

North Dakota vascular plants: manual to the families

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December 1, 2015

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As a rule, you should have plant with stems, leaves and flowers at hands. In some cases, you must also have fruits (Cruciferae, Umbelliferae) and underground parts (Cyperaceae, Gramineae). Plants with fruits only (instead of flowers) are sometimes also possible to identify, but that will require many guesses. It is not possible, however, to determine plants without reproductive structures with keys below. Moreover, as far as I know, there are no such keys for North American flora (except one key for grasses) and only few in the other parts of the world. Exception are woody plants which sometimes are identifiable if only vegetative shoots (stems with leaves and buds) are available.

Step one. Most remarkable big families

Compare your plant with each description. If there is no correspondence, go to the second step.

Group 1. Herbaceous plants, sometimes also shrubs. Leaves alternate or opposite, without stipules. Small flowers gathered in the **flower-like inflorescence** with the receptacle and involucre bracts (modified leaves enveloping the inflorescence). Stamens fused. Fruit seed-like achene, frequently with hairy or toothed attachment developed from sepals. $\ast \vee \uparrow K_{0\vee 5} C_{(5\vee 3)} A_{(5)} G_{(2)}$, or unisexual, or sterile¹ Family **Compositae (Asteraceae)**.
Check here carefully if what you see as a flower is actually an inflorescence.

Group 2. Herbaceous plants, usually perennial with **underground rhizomes**. Stems green, upright, bear linear leaves with parallel venation and sheaths (sometimes leaves reduced). Flowers simplified, with bract scales and scaly simple perianth (if any), in various inflorescences. Fruit dry.

1. Stem is **hollow** between **filled nodes**. Leaves flat, folded lengthwise, without keel. Flowers in spikelets, every flower usually has 2 flower scales. Fruit seed-like. $\uparrow P_{2\vee 3} A_{[3-1]\vee 6} G_{(2)}$ or unisexual Family **Gramineae (Poaceae)**.

¹Fruit and formula data provided to make identification more efficient, but they are **not** absolutely necessary for identification and does not take part in keys.

- Stem is not hollow between filled nodes. Leaves flat, non-flat or reduced. There is one flower scale, if two, then flowers are not in spikes 2.
- 2. Flowers in spikes. Leaves (if present) with sharp keels. Stem sometimes with three edges. Tepals are frequently reduced into scales or hairs. Fruit is a nutlet. $\uparrow \vee *P_{0-6}A_3 \vee G_{(3 \vee 2)}$ or unisexual Family **Cyperaceae**.
- Flowers solitary or in small clusters. Leaves tubular or flat, without keels. Perianth is not reduced. Fruit is a capsule. $*P_{3+3}A_{[3+3]} \vee G_{(3)}$ Family **Juncaceae**.
- = Flowers either in terminal spadices or in round heads. Leaves without keels, more or less flat. Perianth reduced, scaly or hairy. Fruit is a nut. $*P_{3-6}A_3 \vee *P_{3-6}G_1$ Family **Typhaceae**.
(genera *Typha* and *Sparganium*)

Group 3. Herbaceous plants. Leaves whole, with whole margin, opposite, mainly with only one central vein visible (hyphodromous). Flowers white or pink, in **dichotomously branched inflorescences**. Fruit is a capsule. $*K_{5 \vee (5)}C_{5 \vee 0}A_{5 \vee 10}G_{(3 \vee 5)}$ Family **Caryophyllaceae**.

Group 4. Herbaceous plants, sometimes also trees or shrubs. Leaves alternate, compound, with stipules. Flower usually with keel and banner (“papilionate”). Fruit is a **pod** (legume).

$\uparrow K_{(5 \vee 3)}C_{[1,2,(2)] \vee (1,2,2)}A_{[1,(4+5)] \vee (10)}G_1$ Family **Leguminosae (Fabaceae)**.

There are few remarkable exceptions from the typical papilionate flower. For example, *Amorpha* has only one petal ($\uparrow K_{(5)}C_1A_{(10)}G_1$), whereas *Gleditsia* and *Dalea* have “normal”, usually 5-merous flowers (for example, *Dalea* flower formula is $*K_{(5)}C_5A_{(5) \vee (9-10)}G_1$). However, structure of pistil and fruit is stable within legumes.

Group 5. Herbaceous plants, rarely sub-shrubs. Many representatives have pubescent, quadrangular stem with opposite (sometimes alternate) leaves having pungent smell of essential oils when crushing. In flowers, the most typical combination of characters is 5 fused sepals, 4 or 5 petals making **two flower lips**, 4 stamens and 2-celled superior ovary. Fruit is a capsule or consists of several (usually four) nutlets. $\uparrow \vee *K_{(5)}C_{(2,3) \vee (5) \vee (4)}A_{[2,2] \vee 2}G_{(2 \times 2) \vee (2) \vee (1)}$... Family **Labiatae s.l. (Lamiaceae)**.

Here family is understood in the radically broad way, it includes plants which are typically listed under Scrophulariaceae, Plantaginaceae, Lentibulariaceae, Orobanchaceae, Phrymaceae, Pedaliaceae, Bignoniaceae, Verbenaceae and some other families. In most of these cases, their previous affiliations are listed below.

Group 6. Herbaceous plants, rarely sub-shrubs. Leaves alternate. Inflorescence is a panicle, flowers are typically **cross-shaped**, yellow or white (sometimes purple). Fruit is usually a siliqua.

$*K_4C_4A_{2+4 \vee \infty}G_{(2)}$ Family **Cruciferae (Brassicaceae)**.

Here family is understood in the broad way, it includes plants which are typically listed elsewhere under Capraceae (*Cleome* and *Polanisia*). These two genera have triple or palmate leaves, multiple stamens and pistil on the pedicel (gynophore).

Group 7. Herbaceous plants. Stem is hollow. Leaves, as a rule, heavily dissected, alternate, contain essential oils (careful, some representatives are poisonous when digested!). Flowers small, with minute calyx, white or yellow-green petals, gathered into **double umbels** (sometimes also into heads). Anthers come out of the disk located on the top of ovary. Fruit is a segmented schizocarp of two mericarps. $* \vee \uparrow K_5C_5A_5G_{(2)}$ Family **Umbelliferae (Apiaceae)**.

* * *

Another remarkable family is herbaceous (in North Dakota) **Polygonaceae**. Most of its representatives are easily recognizable by the presence of simple leaves with **ochrea**: leathery or filmy “sleeve” growing upwards along the stem from the base of leaf. Stem nodes usually swollen. Flowers small, usually in dense inflorescences. Fruit is a three-edged nut. $P_{(4 \vee 5) \vee 3-6}A_{5-9}G_{(3)}$ Family **Polygonaceae**.

Step two. Groups 8, 9, 10: Woody, water and spore plants

- A. Cacti: stem succulents with spines and areoles. Fruit is a berry. $*K_{\infty}C_{\infty}A_{\infty}G_{(\infty)}$ Family **Cactaceae**.
 – Not cacti B.
- B. Woody plants, their perennial aboveground stem stem accumulates secondary tissues, at least at the base **Group 8** (go to p. 3)
 – Herbaceous plants C.
- C. True water plants—completely submerged into water or floating on the water surface, only flowers sometimes are above the level of water **Group 9** (go to p. 7)
 – Terrestrial plants (they might grow in water but in that case their stems are not carried with water) D.
- D. Plants which never have flowers, reproducing with spores **Group 10** (go to p. 10)
 This key includes only vascular plants so mosses are not covered.
 – Seed plants **Group 11** (go to p. 11)

Group 8. Woody plants. Trees, shrubs, sub-shrubs (plants woody only at the base), and woody vines.

Woody species of the described above “most remarkable big families” Leguminosae (*Amorpha*, *Caragana*, *Halimodendron* and others) and Compositae (*Artemisia*, *Gutierrezia* and others) are not included below. This key also does not include tools for identification trees and shrubs in winter, without leaves. Please see recommended literature in the end of the manual.

