pycnostachya*
- 2 Leaves not large, to 3 dm long and 4 mm wide ..... *Tragopogon dubius*
- 1 Blades not linear, rarely more than 20 times longer than broad.
- 3 Leaves hairy (10×).
- 4 Surface strigose or strigulose, hairs less than 1 mm long, appressed, and stiff.
- 5 Margins remotely or shallowly toothed; blade lanceolate to oblanceolate, often more than 2 times longer than wide ..... *Erigeron strigosus*
- 5 Margins coarsely toothed; blade ovate to obovate, rarely more than 2 times longer than wide.
- 6 Leaves large, sometimes more than 21 cm long, or the blades more than 12 cm long or 7 cm wide ..... *Erigeron annuus*
- 6 Leaves not large, to about 21 cm long, the blades to about 12 cm long and 7 cm wide ..... *Erigeron annuus* or *strigosus*
- 4 Surface hirsute or villous, at least on the lower surface or toward the base of the blade, at least some hairs longer than 1 mm or spreading.
- 7 Leaves hirsute, the hairs somewhat stiff, articulate, basal cell somewhat swollen (30×); venation imperfect acrodromous, suprabaasal, the lateral veins diverging at some point above the base of the blade ..... *Rudbeckia hirta*
- 7 Leaves villous, the hairs somewhat soft, filiform, or mixed with short-multicellular hairs, not articulate; venation paralleldromous or acrodromous, basal, the lateral veins diverging near the base of the blade.
- 8 Blade somewhat broad, obovate or oval, to oblanceolate, 2–6 times longer than broad; blade thinly to densely hairy with short multicellular hairs (30×) ..... *Plantago virginica*
- 8 Blade narrowly elliptic to narrowly oblanceolate, more than 5 times longer than broad; blade often glabrous above, or hairy, the hairs filiform or shorter but not multicellular ..... *Plantago lanceolata*
- 3 Leaves glabrous or only sparsely hairy.
- 9 Blades more than 4 times longer than broad.
- 10 Rosettes arising from creeping rhizomes and superficially acaulescent, the stem often apparent below the rosette; apical ½ of blades mostly denticulate (some may be entire), with 2–4 teeth per cm ..... *Solidago missouriensis*
- 10 Rosettes not rhizomatous, with a short taprooted caudex and fibrous roots; margin entire or remotely denticulate, with fewer than 2 teeth per cm ..... *Plantago lanceolata*
- 9 Blades less than 4 times longer than broad.
- 11 Plants of damp prairies with a tuberous caudex and fleshy-fibrous roots; petioles long, mostly much longer than the blade; base somewhat evenly tapered ..... *Cacalia plantaginea*
- 11 Plants of lawns and waste ground, fibrous-rooted, taprooted, or with a short caudex, but never tuberous; petioles short or long, occasionally longer than the blade; base constricted or rounded before tapering to the petiole. [NOTE: The following species of *Plantago* cannot be separated vegetatively with assurance. However, *P. rugelii* can often be recognized with some degree of confidence.]



- 12 Plants common; petioles usually reddish or purple at the base, sometimes green; blade often glabrous, sometimes sparsely puberulent toward the base or margins; found in open to shaded and dry or damp places ..... *Plantago rugelii*
- 12 Plants uncommon; petioles usually green at the base, sometimes reddish or purple; blade often sparsely puberulent toward the base or margins; not often found in shaded to damp places ..... *Plantago major*