- 1. Leaves are needle-like or scale-like 2.
 – Leaves typical, blade-like 5.
- 2. Plants without flowers, they bear cones instead (which sometimes are berry-like). Frequently, plants are evergreen and rich of resins 3.
 – Plants with small pink flowers in spikes, no cones. Deciduous, no resins. Leaves 1–2 mm size, scale-like, alternate. Fruit is a capsule with hairy seeds. $*K_5C_5A_{5+5}G_{(3)}$ Family **Tamaricaceae**.
 (genus *Tamarix*)
- 3. Needles or scales opposite or whorled, brachyblasts absent Family **Cupressaceae**.
 – Needles alternate or arranged in groups on the short shoots (brachyblasts) 4.
- 4. Needles with the middle vein visible from above. Cones are red, berry-like ... Family **Taxaceae**.
 (genus *Taxus*)
 Sometimes cultivated in North Dakota.
- Needles without visible middle vein or with middle vein visible only from beneath. Cones are woody Family **Pinaceae**.
- 5 (2). Palmoids (rosette woody plants, Corner model): unbranched short woody stem bears multiple long sharp linear leaves. Fruit is a capsule. $*P_{3+3}A_{3+3}G_{(3)}$ Family **Asparagaceae**.
 (genus *Yucca*)
 Sometimes, yuccas (*Yucca*) are treated as members of Agavaceae.
- Not palmoids 6.
- 6. See the table below:

	Leaves simple, whole or lobed	Leaves compound
Leaves alternate	7.	27.
Leaves opposite (or whorled)	31.	40.

7. Woody vines 8.
 – Trees, shrubs, sub-shrubs 11.
8. Venation acrodromous. Flowers in umbels. Fruit is a berry. $*P_{3+3}A_{3+3}G_{(3)}$
 Family **Smilacaceae**.
 (genus *Smilax*)
 – Venation pterodromous 9.
 = Venation actinodromous (best seen at the base of leaf) 10.
9. Flowers in racemes. Leaves are always whole. Fruit is a three-valved capsule which opens to
 release seeds covered with brightly colored red aril. $*K_{(4)}C_4A_4G_{(3)}$ Family **Celastraceae**.
 (*Celastrus scandens*)
 – Flowers solitary or in dichasia (dichotomously branched inflorescences). Leaves sometimes
 lobed or dissected. Fruit is a berry. $*K_{(5)}C_{(5)}A_5G_{(2)}$ Family **Solanaceae**.
- 10 (8). Leaves with pilose or toothed margins, whole or lobed. Tendrils present. Fruit is a berry.
 $*K_5C_5A_5G_{(2)}$ Family **Vitaceae**.
 – Leaf margins without small teeth (but leaves are sometimes lobed). No tendrils. Fruit is a mul-
 tiple drupe. $*P_{[0\vee3]+3+3}A_{3+3}G_{3\vee6}$ Family **Menispermaceae**.
- 11 (7). Leaves 2-ranked (i.e., most of leaves on the terminal branches are more or less in one plane),
 with asymmetric base 12.
 – Leaves are not 2-ranked and with asymmetric base 13.
12. Fruit is a solely winged nut. $*P_{(4-6)}A_{4-6}G_{\perp}$ Family **Ulmaceae**.
 (genus *Ulmus*)
 – Fruit is a drupe. $*P_{(5)}A_5G_{\perp}$ Family **Cannabaceae**.
 (genus *Celtis*)
- 13 (11). Leaves with actinodromous venation, usually wide, more or less heart-shaped 14.
 – Leaves more narrow, venation different 16.
14. Shrubs, sometimes spiny. Fruit is a berry. $*K_{(5\vee4)}C_{5\vee4}A_{5\vee4}G_{(\bar{2})}$ Family **Saxifragaceae**.
 (genus *Ribes*)
 Currants and gooseberries (*Ribes*) are sometimes considered as members of Grossulariaceae.
 – Trees, no spines 15.
15. Leaves whole. Inflorescence with few showy bisexual flowers and a sole conspicuous bract. Fruit
 is a nut. $*K_5C_5A_{\infty}G_{(3)}$ Family **Malvaceae**.
 (genus *Tilia*)
 Sometimes, lindens (*Tilia*) are listed under its own family, Tiliaceae.
 – Leaves whole or lobed. Inflorescences unisexual, catkins (male) or heads (female) without bracts.
 Fruit is a compound drupe. $P_4A_4 \vee P_4G_{(2)}$ Family **Moraceae**.
 (genus *Morus*)
- 16 (13). Semi-desert and dry prairie shrubs with narrow, hypodromous or apodromous leaves and
 usually winged fruits 17.
 – Plants with the combination of characters different from the above 18.

17. Leaves not succulent, covered with at least few trichomes, with pterodromous or hypodromous venation. Fruit is a nut, sometimes winged. $*P_{3-5}A_{1-5}G_{(2)}$ or unisexual Family **Amaranthaceae**

 In the past, woody genera of this family were placed in Chenopodiaceae.
- Leaves curved, succulent, glabrous, apodromous. Fruit is a winged nut. $P_1G_{(2)} \vee A_{2-4}$ Family **Phytolaccaceae**.

 (*Sarcobatus vermiculatus*)
 These plants were formerly treated in the family Chenopodiaceae, and now frequently in its own family, Sarcobataceae.
- 18 (16). Small spiny shrubs. Leaves concentrated in multiple groups along the stem. Flowers 3-merous, in racemes. $*K_{3+3}C_{3+3}A_{3+3}G_{\underline{1}}$ Family **Berberidaceae**.

 (genus *Berberis*)
- Not barberries: plants with the combination of characters different from the above 19.
19. Plants dioecious (there are male and female plants). Leaves often narrowly lanceolate, with stipules. Buds are either sticky from resin, or covered with one cup-shaped scale. Fruit is a bivalved capsule containing hairy seeds. $A_{3-20} \vee G_{(2)}$ Family **Salicaceae**.
- Not willows or poplars: plants with the combination of characters different from the above ...
 20.
20. Leaves, annual stems and fruits covered with shining, flat trichomes. Ovary inferior. Fruit is a drupe. $*P_{(2-4)}A_4G_{(\bar{2})}$, or unisexual Family **Elaeagnaceae**.

 (genus *Elaeagnus*)
- Not silverberries: plants with the combination of characters different from the above 21.
21. Leaves with under-folded margins. Small, evergreen, sometimes creeping shrubs. Leaves also with hairs and/or dotted glands. Fruit is a capsule (*Ledum*) or berry (*Arctostaphylos*).
 $*K_{(5)}C_{(5)\vee 5}A_5G_{(5)}$ Family **Ericaceae**.
 In cultivation, one may find also a common boxwood, *Buxus sempervirens* from Buxaceae (fruit is a capsule, flower $P_4A_4 \vee P_{2-4}G_{(3)}$). Boxwoods always have smooth leaves, without hairs or glands.
- Not ericoid shrubs: leaves without under-folded margins 22.
22. Trees, sometimes shrubs with unisexual non-conspicuous flowers in catkins or small clusters. Fruit is either acorn or nut, winged or not winged. Ovary inferior 23.
- Flowers more or less showy, bisexual. Fruits are not nuts or acorns 24.
23. Leaves pinnately lobed, lobes unequal. Buds covered with multiple tiling scales. Male catkins loose. Fruit is a nut-like acorn. $*P_{(5-9)}A_{5-10} \vee *P_{\infty}G_{(\bar{2})}$ Family **Fagaceae**.

 (genus *Quercus*)
- Leaves whole or only slightly lobed, with serrate or toothed margin. Buds with few scales. Male catkins dense. Fruit is a nut, with or without wing. $P_{0\vee 2\vee(4)}A_{4-12} \vee P_{0\vee(\infty)}G_{(\bar{2})}$
 Family **Betulaceae**.
- 24 (27). Leaves with well developed stipules. Fruit is a pome (apple-like) or drupe (cherry-like).
 $*K_{(5)}C_5A_{\infty}G_{\underline{1}} \vee G_{(\bar{2-5})}$ Family **Rosaceae**
- Leaves without stipules, fruit is a drupe or capsule 25.
25. Secondary veins are not arcuate. Fruits are capsules or drupes 26.
- Secondary veins arcuate. Shrubs or small trees. Fruit is a black or red drupe. $*K_{(4\vee 5)}C_{4\vee 5}A_{4\vee 5}G_{(2)}$
 Family **Rhamnaceae**.
26. Small prairie shrubs or sub-shrubs. Fruit is a three-celled capsule. $*K_{2+3}C_5A_{\infty}G_{\underline{3}}$
 Family **Cistaceae**.

- Small forest shrubs. Fruits are red drupes, typically gathered in small clusters. $*P_{(4)}A_8G_{(2)}$...
..... Family **Thymelaeaceae**.
(genus *Dirca*)

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- 27 (6). Woody vines with tendrils. Leaves triple or palmately compound or dissected. Fruit is a berry. $*K_5C_5A_5G_{(2)}$ Family **Vitaceae**.
– Not grapes: shrubs (sometimes creeping, but in that case without tendrils) or trees 28.
28. Leaves double pinnate or triple and then pinnate. Fruit is a berry. $*K_{0\vee 5}C_5A_5G_{(5)}$
..... Family **Araliaceae**.
(genus *Aralia*)
– Leaves triple or once pinnate 29.
29. Leaves with well developed stipules. Fruit is a multiple nut (*Dasiphora*, *Rosa*), or multiple raspberry-like drupe (*Rubus*). $*K_{(5)}C_5A_\infty G_1 \vee G_{(2-5)}$ Family **Rosaceae**
– Leaves without well developed stipules 30.
30. Stems spiny. Leaves pinnate. Fruit is a multiple follicle. $*C_{4-5}A_{4-5} \vee C_{4-5}G_{2-5}$
..... Family **Rutaceae**.
(*Zanthoxylum americanum*)
– Stems are not spiny. Leaves pinnate or triple. Fruit is a drupe. $*K_{(5)}C_5A_5G_1$ or unisexual
..... Family **Anacardiaceae**.
One may also come to this point identifying woody plants from legume family (Leguminosae).

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- 31 (6). Leaves and annual stems covered with shiny, flat trichomes. Fruit is a drupe. $*P_{(2-4)}A_4G_{(2)}$,
or unisexual Family **Elaeagnaceae**.
(genus *Shepherdia*)
– Not silverberries or buffaloberries: flat shiny trichomes absent 32.
32. Venation actinodromous, leaves usually wide 33.
– Venation pterodromous 34.
33. Leaves lobed or toothed. Fruit is a double winged, schizocarpic. $*\vee \uparrow K_5C_5A_{5-12}G_{(2\vee 3)}$
..... Family **Sapindaceae**.
(genus *Acer*)
Maples (*Acer*) are sometimes listed under its own family, Aceraceae.
– Leaves large, heart-shaped, whole, with smooth margin. Fruit is a capsule. $\uparrow K_{(2)}C_{(4-5)}A_{3,2}G_{(2)}$
..... Family **Labiatae s.l.**
(genus *Catalpa*)
Usually, *Catalpa* is listed under Bignoniaceae.
- 34 (32). Leaf margin smooth (or serrate but in this case flowers zygomorphic) 35.
– Leaf margin toothed or serrate, flowers actinomorphic 38.
35. Secondary veins are arcuate 36.
– Secondary veins are not arcuate 37.
36. Stamens opposite to petals. Leaf veins not sunken. Fruit is a superior drupe. $*K_{(4\vee 5)}C_{4\vee 5}A_{4\vee 5}G_{(2)}$
..... Family **Rhamnaceae**.
– Stamens alternate with petals. Leaf veins sunken. Fruit is an inferior drupe. $*K_{(4)}C_4A_4G_{(2)}$
..... Family **Cornaceae**.

- 37 (35). Stamens two. Fruit is a bivalved capsule. $*K_{(4)}C_{(4)}A_2G_{(2)}$ Family **Oleaceae**.
(genus *Syringa*)
- Stamens 4 or 5. Fruit is a berry. $\uparrow K_{(5)}C_{(5)}A_{5\vee 4}G_{(2)}$ Family **Caprifoliaceae**.
 - = Stamens (and perianth) multiple. Multiple pistils are within the cup-shaped receptacle (like in *Rosa*). Fruit is a multiple nut. $*P_{\infty}A_{\infty}G_{\infty}$ Family **Calycanthaceae**.
(*Calycanthus floridus*)
- 38 (34). Petals free. Fruit is a drooping capsule with hanging, colored arillate seeds. $*K_{(4)}C_4A_4G_{(2)}$
..... Family **Celastraceae**.
(genus *Euonymos*)
- Petals fused 39.
39. Fruit is a capsule. Flowers with multiple stamens. $*K_{4\vee 5}C_{4\vee 5}A_{\infty}G_{(4)}$
..... Family **Hydrangeaceae**.
(genus *Philadelphus*)
- Fruit is a drupe. Flowers small, with 5 stamens. $*K_{(5)}C_{(5)}A_5G_{-(2)}$ - Family **Adoxaceae**.
(genus *Viburnum*)
- Sometimes, one can find *Viburnum* under Caprifoliaceae or Viburnaceae.

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- 40 (6). Leaves palmately compound. Fruit is a three-celled spiny capsule. $*\vee \uparrow K_5C_5A_{5-12}G_{(2\vee 3)}$
..... Family **Sapindaceae**.
(genus *Aesculus*)
- Sometimes, *Aesculus* (buckeyes) listed under Hippocastanaceae.
- Leaves double dissected or double compound. Fruit is a multiple nut. $*K_4C_4A_{\infty}G_{\infty}$
..... Family **Ranunculaceae**.
(genus *Clematis*)
 - = Leaves triple or pinnate 41.
41. Leaves rigid, with spiny margins, pinnate. Flowers 3-merous, in racemes. $*K_{3+3}C_{3+3}A_{3+3}G_1$
..... Family **Berberidaceae**.
(genus *Mahonia*)
- Leaves not spiny 42.
42. Leaves triple or pinnate, usually with no more than 5 leaflets. Fruits schizocarpic, with two wings. $*P_{(5)}A_{4-6} \vee *P_5G_{(2)}$ Family **Sapindaceae**.
(*Acer negundo*)
- Leaves odd-pinnate, typically with more than 5 leaflets 43.
43. Woody vines with orange or red, trumpeted, showy flowers. Fruit is a capsule. $\uparrow K_{(5)}C_{(5)}A_4G_{(2)}$
..... Family **Labiatae s.l.**
(*Campsis radicans*)
- Usually, these plants are listed under Bignoniaceae. There is also small tree of that group (*Tecoma stans*) under cultivation. It has similar leaves and similarly looking but yellow flowers.
- Trees, leaves odorless. Fruit is a winged 1-seeded nut. $K_{0\vee 4}A_2G_{(2)}$ or unisexual
..... Family **Oleaceae**.
(genus *Fraxinus*)
 - = Shrubs, leaves with unpleasant odor. Fruit is a drupe. $*K_{(5)}C_{(5)}A_5G_{-(2)}$ - ... Family **Adoxaceae**.
Sometimes, one can find *Sambucus* (elderberry) under Sambucaceae or Caprifoliaceae.

Group 9. True water plants. Completely submerged into water or floating on the water surface, only flowers sometimes are above the level of water.