**GROUP 8: Leaf margins entire.**

- 1 Leaves hairy.
- 2 Hairs 5–10 mm long ..... *Hieracium longipilum*
- 2 Hairs much less than 5 mm long.
- 3 Base of the blade cordate or truncate; leaves often very large, usually much more than 6 cm wide ..... *Arctium minus*
- 3 Base of the blade tapering; leaves less than 6 cm wide.
- 4 Blades very narrow, eight or more times longer than wide, to 2.5 cm wide, mostly lanceolate; densely glandular puncticulate (10×) ..... *Liatris aspera*
- 4 Blades less than eight times longer than wide, often more than 2.5 cm wide, oblanceolate to ovate or elliptic, not glandular.
- 5 Plants taprooted; blades narrowly oblanceolate, apex acute ..... *Gaura longiflora*
- 5 Plants not taprooted; blades elliptic to broadly oblanceolate, apex obtuse or rounded ..... *Erigeron philadelphicus*
- 1 Leaves glabrous or glabrate.
- 6 Blades linear, grass-like, more than 20 times longer than broad ..... *Tragopogon dubius*
- 6 Blades not more than 20 times longer than broad.
- 7 Base hastate on some blades ..... *Rumex acetosella*
- 7 Base of the blades never hastate.
- 8 Leaves, although crowded, clearly opposite, decussate, the opposite pairs clasping, not stipulate .. *Penstemon grandiflorus*
- 8 Leaves not opposite; petiole sheathing younger leaves with a papery stipule.
- 9 Blades mostly orbiculate to oblong-ovate, apex rounded, base usually strongly cordate, or truncate ..... *Rumex obtusifolius*
- 9 Blades oblanceolate to oblong or ovate, not orbiculate, apex usually acute, sometimes rounded, base tapering to rounded or subcordate.
- 10 Plants with weak and branching or fibrous roots; annuals or biennials ..... *Rumex maritimus*
- 10 Plants with stout taproots; perennials. [NOTE: The following species of *Rumex* are difficult to separate, form hybrids, and the key characters are often inconclusive.]
- 11 Introduced plants of waste places and cultivated ground, often ruderal, sometimes in moist places but not in water; margins crispate or wavy.
- 12 Leaves with short vesiculate hairs or papillae on the petiole (20×), sometimes densely so; margins of all leaves usually decidedly crispate (except first leaves); leaves to about 4 dm long ..... *Rumex crispus*
- 12 Leaves without papillae, or these sparse; margins crispate or flat; leaves to about 5.5 dm long ..... *Rumex patientia*
- 11 Native plants of wet places, sometimes growing in water, sometimes in disturbed ground but not usually ruderal; margins flat, wavy, or irregular, but not crispate.
- 13 Leaves usually with short vesiculate hairs or papillae on the margins or on veins toward the base of the lower blade surface (20×); blade surface usually somewhat granular (10×) ..... *Rumex altissimus*
- 13 Leaves without short hairs or papillae; blade surface usually smooth ..... *Rumex stenophyllus*

**GROUP 9: Blades palmately or ternately cut.**

- 1 Blades trifold with three apically directed lobes, or with additional smaller lobes, the lobes confined to the upper half of the blade, basal half of the blade tapering ..... *Conyza canadensis*
- 1 Blades not trifold, or the lobes spreading and not confined to the upper half of the blade, base of the blade not tapering, or hardly so.
- 2 Petioles hirsute with gland-tipped hairs (20×) the glands reddish or rusty ..... *Heuchera richardsonii*
- 2 Petioles glabrous or hairy but lacking gland-tipped hairs.
- 3 Plants taprooted.
- 4 Leaves glabrous, or with stellate hairs on the petiole or base of the blade; lobes rounded or crenate with angled sinuses; plants with fleshy napiform roots ..... *Callirhoe alcaeoides*
- 4 Leaves hairy, but not stellate; lobes acute with broad sinuses; plants taprooted but roots not napiform ..... *Hydrophyllum appendiculatum*
- 3 Plants not taprooted.
- 5 Blades and petioles hairy ..... *Geum canadense*
- 5 Blades glabrous, or obscurely puberulent below; petiole glabrous or hairy.
- 6 Plants of wet places, margins of ponds or flowing waters; plants with fleshy-fibrous roots; petiole glabrous ..... *Ranunculus sceleratus*
- 6 Plants of dry places, prairies, open woodlands; plants rhizomatous; petiole glabrous or hairy .  
..... *Viola pedatifida*

**GROUP 10: Leaf base cordate or truncate.**

- 1 Leaves, or some of them, hastate ..... *Rumex acetosella*
- 1 Leaves not hastate.
- 2 Blades reniform to rotund-cordate, without a distinct apex; margins crenate.
- 3 Leaves densely puberulent; lower surface of blade much lighter than the upper; petiole not strongly dilated ..... *Leonurus marrubiastrum*
- 3 Leaves glabrous, or basal sinus and petiole ciliolate; lower surface not much lighter than the upper; petiole strongly dilated ..... *Alliaria petiolata*
- 2 Blades deltate, cordate, or ovate, sometimes reniform, but at least some leaves with an acute or obtuse apex; margins sometimes crenate-serrate, but rarely crenate.
- 4 Leaves mostly large, the blades often much more than 10 cm long.
- 5 Lower surface of blades arachnoid to tomentose; plants with a stout taproot; petiole thick .....  
..... *Arctium minus*
- 5 Lower surface glabrous, glaucous; plants with a woody caudex; petiole thin .....  
..... *Cacalia atriplicifolia*
- 4 Leaves not large, blades not much more than 10 cm long.
- 6 Surfaces hairy, at least on the lower surface or petiole.
- 7 Upper surface glabrate to spreading hairy ..... *Viola sororia*
- 7 Upper surface downy with short, soft, somewhat appressed hairs ..... *Geum canadense*
- 6 Surfaces essentially glabrous, weakly or thinly puberulent, or ciliolate.
- 8 Teeth denticulate to dentate, with rounded sinuses, not ciliolate ..... *Lactuca floridana*
- 8 Teeth serrate or crenate-serrate, with angular sinuses; ciliolate, sometimes weakly so.
- 9 Margins serrulate, usually with 3–6 teeth per cm, and tipped with reddish or brown glands (10×); apex rounded to acute ..... *Viola pratincola*
- 9 Margins usually somewhat broadly crenate-serrate, with 1–3 teeth per cm, not glandular; apex obtuse to acuminate ..... *Aster sagittifolius*