In case if plant grows both in water and on land, some families are repeated again on the next step (Group 11).

1. There are always leaves floating on the water surface 2.
Please note that its this subgroup, one duckweed species, *Lemna trisulca*, typically floats just **below** the water surface.
- All leaves are usually submerged, they might raise on or above water only in the time of flowering 9.
2. Minuscule plants “made” of floating leaf-like modified shoots and also (usually) roots. Fruit is a capsule (but flowering is really rare). $A_1 \vee G_1$ Family **Araceae**.
(genera *Lemna* (1 root), *Spirodela* (multiple roots) and *Wolffia* (no roots))
- Larger plants with leaves floating on the surface of water 3.
3. Floating leaves lobed or dissected. Fruit is a multiple nut. $*K_5 C_5 A_\infty G_\infty$ Family **Ranunculaceae**.
(species of *Ranunculus*)
- Floating leaves are whole 4.
4. Leaf base heart-shaped, large. Flowers solitary. Fruit is berry-like. $*K_{4-6} C_\infty A_\infty G_{(\infty)} \vee G_{-(\infty)}$ Family **Nymphaeaceae**.
- Leaf base is not heart-shaped 5.
5. Flowers lacking. Leaves scaly. Plant small, moss-like Family **Azollaceae**.
(genus *Azolla*)
Does not occur in North Dakota but found in neighboring territories.
- Flowers present. Leaves not scaly. Plants larger 6.
6. Flowers solitary, axillary. Leaves opposite. Fruit schizocarpic, splits in 4 fragments. $A_1 \vee G_{(2 \times 2)}$ Family **Labiatae s.l.**
(genus *Callitriche*)
Water-starworts (*Callitriche*) are frequently treated as members of Calitrichaceae or Plantaginaceae.
- Flowers in heads or spikes 7.
7. Leaves linear, sheathed (grass-like). Fruit is a nut. $*P_{3-6} A_3 \vee *P_{3-6} G_1$ Family **Typhaceae**.
(genus *Sparganium*)
Sometimes, bur-reeds (Sparganium) are treated as its own family, Sparganiaceae.
- Leaves petiolate, more or less elliptic 8.
8. Leaf venation pterodromous. Flowers pink. Fruit is a nut. $*P_5 A_5 G_{(3)}$... Family **Polygonaceae**.
(*Persicaria amphibia* [*Polygonum amphibium*])
- Leaf venation acrodromous. Flowers green or brown. Fruit is a multiple nut. $*P_4 A_4 G_4$ Family **Potamogetonaceae**.
(genus *Potamogeton natans*)
- 9 (1). Leaves whole 10.
- Leaves variously segmented 21.
10. Leaf margins with prominent teeth, leaves opposite or whorled by 3. Fruit is a drupe. $P_1 A_1 \vee G_1$ Family **Hydrocharitaceae**.
(genus *Najas*)
Waternymphs (*Najas*) are sometimes treated under Najadaceae.
- Leaves with smooth or serrate margin 11.
11. Leaves in rosettes 12.

- Leaves not in rosettes 14.
12. Leaves quill-shaped, with minute axillary attachments—ligules. No flowers, sporangia located at the inner side of leaf bases Family **Isoëtaceae**.
(genus *Isoëtes*)
- Leaves without sporangia at bases 13.
13. Leaves petiolate, narrowly lanceolate. Fruit is a capsule. $*K_{(5)}C_{(5)}A_{4\vee 2}G_{(2)}$
..... Family **Labiatae s.l.**
(genus *Limosella*)
- Mudworts (*Limosella*) are usually listed under Scrophulariaceae.
- Leaves linear, undulate, without petioles. Fruit is a capsule. $*K_{(3)}C_3G_{\bar{3}} \vee *K_{(3)}C_3A_2$
..... Family **Hydrocharitaceae**.
(*Vallisneria americana*)
- 14 (12). Leaves alternate 15.
- Leaves opposite 16.
- = Leaves whorled 18.
15. Flowers in aerial or underwater spikes, green or brown. Leaves linear, hyphodromous or thread-like. Fruit is a multiple nut. $*P_4A_4G_4$ Family **Potamogetonaceae**.
- Flowers in small underwater clusters. Leaves thread-like. Fruit is a multiple nut where individual nuts sit on very long stalks. A_2G_4 Family **Ruppiaceae**.
(genus *Ruppia*)
- = Flowers solitary, aerial, yellow. Leaves linear, parallelodromous. Fruit is a capsule. $*P_{3+3}A_{2,1}G_3$
..... Family **Pontederiaceae**.
(*Heteranthera dubia*)
- Podostemum ceratophyllum*, hornleaf riverweed (Podostemaceae) is registered for North Dakota but herbarium material is wanted. Superficially, it is similar to the representatives of families above but in fact, its “leaves” are modified shoots. Flowers of riverweed are radically simplified, $A_2G_{(2)}$. Fruit is a capsule.
- 16 (14). Flowers axillary, solitary 17.
- Flowers in racemes. Fruit is a two-celled capsule. $\uparrow K_{(4)}C_{(4)}A_2G_{(2)}$ Family **Labiatae s.l.**
(*Veronica anagallis-aquatica*)
- Speedwells (*Veronica*) are frequently listed under Scrophulariaceae or Plantaginaceae.
17. No perianth. Leaves opposite. Fruit schizocarpic, splits in 4 fragments. $A_1 \vee G_{(2 \times 2)}$
..... Family **Labiatae s.l.**
(genus *Callitriche*)
- Water-starworts (*Callitriche*) are frequently treated as members of Calitrichaceae or Plantaginaceae.
- Flowers with double perianth. Fruit is a capsule. $*K_{2-4}C_{2-4}A_{3-8}G_{(2-4)}$... Family **Elatinaceae**.
(genus *Elatine*)
- 18 (14). Leaf whorls consist of three thread-like leaves. Fruit is a multiple drupe. $A_1 \vee G_1$
..... Family **Potamogetonaceae**.
(genus *Zannichellia*)
- Sometimes, horned pondweeds (*Zannichellia*) are treated as the family of its own, Zannichelliaceae.
- Leaves are not thread-like, 3–13 in a whorl 19.
19. Flowers with very long calyx tube. Leaves sometimes paired but mostly 3–7 per node. $*K_{(3)}C_3G_{\bar{3}} \vee *K_{(3)}C_3A_{7-9}$ Family **Hydrocharitaceae**.
(genus *Elodea*)
- Flowers axillary, small. Leaves 3–many in the whorl 20.

20. No perianth. Fruit is a nut $\uparrow(A_1 G_1^-)$ Family **Labiatae s.l.**
(genus *Hippuris*)
Mare's-tails (*Hippuris*) are frequently listed under Hippuridaceae or Plantaginaceae.
- Perianth double. Fruit is a capsule. $*K_4 C_4 A_8 G_{(2)}$ Family **Elatinaceae.**
(genus *Elatine*)
- 21 (9). Leaves with bubbles, carnivorous plant. Fruit is a capsule. $\uparrow K_{(2)} C_{(2)} A_2 G_{(2)}$
..... Family **Labiatae s.l.**
(genus *Utricularia*)
Bladderworts (*Utricularia*) are usually listed as members of Lentibulariaceae. By the way, their “leaves” are modified shoots.
- Leaves without bubbles 22.
22. Leaves whorled 23.
- Leaves opposite, fan-shaped. Fruit is a multiple nut. $*P_{3+3} A_{3+3} G_3$ Family **Cabombaceae.**
(*Cabomba carolineana*)
- = Leaves alternate. Fruit is a multiple nut. $*K_5 C_5 A_\infty G_\infty$ Family **Ranunculaceae.**
(species of *Ranunculus*)
- 23 (21). Flowers axillary. Leaves dichotomously dissected, rough, toothed. Roots absent. Fruit is a nut. $A_1 \vee G_1$ Family **Ceratophyllaceae.**
- Flowers in the aerial spikes. Leaves pinnately dissected, soft. Roots present. Fruit shizocarpic, consists of 4 nutlets. $*K_4 C_4 A_{4+4} \vee *K_4 C_4 G_4^-$ Family **Haloragaceae.**
(genus *Myriophyllum*)

Group 10. Terrestrial spore plants.

1. Leaves well developed, multiple (up to 3 times) pinnate, or clover-like with 4 lobes 2.
– Leaves scale-like, needle-like or reduced into teeth 3.
2. Leaves spirally folded in bud. Sporangia typically gathered in sori located on the back side of leaves (sometimes, there are specialized generative leaves) Family **Polypodiaceae.**
This family understood here in the extreme broad way. However, modern classifications of ferns recognize multiple families: (1) **Aspleniaceae**: *Asplenium*, *Athyrium*, *Cystopteris*, *Gymnocarpium*, *Onoclea*, *Thelypteris*, *Woodsia*; (2) **Dennstaedtiaceae**: *Pteridium*; (3) **Marsileaceae**: *Marsilea*; (4) **Osmundaceae**: *Osmunda*; (5) **Polypodiaceae**: *Dryopteris*; (6) **Pteridaceae**: *Cheilanthes*, *Pellaea*.
- Leaves are not folded spirally, they are divided into vegetative and generative parts. Sporangia are not gathered in sori Family **Ophioglossaceae.**
3. Leaves needle-like or scale-like. Shoot branches dichotomously 4.
– Leaves reduced into teeth, usually black or filmy. Stem articulated Family **Equisetaceae.**
4. Leaves with minute axillary attachments—ligules. Sporangia in 4-sided spikes
..... Family **Selaginellaceae.**
- Leaves without ligules. Sporangia in cylindrical spikes Family **Lycopodiaceae.**

Step three. Group 11: Choices, Choices...

Note. Read statements below, then summarize numbers of points from only those statements which describe your plant. Then go to the group which your sum indicates.

Statements:

(α) All flowers zygomorphic or asymmetric	1 point
(β) Perianth simple or absent ²	2 points
(γ) Petals (not tepals) fused in at least a short tube	4 points
(δ) There are more than 12 stamens and/or more than 1 pistil	8 points
(ϵ) Ovary inferior or half-inferior	16 points

Results:

0 points	Group 11A	(go to page 11)
1 point	Group 11B	(go to page 13)
2 or 3 points	Group 11C	(go to page 13)
4 or 5 points	Group 11D	(go to page 16)
8, 9, 10 or 11 points	Group 11E	(go to page 17)
12 points	Group 11F	(go to page 18)
16 points	Group 11G	(go to page 18)
18 points	Group 11H	(go to page 18)
17 or 19 points	Group 11I	(go to page 19)
20 points	Group 11J	(go to page 19)
21 points	Group 11K	(go to page 19)
24 points	Group 11L	(go to page 20)

Group 11A. Flowers actinomorphic, with double perianth, free petals, 12 or less stamens, one pistil, superior ovary: $*K_a C_b A_{c \leq 12} G_{(d)}$.

If you skip the Step One, carnation family (Caryophyllaceae) and cabbage family (Cruciferae), as well as prairie clover (*Dalea*) from Leguminosae, will fall under this group.

- Plants without chlorophyll. Fruit is a 4–5-celled capsule. $*K_{4\vee 5} C_{4\vee 5} A_{4\vee 5+4\vee 5} G_{(4\vee 5)}$
 Family **Ericaceae**.
 (genus *Monotropa*)

²Please note that spurges (*Euphorbia*) from Euphorbiaceae have unisexual flowers without perianths which, however, gathered into flower-like inflorescence with perianth-like bracts, male and female flowers. Milky sap in all parts of these plants might help to identify them.

- Plants with chlorophyll 2.
- 2. Stamens 3–7 3.
- Stamens 10–12 11.
- 3. Stamens 7. Fruit is a 1-celled capsule. *K₇C₇A₇G₍₇₎ Family **Primulaceae**.
(genus *Trientalis*)
Not found in North Dakota but presents in neighboring territories.
- Stamens 3–6 4.
- 4. Plant with a root leaf rosette 5.
- Root leaf rosette absent 6.
- 5. Typically, there is one stem leaf; rosette leaves glabrous. Fruit is a 3-celled capsule.
*K₍₅₎C₅A₅₊₅G₍₃₎ Family **Celastraceae**.
(genus *Parnassia*)
Grass of Parnassus (*Parnassia*) is sometimes listed under Saxifragaceae or Parnassiaceae.
- No stem leaves; rosette leaves covered with sticky glands. Fruit is a 3-celled capsule. *K₅C₅A₅G₍₃₎
..... Family **Droseraceae**.
(genus *Drosera*)
- 6 (4). Small (several cm) coastal or water plants, flowers sit in leaf axils. Fruit is 3–4-celled capsule.
*K₂₋₄C_{3√4}A₃₋₈G_(3√4) Family **Elatinaceae**.
(genus *Elatine*)
- Plants usually bigger, flowers on pedicels 7.
- 7. Stem climbing. Fruit is a berry. *K₅C₍₅₎A₅G₍₂₎ Family **Vitaceae**.
- Stem upright. Fruit is a capsule or berry 8.
- 8. Flowers 3-merous 9.
- Flower 4–5-merous. Stamens glabrous. Leaves simple. Fruit is a 8–10-celled capsule.
*K_{4√5}C_{4√5}A_{4√5}G_(4√5) Family **Linaceae**.
Species of *Dalea* (prairie clover) might fall here, but they have compound leaves with stipules.
- = Flower with 2 sepals, 5 petals and 3 carpels (correspond with 3 stigmas). Leaves simple. Fruit is
a 1-celled capsule. *K₍₂₎C₍₅₎A₄₋₆G₍₃₎ Family **Montiaceae**.
(genus *PheMERanthus*)
Sometimes, this genus is treated a a member of Portulacaceae.
- 9. Leaves dissected. Plant small, usually just several cm. Fruit schizocarpic, has 3 nutlets.
*K₃C₃A_{3√6}G_(1×3) Family **Limnanthaceae**.
(*Floerkea proserpinacoides*)
- Leaves whole. Plant more than several cm 10.
- 10. Flowers blue or purple, in umbels. Stamens hairy. Fruit is 3-celled capsule. *K₃C₃A₃₊₃G₍₃₎
..... Family **Commelinaceae**.
(genus *Tradescantia*)
- Flowers solitary, red or white. Stamens glabrous. Fruit is a berry. *K₃C₃A₃G₍₃₎
..... Family **Melanthiaceae**.
(genus *Trillium*)
Trilliums (*Trillium*) are sometimes listed under Trilliaceae or Liliaceae.
- 11 (2). Stigmas 5, sometimes short 12.
- Stigmas 1 or 2 13.
- 12. Leaves simple, but frequently palmately dissected. Fruit is a 5-celled capsule. *K₅C₅A_{[5+5]√(5)}G₍₅₎
..... Family **Geraniaceae**.