**GROUP 11: Leaves petiolate.**

- 1 Plants taprooted.
- 2 Leaves densely resinous-glandular (10×); blades deciduously arachnoid-floccose, petiole to arachnoid-tomentose; most leaves pinnatifid with oblong segments, the margins otherwise entire .....  
..... *Centaurea maculosa*
- 2 Leaves not densely glandular; blades not arachnoid-floccose; margins various, if pinnatifid the segments not oblong.

- 3 Lobes or teeth mostly confined to the upper half of the blade and directed apically; angle of divergence of secondary veins from the midrib narrow, less than 45°, lower secondary veins diverging at a steeper angle than the upper; leaves green; plants ruderal annuals with short-lived spring rosettes ... *Conyza canadensis*
- 3 Lobes or teeth not confined to the upper half of the blade; lower secondary veins diverging at about the same angle as the upper, the angle steep or not; leaves grayish, canescent, or light green; plants mostly winter annuals (rosettes lasting through spring) and biennials of open prairies, or ruderal.
  - 4 Intersecondary veins present (use transmitted light); margins usually with short-stalked apically-directed glands (30×), these appearing as remote serrulations or mucros; blades not lobed, at most sinuate-dentate toward the base ..... *Gaura longiflora*
  - 4 Intersecondary veins uncommon; margins lacking stalked glands; blades remotely toothed to lobed.
    - 5 Leaves remotely dentate to sinuate-dentate, not lobed; angle of divergence of secondary veins from the midrib usually greater than 45° ..... *Oenothera villosa*
    - 5 Leaves often lobed, or strongly sinuate-toothed; if not lobed the secondary veins diverging at an angle of less than 45°.
      - 6 Blades canescent, grayish and densely hairy, larger hairs often longer than 0.5 mm; biennial or winter annual, found in open sandy places, common in sandhills prairie ..... *Oenothera rhombipetala*
      - 6 Blades light green, glabrate or thinly puberulent, hairs less than 0.5 mm long, mostly less than 0.2 mm long; annual or winter annual ruderals of roadsides, fields and waste places ..... *Oenothera laciniata*
- 1 Plants not taprooted.
  - 7 Leaves strongly and deeply cut, cleft to divided, or pinnatifid.
    - 8 Blades evenly pinnatifid with many segments; segment margins crenate or lobed; leaves not large, to about 4 cm wide ..... *Pedicularis canadensis*
    - 8 Blades unevenly cut with 3 or 5 segments; segment margins denticulate to sharply dentate; leaves large, usually much more than 4 cm wide ..... *Lactuca floridana*
  - 7 Leaves not deeply cut, if lobed then not deeply so, or the lobes confined mostly to the base of the blade, not pinnatifid. [Cauline leaves of *Senecio plattensis* are pinnatifid.]
    - 9 Leaves essentially glabrous and margins ciliolate or ciliate (10×) ..... *Aster laevis*
    - 9 Leaves hairy or margins not at all ciliate.
      - 10 Margins remotely denticulate or serrulate ..... *Erigeron strigosus*
      - 10 At least some margins strongly toothed, occasionally only shallowly crenulate-serrulate, but not remotely so.
        - 11 Teeth mostly sharp, serrulate to doubly serrate, sometimes crenulate-serrulate; blades not lobed.
          - 12 Leaf apices mostly rounded; lower surface of blades sometimes deep purple; plants of prairie ..... *Senecio plattensis*
          - 12 Leaf apices acute; ; lower surface never deep purple; plants of woodland ..... *Solidago ulmifolia*
        - 11 Teeth mostly rounded, doubly crenate or mucronulate-crenate; blades often somewhat lobed or parted, especially toward the base.
          - 13 Blades glabrous or weakly puberulent; margins not ciliolate ..... *Chrysanthemum leucanthemum*
          - 13 Blades thinly to densely strigulose, especially toward the margins; margins somewhat ciliolate.
            - 14 Leaves large, sometimes more than 21 cm long, or the blades more than 12 cm long or 7 cm wide ..... *Erigeron annuus*
            - 14 Leaves not large to about 21 cm long, the blades to about 12 cm long and 7 cm wide ... *Erigeron annuus* or *strigosus*

**GROUP 12: Petiole short or lacking.**

- 1 Leaves abundantly resinous glandular on the lower surface of the blade ..... *Grindelia squarrosa*
- 1 Leaves not abundantly glandular on the lower surface.

- 2 Blades hairy.
- 3 Plants not taprooted; margins mostly shallowly and broadly crenate, or crenate-sinuate ..... *Erigeron philadelphicus*
- 3 Plants taprooted; margins remotely serrulate to lobed, but not broadly crenate.
- 4 Lobes or teeth mostly confined to the upper half of the blade and directed apically; venation somewhat acrodromous, the angle of divergence of lateral veins from the midrib narrow, less than 45°, the lower laterals diverging at a steeper angle than the upper; ruderal annuals with short-lived spring rosettes ..... *Conyza canadensis*
- 4 Lobes or teeth not confined to the upper half of the blade, mostly spreading; venation clearly pinnate, the lower lateral veins diverging at about the same angle as the upper, the angle narrow or wide; habit various, with winter (lasting through spring), first-year, or perennial rosettes.
- 5 Leaves dull to dark green; blades strongly dentate to pinnatifid; hairs sparse to hirsute and spreading ..... *Cichorium intybus*
- 5 Leaves light green or somewhat canescent; blades remotely serrulate to sinuate-dentate; hairs dense, soft, somewhat appressed.
- 6 Intersecondary veins present (use transmitted light); margins usually with short-stalked apically-directed glands (30×), these appearing as remote serrulations or mucros; blade, at most, sinuate-dentate toward the base ..... *Gaura longiflora*
- 6 Intersecondary veins uncommon; margins lacking stalked glands; blade remotely dentate to sinuate-dentate, in either case spreading and not confined to the basal half of the blade ..... *Oenothera villosa*
- 2 Plants glabrous or sparsely hairy.
- 7 Rosettes arising from slender rhizomes or creeping roots, the leaves essentially cauline, a stem usually apparent on close examination; leaves glabrous.
- 8 Blade margins prickly spinulose-toothed ..... *Sonchus arvensis*
- 8 Blade margins not prickly ..... *Rorippa sinuata*
- 7 Rosettes not rhizomatous, the leaves not cauline; leaves glabrous or sparsely hairy.
- 9 Leaves pinnatifid, the segments usually directed apically; margins rounded-toothed or serrate ..... *Rorippa palustris*
- 9 Leaves oblanceolate to pinnatifid, the segments usually directed basally; margins dentate or spinulose-toothed (plants with milky juice) ..... **SEE GROUP 5**

### GROUP 13: Leaves dissected.

- 1 Lower surface of blades densely crowded with globular glands ..... *Hymenopappus tenuifolius*
- 1 Lower surface not prominently glandular.
- 2 Plants with fibrous roots; foliage aromatic with a strong medicinal odor ..... *Achillea millefolium*
- 2 Plants taprooted; foliage aromatic or not, when aromatic, odor of carrot, parsnip, mustard, or tansy, but not medicinal (caution, do not taste).
- 3 Segments long and linear, about 0.5–1.5 mm wide, and the segment margins entire; upper blade surface shiny green; youngest leaves canescent or white-tomentose ..... *Artemisia campestris*
- 3 Segments either not linear, or, if linear then the margins toothed or incised; upper surface various; youngest leaves glabrous, hairy, to arachnoid, but not tomentose.
- 4 Segments rounded, mostly obovate; plants with a mustard odor; youngest leaves somewhat canescent, with branched hairs (50×); petiole not dilated ..... *Descurainia pinnata*
- 4 Segments sharp, toothed or incised; plants without a mustard odor; youngest leaves glabrous, hairy, or weakly arachnoid, but not canescent and without branched hairs (50×); petiole dilated.
- 5 Plants non-aromatic or with a slight tansy odor; native plants of sandy floodplains and shorelines ..... *Artemisia biennis*
- 5 Plants aromatic, with a carrot or parsnip odor; introduced plants of waste places, roadsides, open places, or wood-edge, sometimes of disturbed or shaded shorelines.
- 6 Leaves glabrous ..... *Conium maculatum*
- 6 Leaves hairy, especially the petiole ..... *Daucus carota*