- Leaves triple. Styles 5. Fruit is a 5-lobed capsule. $*K_5C_5A_{(5+5)}G_{(5)}$ Family **Oxalidaceae**.
(genus *Oxalis*)
- = Leaves pinnate. Fruit schizocarpic, with 5 spiny nutlets. $*K_5C_5A_{5+5}G_{(5)}$
..... Family **Zygophyllaceae**.
(*Tribulus terrestris*)
- 13 (11). One style with globose stigma 14.
- Two styles. Fruit is a 2-celled capsule. $*K_5C_5A_{10}G_{(2)}$ Family **Saxifragaceae**.
- 14. 10 stamens, flower 5-merous. Fruit is a 5-celled capsule. $*K_{(5)}C_5A_{10}G_{(5)}$... Family **Ericaceae**.
(Subfamily Pyroloideae: genera *Orthilia* and *Pyrola*)
- 12 stamens, flower 6-merous or 4-merous. Fruit is a 2- or 4-celled capsule.
 $*K_{(6+6)\vee(4)}C_{6\vee4}A_{[6+6]\vee6\vee[4+4]}G_{(2\vee4)}$ Family **Lythraceae**.
(genera *Lythrum* and *Ammania*)

Group 11B. Flowers zygomorphic or asymmetric, with double perianth, free petals, 12 or less stamens, 1 pistil, superior ovary: $\uparrow \vee \nless K_a C_b A_{c \leq 12} G_{(d)}$.

If you skip the Step One, most of legumes (Leguminosae) will fall under this group.

1. 10 or more stamens. Ovary open on top. Fruit is an open capsule. $\uparrow K_{4-6}C_{4-6}A_{10-\infty}G_{(3)}$
..... Family **Resedaceae**.
(genus *Reseda*)
- Stamens less than 10 2.
2. Three stamens fused in two blades, each blade bears 3 anthers. Fruit is a silique.
 $\uparrow K_2C_{1,3}A_{2 \times 1,5}G_{(2)}$ Family **Papaveraceae**.
(subfamily Fumarioideae)
Sometimes, members of this group treated as separate family, Fumariaceae.
- Androecium is different from the above 3.
3. Corolla has 3 petals, two of them are bigger than the third one. Fruit is 3-celled capsule.
 $K_3C_{1,2}A_{3,3}G_{(3)}$ Family **Commelinaceae**.
(genus *Commelina*)
- Petals are not like above 4.
4. Stamens 5 5.
- Stamens 3 or 8 6.
5. Stamens are fused by filaments. One of sepals petal-like, with spur. Stem transparent. Fruit is 5-celled capsule. $\uparrow K_{1,2}C_{1,2,2}A_{(5)}G_{(5)}$ Family **Balsaminaceae**.
(genus *Impatiens*)
- Stamens do not fuse with filaments. Calyx all green. Corolla with spur. Fruit is 3-celled capsule.
 $\uparrow K_5C_{[1,4]\vee 0}A_{2,3}G_{(3)}$ Family **Violaceae**.
- 6 (4). Stamens free. Flowers orange or yellow. Leaves peltate. Fruit schizocarpic, with 3 nutlets.
 $\uparrow K_{1,4}C_{2,3}A_8G_{(3)}$ Family **Tropaeolaceae**.
(genus *Tropaeolum*)
These South American plants are sometimes cultivated as ornamentals.
- Stamens fused. Flowers white or blue. Leaves narrow. Fruit is 2-celled capsule.
 $\uparrow K_{2,3}C_{[1,2]\vee[1,4]}A_{(8)}G_{(2)}$ Family **Polygalaceae**.
(genus *Polygala*)

Group 11C. Perianth simple or absent, stamens 12 or less, pistil 1, ovary superior: $P_{a \vee 0} A_{b \leq 12} G_{(c)}$.

If you skip the Step One, graminoid families (Gramineae, Cyperaceae and Juncaceae) will fall under this group.

1. Annuals or perennials without rhizomes. Leaves palmate (or at least deeply palmate or triple lobed), rough. Flowers green or brown, unisexual, usually surrounded with bracts. Fruit is a nut. $P_5 A_5 \vee P_1 G_{(2)}$ Family **Cannabaceae**.
 - Rhizomatous, semi-aquatic or helobious herbaceous plants. Leaves triple lobed or whole. Inflorescences are heads or spadices. Flowers without perianth or with non-conspicuous perianth 2.
 - = Plants different from both descriptions given above 4.
2. Leaves triple lobed or elliptic. Bract of the spadiceous inflorescence large, non-green. Fruit is a berry. $*A_6 G_{(3)}$ Family **Araceae**.
 - Leaves linear. Inflorescence is different from the above 3.
3. Inflorescence is a spadix, deviated with a sharp angle from the axis. Bract green, leaf-like. Fruit is a berry. $*P_6 A_6 G_{(3)}$ Family **Acoraceae**.
 - Inflorescence is a terminal spadix or round head. Fruit is a nut. $P_{0 \vee 3-6} A_{3 \vee (3)} \vee P_{0 \vee 3-6} G_1$ Family **Typhaceae**.
(genera *Typha* and *Sparganium*)
- 4 (1). Unisexual flowers without perianth are located in axils of opposite leaves. Stems are weak. Fruit schizocarpic, consists of 4 nutlets. $A_1 \vee G_{(2 \times 2)}$ Family **Labiatae s.l.**
(genus *Callitriche*)

Water-starworts (*Callitriche*) are frequently treated as members of Calitrichaceae or Plantaginaceae.

 - Plants with combination of characters different from the above 5.
5. Leaves with an ochrea—leathery or filmy “sleeve” growing upwards along the stem from the base of leaf. Stem nodes usually swollen. Fruit is a nut. $P_{(4 \vee 5) \vee 3-6} A_{5-9} G_{(3)}$ Family **Polygonaceae**.
 - Leaves without ochrea 6.
6. Perianth corolla-like, colored 7.
 - Perianth calyx-like or absent 15.
7. Flowers 4–5-merous. Leaf venation pterodromous, hyphodromous or apodromous (veins not visible). Fruits are nuts or capsules. 8.
 - Flowers 3-merous. Leaf venation acrodromous or parallelodromous. Fruits are berries or capsules 10.
 - = Flowers 3-merous. Leaf venation pterodromous, hyphodromous or apodromous. Flowers in terminal involucrate umbel- or head-like inflorescences. Fruits are nuts. $P_{(6)} A_9 G_{(3)}$ Family **Polygonaceae**.
(genus *Eriogonum*)
8. Flowers in the involucrate inflorescences, sometimes (*Mirabilis*) reduced into one flower but then involucre covers this flower from outside. Perianth fused, with tube. Pistil 1-carpellate. Fruit is a nut. $*P_{(4-5)} A_{4-5} G_1$ Family **Nyctaginaceae**.
 - Flowers solitary, axillary 9.
9. Flowers white. Fruit is a 3-celled capsule³. $*P_{(5)} A_5 G_{(3)}$ Family **Molluginaceae**.
(genus *Mollugo*)

³You might also come here if you take the inflorescence of spurge (*Euphorbia* from Euphorbiaceae) as a bisexual flower with simple perianth