**GROUP 14: Leaves pinnately compound or decompound, or ternately decompound.**

- 1 Upper surface of blades distinctly rough-scabrous ..... *Ratibida pinnata*
- 1 Upper surface not distinctly rough.
  - 2 Stipules present, the top of the stipules free from the petiole and with acute tips.
    - 3 Leaves often much longer than 12 cm; plants of dry places especially prairie slopes ..... *Potentilla arguta*
    - 3 Leaves less than 12 cm long; plants of moist places, lakesides, riverbanks ..... *Potentilla paradoxa*
  - 2 Stipules absent or adnate their entire length to the petiole.
    - 4 Petiole noticeably hairy.
      - 5 Lower surface of blade hirsute or hispid, the hairs mostly confined to the veins; upper surface glabrate; petiole hispid ..... *Geum aleppicum*
      - 5 Lower surface somewhat velvety, the hairs not confined to the veins; upper surface sparsely to densely covered with soft hairs; petiole hirsute ..... *Geum canadense*
    - 4 Petiole glabrous, minutely and thinly puberulent, or with a few scattered hairs.
      - 6 Leaflet margins entire; leaves lyrate-pinnate, the terminal segment much larger than the lateral segments ..... *Barbarea vulgaris*
      - 6 Leaflet margins toothed; leaves not lyrate, the terminal and lateral segments more or less similar in general appearance.
        - 7 Lateral secondary veins directed to the sinuses between the teeth ..... *Cicuta maculata*
        - 7 Lateral secondary veins not directed to the sinuses of the teeth.
          - 8 Leaves pinnately compound with 7-13 leaflets, or twice pinnate; plant with a fleshy, fusiform taproot ..... *Pastinaca sativa*
          - 8 Leaves ternate or ternate-pinnate; plant with fascicle of fleshy or fibrous roots.
            - 9 Leaflets more or less regularly narrowly ovate; margins evenly or doubly serrate, not ciliate; surfaces glabrous ..... *Zizia aurea*
            - 9 Leaflets irregular; margins irregularly cut, ciliate; lower surface sparsely strigulose ..... *Rudbeckia laciniata*

**GROUP 15: Leaves palmately compound or trifoliate.**

- 1 Petioles hairy.
  - 2 Leaves palmately compound with 5 or 7 leaflets ..... *Potentilla recta*
  - 2 Leaves with 3 leaflets.
    - 3 Stipules adnate their entire length to the petiole; leaflets often lobed or parted; leaflet venation somewhat actinodromous, weakly palmate ..... *Geum canadense*
    - 3 Stipules partly free from the petiole with acute tips; leaflets never lobed or parted; leaflet venation strongly pinnate.
      - 4 Plants stoloniferous; margins more or less evenly serrate.
        - 5 Leaflets short-petiolulate, at least the largest leaves with the terminal tooth shorter than the subterminal teeth; petiolar hairs abundant, spreading ..... *Fragaria virginiana*
        - 5 Leaflets sessile, the largest leaves with the terminal tooth longer than the subterminal teeth; petiolar hairs rather sparse, more or less appressed ..... *Fragaria vesca*
      - 4 Plants not stoloniferous; margins mostly irregularly or doubly serrate ..... *Potentilla norvegica*
- 1 Petioles glabrous.
  - 6 Leaves clearly ternate with three strongly petiolulate leaflets ..... *Zizia aurea*
  - 6 Leaves palmately compound, or the leaflets lobed or parted so that the overall appearance of the leaf is palmate, or the leaflets palmately cut.
    - 7 Teeth acuminate, not spinulose (10×); margin not thickened or white-bordered (10×); petiole strongly dilated, the wings often more than 1.5 cm long ..... *Cryptotaenia canadensis*
    - 7 Teeth spinulose; margin thickened or white-bordered; petiole only moderately dilated, the wings mostly less than 1.5 cm long.
      - 8 Areolae formed by the most pronounced reticulate network mostly about 1 mm wide (do not use transmitted light); leaves never with 5 petiolulate leaflets (although often deeply parted into 5 segments) ..... *Sanicula canadensis*
      - 8 Areolae formed by the reticulate network mostly about 0.5 mm wide; leaves sometimes with 5 petiolulate leaflets ..... *Sanicula gregaria*

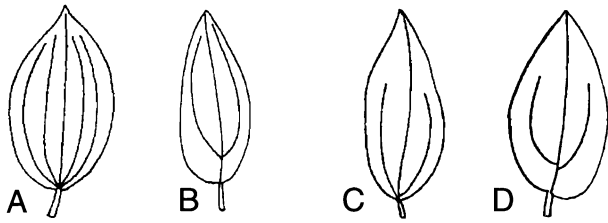


Figure 1. *Acrodromous* leaves. A and B are *perfect*; C and D are *imperfect*. A and C are *basal*; B and D are *suprabaasal*.

## GLOSSARY

**Acaulescent.** Stemless, or apparently so.

**Acrodromous** (of venation). With two or more primary or strongly developed secondary veins running in convergent arches toward the leaf apex: strongly to weakly ribbed, but not parallelodromous (Fig. 1.)

**Actinodromous** (of venation). With three or more primary veins diverging radially from a single point (Fig 2A).

**Acuminate** (of blade tips). Acute with concave margins; (of trichomes) Tapering to a narrow tip.

**Acute** (of blade bases or tips). Pointed, the angle about 90° or less.

**Adnate.** Fused (referring to the fusion of unlike parts, as in the fusion of stipules to petioles).

**Angular** (of marginal teeth). Margins of each sinus V-shaped.

**Annual.** Completing the life cycle in a single year. Most annuals grow, flower, and produce fruit in a single growing season, but winter annuals often germinate in the fall, spend the winter in a rosette stage, and produce flowers and fruit the following season.

**Antorse, antorsely.** Directed toward the apex.

**Apex** (of blades, blade segments, or teeth). The tip, the uppermost one-fourth.

**Appressed.** Resting against the surface.

**Arachnoid.** Cobwebby with long slender, loosely entangled hairs.

**Areolae.** The smallest areas of the leaf tissue surrounded by veins, which taken together form a continuous field over most of the blade.

**Areolate.** With well-developed areolae.

**Articulate.** Jointed (Fig. 3B).

**Basal** (of venation). With lateral primary or strong secondary veins originating at the base of the blade (Figs. 1A and 1C).

**Biennial.** Completing the life cycle in two years. Many biennials form rosettes in the first growing season and produce flowers and fruit the second season. In this respect they resemble winter annuals, but the rosettes are of much longer duration.

**Calloused** (of leaf teeth). Hardened, thickened.

**Camptodromous** (of venation). Pinnate with secondary veins not reaching the margin (Fig. 2B).

**Candelabrate** (of trichomes). With a central axis and whorls of branches (Fig 3I).

**Canescent** (of vestiture). Densely covered with short hairs and appearing whitish or grayish.

**Caudex.** A root crown.

**Cauline** (of leaves). Attached to a stem.

**Ciliate** (of margins). With conspicuous marginal hairs.

**Ciliolate** (of margins). With short, inconspicuous marginal hairs.

**Clasping** (of leaves). With blade or expanded petiole base surrounding or nearly surrounding the stem.

**Clavate** (of trichomes). Club-shaped, largest at the end and rounded.

**Cleft** (of leaf blades). Cut about halfway to the midvein.

**Complex.** With more than one main part.

**Compound** (of blades). Divided into distinct leaflets.

**Conical.** Cone-shaped.

**Cordate** (of leaf blades). Heart-shaped; (of blade bases) With a basal sinus and rounded basal lobes.

**Craspedodromous** (of venation). Pinnate with secondary veins terminating at the margins (Fig. 2C).

**Crenate** (of margins). With rounded teeth and angular sinuses.

**Crenulate** (of margins). Finely crenate.

**Crispate** (of margins). Minutely ruffled or curled.

**Deciduous.** Dropping off.

**Decomound** (of leaf blades). More than once compound.

**Decussate** (of leaf arrangements). Opposite, with successive pairs at right angles.

**Deltate** (of blades). More or less triangular.

**Deltoid** (of leaf segments). Triangular and about as wide as long.

**Dentate** (of leaf margins). With pointed, spreading teeth.

**Denticulate** (of leaf margins). Finely dentate.

**Dilated** (of petioles). With lower portion expanded.

**Dissected** (of leaf blades). More than once divided and with narrow or small segments.

**Divided** (of leaf blades). Cut nearly or entirely to the midrib.

**Dolabriform** (of trichomes). Attached in the middle with two opposite rotate branches (Fig 3J).

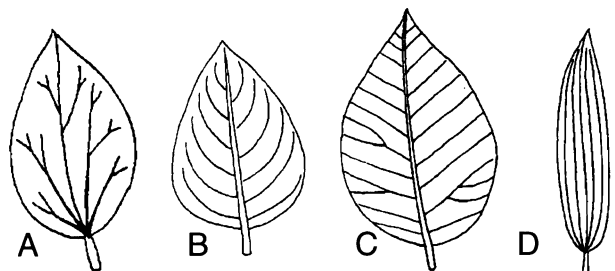


Figure 2. Venation types. A is *actinodromous*; B is *camptodromous*; C is *craspedodromous*; and D is *parallelodromous*.