- Flowers pink, at least in the center. Fruit is a 1-celled capsule. $*P_5A_5G_{(5)}$
 Family **Primulaceae**.
 (*Glaux maritima*)
- 10 (7). Leaves 2-ranked (in one plane), linear, most of them concentrated at the base of stem. Fruit is a capsule. $*P_{3+3}A_{3+3}G_{\underline{3}}$ Family **Tofieldiaceae**.
 (*Triantha glutinosa*)
- Leaves not two-ranked 11.
11. Fruit is a berry of different colors, but not bright orange or red. Flowers are white, often in racemes (paired in *Polygonatum*, solitary in *Leucocrinum*). Plants with horizontal rhizomes (but *Leucocrinum* has no stem). $*P_{4\vee(6)}A_{3+3}G_{(3)}$ Family **Asparagaceae**.
 In the past, some genera of Asparagaceae were members of Liliaceae or Convallariaceae.
- Fruit is a capsule or bright orange or red berry. Flowers not white or sometimes white (*Prosarthes*), in racemes, umbels, or solitary, or paired. Plants with bulbs, sometimes rhizomatous 12.
12. At least some (usually most) photosynthetic leaves are attached to the vertical part of stem ...
 13.
- All photosynthetic leaves concentrated near stem base, stem leafless except for bracts 14.
13. Plants bulbous (if rhizomatous, then fruit is bright orange or red berry). Flowers not drooping and yellow. Fruit is a capsule or berry. $*P_{3+3}A_{3+3}G_{(3)}$ Family **Liliaceae**.
- Plants with rhizomes, fruit is a drooping green capsule. Flowers drooping, yellow. $*P_{3+3}A_{3+3}G_{\underline{3}}$ Family **Colchicaceae**.
 (genus *Uvularia*)
- 14 (12). Diversely colored flowers (and fruits) in umbels. Leaves with onion or garlic smell. Fruit is a capsule. $*P_{3+3}A_{3+3}G_{\underline{3}}$ Family **Amaryllidaceae**.
 (genus *Allium*)
- Onions (*Allium*) are frequently listed under Alliaceae.
- Flowers white-green, in racemes. Leaves without onion or garlic smell (careful, some species are poisonous when digested!). Fruit is a capsule. $*P_{3+3}A_{3+3}G_{(3)}$ Family **Melanthiaceae**.
 (genus *Zigadenus*)
- Deathcamas (*Zigadenus*) is sometimes listed under Liliaceae.
- 15 (6). Fruit schizocarpic with 3 or 2 nutlets. Milky sap is frequently present in all parts of plants. Flowers in dense inflorescences (cyathia) surrounded with bracts, $A_1 \vee G_{(3)}$
 Family **Euphorbiaceae**.
- Fruit is a capsule or nut. Milky sap absent. Flowers not in cyathia 16.
16. Leaves opposite, if alternate then covered with stinging hairs or at least coarse “velcro” hairs. Flowers in relatively short but branched inflorescences starting from leaf axils (sometimes inflorescences reduced into groups of few flowers). Fruit is a nut. $*P_{4\vee 5}A_{4\vee 5} \vee *P_{4\vee 0}G_{\underline{1}}$ or bisexual
 Family **Urticaceae**.
- Leaves mostly alternate, other characters are not as above 17.
17. Stems climbing. Leaves with acrodromous venation. Flowers in umbels. Fruit is a berry.
 $*P_{3+3}A_{3+3}G_{(3)}$ Family **Smilacaceae**.
 (genus *Smilax*)
- Stems upright. Leaves and flowers different from above 18.
18. Leaves linear, grooved, with sheaths. Fruit is a 3-celled capsule. $*P_3A_3P_3A_3G_{(3)}$
 Family **Juncaginaceae**.
 (genus *Triglochin*)
- Leaves without sheaths 19.

19. Flowers usually small, few millimeters in diameter. Carpels completely fused. Fruit is a nut.
 $*P_{3-5}A_{1-5}G_{(2)}$ or unisexual Family **Amaranthaceae**
 In the past, some genera (they frequently have fleshy leaves) of this family were placed in Chenopodiaceae.
- Flowers bigger (more than 5 mm in diameter). Carpels partly free. Fruit is a 5–7-celled capsule.
 $*P_5A_{10}G_{(5-7)}$ Family **Haloragaceae**
 (*Penthorum sedoides*)
 Ditch stonewort (*Penthorum sedoides*) is frequently listed under Crassulaceae or Penthoraceae.

Group 11D. Perianth double, petals fused in at least short tube, pistil one, ovary superior, stamens 12 or less: $K_a C_{(b)} A_{c \leq 12} G_{(d)}$.

If you skip the Step One, most of the expanded mint family (Labiatae s.l.) will fall under this group (some of its most deviated representatives are mentioned below).

1. Stem climbing. Fruit is a capsule. $*K_{(5 \vee 4)} C_{(5 \vee 4)} A_{5 \vee 4} G_{(2)}$ Family **Convolvulaceae**.
 – Stem does not climb 2.
2. Fruit schizocarpic, consists of 4 nutlets. Stem and leaves are usually covered with rough hairs.
 $* \vee \uparrow K_{(5)} C_{(5)} A_5 G_{(2 \times 2)}$ Family **Boraginaceae**.
 – Fruit and pubescence are different from the above 3.
3. Stamens opposite to petals. Style 1. Fruit is a capsule. $*K_{(5 \vee 4 \vee 7)} C_{(5 \vee 4 \vee 7)} A_{5 \vee 4 \vee 7} G_{(5 \vee 4 \vee 7)}$
 Family **Primulaceae**.
 – Stamens alternate with petals. Number of styles varies 4.
4. Stamens completely or partly fused 5.
 – Stamens completely free (however, they can fuse with corolla tube) 6.
5. Three stamens fused in two blades, each blade bears 3 anthers. Fruit is a silique. $\uparrow K_2 C_{1,3} A_{2 \times 1,5} G_{(2)}$
 Family **Papaveraceae**.
 (subfamily Fumarioideae)
 Sometimes, members of this group treated as separate family, Fumariaceae.
- Stamens 8, fused, each stamen with one anther. Fruit is 2-celled capsule. $\uparrow K_{2,3} C_{[1,2] \vee [1,4]} A_{(8)} G_{(2)}$
 Family **Polygalaceae**.
 (genus *Polygala*)
- 6 (4). Corolla dry, filmy. Fruit is a capsule opening with round slit. $*K_{4 \vee 3} C_{(4)} A_4 G_{(2)}$
 Family **Labiatae s.l.**
 (genus *Plantago*)
 Most frequently, plantains (*Plantago*) are treated as members of Plantaginaceae.
- Corolla is not dry 7.
7. Ovary 1-celled, ovules (and then seeds) are attached to its walls. Leaves glabrous, either triple or whole, from linear to elliptic with central vein and arcuate lateral veins 8.
 Good character which also unite this subgroup is an extreme bitter taste of their leaves but since in the other subgroup, representatives of Solanaceae could be poisonous, this is not recommended for the identification.
- Ovary 2–3-celled, leaves usually different from the description above 9.
8. Leaves opposite, simple, some attached to the stem. Petals glabrous. Fruit is a 2-valved capsule.
 $*K_{(5 \vee [4-7])} C_{(5 \vee [4-7])} A_{4-7} G_{(2)}$ Family **Gentianaceae**.
 – Leaves alternate, triple, in root rosette. Petals hairy. Fruit is a 2-valved capsule. $*K_{(5)} C_{(5)} A_5 G_{(2)}$
 Family **Menyanthaceae**.
 (genus *Menyanthes*)
- 9 (7). Style with 3 lobes. Fruit is 3-celled capsule. $*K_{(5)} C_{(5)} A_5 G_{(3)}$ Family **Polemoniaceae**.

- Style with 1 lobe or styles 2 10.
- 10. Inflorescence is a cincinnus, sometimes dense, round-shaped. Styles 2. Fruit is 2-celled capsule. $*K_{(5)}C_{(5)}A_5G_{(2)}$ Family **Hydrophyllaceae**.
Sometimes, some genera of this family are treated under Boraginaceae.
- Inflorescence is not a cincinnus, style 1 11.
- 11. Leaves usually alternate. Flower tube usually relatively short, does not have attachments covering its entrance. Stamens 5. Flowers slightly asymmetric because planes of symmetry are different between perianth and ovary. Fruit is a berry or capsule. $*K_{(5)}C_{(5)}A_5G_{(2)}$
..... Family **Solanaceae**.
- Leaves usually opposite. Flower tube usually relatively long, with attachments covering the entrance. Stamens 4. Sometimes, flowers slightly asymmetric because some petals might be bigger than others. Fruit is a capsule. $*K_{(5)}C_{(5)}A_4G_{(2)}$ Family **Labiatae s.l.**
(genus *Verbena*)

Most frequently, verbenas (*Verbena*) are listed in Verbenaceae.