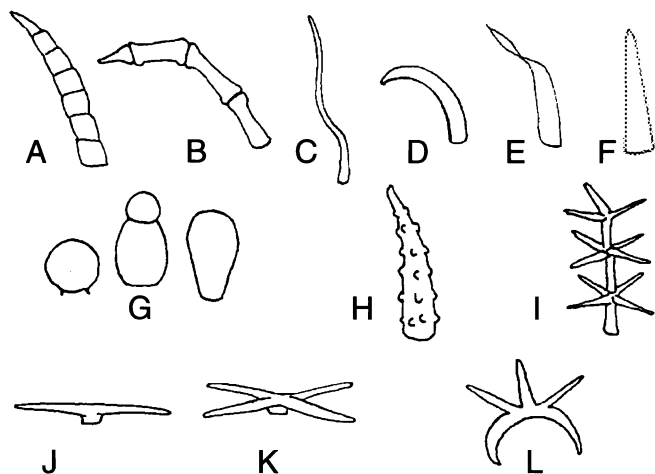


Figure 3. Some trichome types. A and B are *multicellular* trichomes; B is also *articulated*. C-H illustrate *simple* trichomes; C is *filiform*; D, *falcate*; E, *lorate*; F, *subulate*; G, *vesiculate*; and H, *glochidiate*. Of the three vesiculate trichomes at G, the rightmost is *clavate*. I-L illustrate branched trichomes; I is *candelabrate*; J, *dolabriform*; K, *rotate*; and L, *pedate*.

**Doubly crenate** (of margins). Crenate and with the crenations crenulate.

**Doubly serrate** (of margins). Serrate and with the serrations serrulate.

**Elliptic** (of blades or blade segments). Widest near the middle and longer than wide.

**Entire** (of leaf margins). Not toothed.

**Falcate** (of trichomes or leaf-segments). Sickle-shaped or talon-shaped, curved to one side (Fig. 3D).

**Fascicle**. A cluster.

**Fibrous** (of root systems). With many roots of about the same size and slender, lacking a central tap-root.

**Filiform** (of trichomes). Long and thin, thread-like (Fig. 3C).

**Floccose** (of vestiture). With patches of long, soft hairs that can be rubbed off.

**Glabrate** (of surfaces). Nearly glabrous.

**Glabrescent** (of surfaces). Becoming glabrous or glabrate.

**Glabrous** (of surfaces). Without trichomes.

**Glandular**. Bearing glands, these often appearing as glistening punctae on the surface or as glistening tips on trichomes.

**Glaucous** (of surfaces). With a whitish bloom that may rub off.

**Globular**. Spherical.

**Glochidiate** (of trichomes). Glochid-like, bearing numerous barbs (Fig. 3H).

**Hastate** (of blades). With a prominent, pointed basal lobe on each side approximately at right angles to the axis.

**Hirsute** (of vestiture). Densely or moderately covered with long, mostly erect hairs.

**Hispid** (of vestiture). Densely or moderately covered with long, mostly erect, stiff or coarse hairs.

**Imperfect** (of venation). With lateral primary veins or strongly developed secondary veins extending less than  $\frac{2}{3}$  of the distance to the apex (Figs. 1C and 1D).

**Incised** (of margins). Cut sharply and somewhat deeply.

**Intersecondary veins**. Intermediate between secondary and tertiary orders of venation, originating from the midvein, and more or less parallel to, but narrower than, the secondary veins.

**Lanceolate** (of blades). Widest below the middle, three or more times longer than wide, and tapering to both ends.

**Leaflet**. A leaf-like segment of a compound leaf.

**Linear** (of blades). More than twelve times longer than wide; (of leaf segments) Narrow with more or less parallel margins.

**Lobe** (of blades). Any portion of a blade that results from margins that are lobed, cleft, or parted.

**Lobed** (of margins). Cut  $\frac{1}{4}$  to about  $\frac{1}{2}$  of the distance to the midvein.

**Lorate** (of trichomes). Strap-shaped, flat.

**Lyrate** (of leaf blades). Pinnatifid to pinnate, with the terminal lobe much larger than the lateral lobes.

**Mucro**. A small protrusion, usually either an excurrent vein ending or a stalked gland.

**Mucronate** (of a leaf apex or a marginal tooth). Tipped with a protrusion, or mucro.

**Mucronulate** (of a leaf apex or a marginal tooth). Tipped with a small protrusion, or mucro.

**Multicellular** (of trichomes). With many cells and visible cross-septae (Figs. 3A, 3B).

**Napiform**. Turnip-shaped.

**Ob lanceolate** (of a blade). Widest above the middle, three or more times longer than wide, and tapering to both ends.

**Oblong** (of a blade or blade segment). Longer than broad with margins more or less parallel toward the central part.

**Obovate** (of a blade or blade segment). Widest above the middle and longer than wide, but less than three times longer than wide.

**Obtuse** (of blade or segment tips). Bluntly pointed, the angle greater than  $90^\circ$ .

**Orbiculate**. Circular in shape.

**Ovate** (of a blade or blade segment). Widest below the middle and longer than wide, but less than three times longer than wide.

**Palmate**. Radiating approximately from a single point.

**Papillae**. Small pimple-like projections.

**Parallelodromous** (of venation). With two or more primary veins originating at the leaf base and running more or less parallel until converging toward the apex (Fig. 2D).

**Parted** (of blades). Cut more than halfway but not all of the way to the midvein.

- Pedate** (of trichomes). Branched, with the lateral segments again divided (Fig. 3L); (of blades) Palmately cut with the lateral segments again deeply cut.
- Perennial**. With a life cycle lasting more than two years.
- Perfect** (of venation). With lateral primary veins or strongly developed secondary veins running at least  $\frac{2}{3}$  of the distance to the apex (Figs. 1A and 1B).
- Petiole**. A leaf stalk.
- Petiolulate** (of leaflets on a compound leaf). Leaflets with narrow petiole-like bases.
- Pinnate**. Arranged on both sides of an axis; (of venation) with a single primary vein (midvein) serving as the axis for secondary venation.
- Pinnatifid** (of blades). Pinnately cut, but not entirely to the midrib.
- Pinnatisect** (of a blade). Pinnately cut to the midvein, but the segments not organized into distinct leaflets.
- Puberulent** (of vestiture). Minutely pubescent.
- Pubescent** (of vestiture). Hairy, usually with short, soft hairs.
- Punctate** (of surfaces). With dots or pits, these often glandular.
- Puncticulate** (of surfaces). Minutely punctate.
- Reniform** (of blades). Wider than long, with a rounded apex and a basal sinus; kidney-shaped.
- Resinous**. With a sticky, resin-like exudate.
- Reticulate** (of venation). Branching to form a network.
- Retorse**. Directed basally.
- Rhizomatous**. Bearing rhizomes.
- Rhizomes**. Horizontal, underground stems.
- Rotate** (of trichomes). With rays of a branched hair in one plane parallel to the surface (Fig 3K).
- Rotund** (of blades). Nearly circular, but slightly longer than wide.
- Rounded**. Not angular; forming a smooth curve.
- Ruderal**. Growing in a disturbed area.
- Runcinate** (of blades). Sharply incised and/or serrate with the teeth or segments directed toward the base of the blade.
- Scabrous** (of surfaces). Rough to the touch; (of vestiture) with short, thick, stiff hairs or papillae.
- Scapose**. With leaves all or nearly all basal and the flowers borne on a leafless or nearly leafless stem.
- Secondary veins**. Veins arising from the midvein.
- Segment**. Any portion of a blade formed from margins that are lobed, cleft, parted, or divided.
- Serrate** (of margins). With teeth pointing apically.
- Serrulate** (of margins). Finely serrate.
- Simple** (of blades). Not compound, not dissected; (of trichomes) not branched (Figs. 3C–3H).
- Sinuate** (of margins). Indented in more or less smooth arcs less than one fourth of the distance to the midrib.
- Sinus** (of margins). The incision between two marginal projections.
- Spatulate** (of blades). Widest above the middle, more than three times longer than wide, tapering toward the base, and apex rounded; spoon-shaped.
- Spinose**. Tipped with a spine.
- Spinulose**. Tipped with a small, narrow, pointed projection.
- Stellate** (of trichomes). Star-shaped or branched with three or more rays).
- Stipulate**. With stipules.
- Stipules**. Leaf-like projections on either side of the base of a petiole or leaf base.
- Stoloniferous**. With horizontal creeping stems borne aboveground.
- Strigose** (of vestiture). With short, stiff, appressed hairs.
- Strigulose** (of vestiture). Minutely strigose.
- Subcordate**. Nearly, but not quite, cordate.
- Suborbiculate**. Almost, but not quite, circular in shape.
- Subulate**. Awl-shaped, tapering from a broad base to a point (Fig 3F).
- Suprabasal** (of venation). With lateral primary veins or strong secondary veins diverging from a point at some distance above the base of the blade (Figs. 1B and 1C).
- Taprooted**. With a strong central root, the lateral roots much smaller.
- Ternately**. In threes.
- Tomentose**. Densely woolly with soft matted hairs.
- Trichome**. A hair-like protuberance from a plant epidermis.
- Trifid** (of blade or blade segment). Somewhat evenly cut into three segments, or with the middle segment somewhat longer.
- Trifoliolate** (of compound leaves). With three leaflets.
- Truncate** (of leaf bases). Ending abruptly as if cut off.
- Tuber**. Underground, thickened, storage stem.
- Tuberous**. Like a tuber.
- Undulate**. Wavy-margined.
- Velvety** (of vestiture). With short, soft, or silky hairs.
- Vesiculate** (of trichomes). Small and bladder-like (Fig. 3G).
- Villous**. With long, soft hairs, not matted.
- Winged** (of petioles). The blade extending downward and forming flanges on the petiole.

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