Group 11E. Petals (if any) free, pistils more than one and/or stamens more than 12, ovary superior:
 $[K_a C_b] \vee P_c [A_{d>12} G_{(e)\vee e}] \vee [A_d G_e]$

- 1. Leaves with sheaths, venation acrodromous or parallelodromous. Flower 3-merous 2.
- Leaves with actinodromous or pterodromous venation, without sheaths. Flower usually 5-merous
..... 4.
- = Leaves pitcher-shaped, carnivorous. Flower with umbrella-like style covering the whole center of flower including multiple stamens. Fruit is a capsule. $*K_5 C_{0\vee 5} A_{\infty} G_{(5)}$
..... Family **Sarraceniaceae**.
(*Sarracenia purpurea*)
- Was not found in North Dakota but known in western Minnesota (Lake Itasca).
- 2. Venation acrodromous (leaves more or less elliptic). Pistils many. Perianth double. fruit is a multiple nut. $*K_3 C_3 A_{6\vee \infty} G_{\infty}$ Family **Alismataceae**.
- Venation parallelodromous (leaves linear). Pistils 3 or 6. Perianth simple or double 3.
- 3. Pistils 3, perianth simple, non-conspicuous. Fruit is a multiple follicle. $*P_{3+3} A_{3+3} G_3$
..... Family **Scheuchzeriaceae**.
(genus *Scheuchzeria*)
- Pistils 6, perianth double, showy. Fruit is a multiple follicle. $*K_3 C_3 A_9 G_6$
..... Family **Butomaceae**.
(genus *Butomus*)
- 4 (1). Pistil 1, perianth double 5.
- Pistils more than 1 or one (in this last case, perianth always simple) 10.
- 5. Flower zygomorphic. Ovary open on top. Fruit is an open capsule. $\uparrow K_{4-6} C_{4-6} A_{10-\infty} G_{(3)}$
..... Family **Resedaceae**.
(genus *Reseda*)
- Flower actinomorphic 6.
- 6. Stamens more or less fused into one column or three bundles. Leaves with actinodromous venation (most visible at the base) 7.
- Stamens free. Venation diverse 8.
- 7. Stamens fused into one column. Style 1. Leaves alternate. Fruit is a capsule, multiple follicle or schizocarpic. $*H_{0\vee 3-8\vee (3-8)} K_5 C_5 A_{(\infty)} G_{(\infty)\vee \infty}$ Family **Malvaceae**.

- Stamens fuse in 3 bundles. Styles 3. Leaves opposite. Fruit is a capsule. $*K_5C_5A_{3 \times \infty}G_{(3)}$
 Family **Hypericaceae**.
 (genus *Hypericum*)
- 8 (6). Leaves glabrous, with toothed or lobed margins, sometimes almost dissected. Fruit is a capsule or siliqua. $*K_2C_4A_{\infty}G_{(2)}$ Family **Papaveraceae**.
- Leaves with smooth margins, hairy or glabrous 9.
- 9. Leaves succulent. Perianth simple. Fruit is a capsule. $\uparrow P_{(4 \vee 5)}A_{\infty}G_{(3-8)}$ Family **Aizoaceae**.
 (*Tetragonia tetragonoides*)
- Leaves not succulent. Perianth double. Fruit is a capsule. $*K_{2+3}C_5A_{\infty}G_{(3)}$
 Family **Cistaceae**.
- 10 (4). Leaves succulent. Numbers of pistils and sepals equal. Fruit is multiple follicle.
 $*K_{(5-20)}C_{5-20}A_{10-40}G_{5-20}$ Family **Crassulaceae**.
 Was not found in North Dakota but occur in all neighboring territories.
- Leaves are not succulent. Number of pistils bigger than number of petals 11.
- 11. Leaves with stipules. Calyx with calycle (epicalyx). There is also hypanthium (expanded flower receptacle under calyx). Fruit is multiple follicle, multiple nut or multiple drupe.
 $*H_{(5 \vee 4 \vee 0)}K_{(5 \vee 4)}C_{5 \vee 4 \vee 0 \vee 6}A_{4-\infty}G_{1-\infty}$, or sometimes unisexual Family **Rosaceae**.
- Leaves without stipules. Calyx without calycle, deciduous. Hypanthium absent, but receptacle can be conically enlarged. Fruit is multiple nut or multiple follicle. $* \vee \uparrow [K_{3-15}C_{2-25}] \vee [P_{5-6}]A_{5-\infty}G_{1-\infty}$ Family **Ranunculaceae**.
 Sometimes, sepals and stamens are petal-like, and petals become nectaries.

Group 11F. Flowers actinomorphic, perianth double, petals fused into at least short tube, pistils more than 1, ovary superior: $*K_aC_{(b)}A_cG_{d>1}$.

Leaves opposite. Plants with milky sap. Two pistils but styles fuse at least on top. Fruit is a double follicle. $*K_{(5)}C_{(5)}A_5G_2$ Family **Apocynaceae**.

Some genera of Apocynaceae were in the past in their own family, Asclepiadaceae (they differ by having pollinia, like orchids).

Group 11G. Flowers actinomorphic, perianth double, petals free, stamens 12 or less, pistil 1, ovary inferior: $*K_aC_bA_{c \leq 12}G_{(\bar{d})}$.

If you skip the Step One, umbel family (Umbelliferae) will fall under this group.

- 1. Flower 2–4-merous. Leaves simple. Fruit is a 2–5-celled capsule. $*K_{2 \vee 4}C_{2 \vee 4}A_{2 \vee [4+4]}G_{(2-5)}$
 Family **Onagraceae**.
- Flower 5-merous. Leaves double pinnate or triple and then pinnate. Fruit is a berry. $*K_{0 \vee 5}C_5A_5G_{(5)}$
 Family **Araliaceae**.
 (*Aralia nudicaulis*)

Group 11H. Flowers actinomorphic, perianth simple or absent, stamens 12 or less, pistil 1, ovary inferior or half-inferior: $*P_{a \vee 0}A_{b \leq 12}G_{(\bar{d})} \vee G_{-(d)-}$.

- 1. Leaves linear 2.
- Leaves not linear 3.
- 2. Leaves two-ranked. Flowers blue or light blue. Fruit is a 3-celled capsule. $* \vee \uparrow P_{(3+3)}A_3G_{(3)}$
 Family **Iridaceae**.

- Leaves not two-ranked. Flowers yellow. Fruit is a 3-celled capsule. $*P_{3+3}A_{3+3}G_{(3)}$ Family **Hypoxidaceae**.
(*Hypoxis hirsuta*)
- 3 (1). Flowers lay almost on the ground, solitary, green-purple. Stamens 12. Fruit is a capsule. $*P_{(3)}A_{12}G_{(3)}$ Family **Aristolochiaceae**.
(*Asarum canadense*)
- Flowers above the ground, axillary or in inflorescences 4.
- 4. Flowers white. Fruit is a nut. $*P_{(5\vee4)}A_{5\vee4}G_{(2)}$ Family **Santalaceae**.
- Flowers green. Fruit is a drupe. $*P_{(2\vee3)+(4\vee5)}A_{[4\vee5]\times 2}G_{-(2)-}$ Family **Adoxaceae**.
(*Adoxa moschatellina*)

Was not found in North Dakota but occurs in most neighboring territories.

Group 11I. Flowers zygomorphic or asymmetric, perianth any (simple, double or absent), stamens 12 or less, pistil 1, ovary inferior: $\uparrow \vee \zeta \dots A_{b \leq 12} G_{(\bar{d})}$.

1. No perianth. Fruit is a nut $\uparrow(A_1 G_{\bar{1}})$ Family **Labiatae s.l.**
(genus *Hippuris*)
Mare's-tails (*Hippuris*) are frequently listed under Hippuridaceae or Plantaginaceae.
- Perianth presents 3.
2. Perianth with a lip, stamen 1 or 2. Venation not pterodromous. Fruit is 1-celled capsule with tiny seeds. $\uparrow P_{3\vee[(2),1]+2,1}(A_{1\vee 2} G_{(3)})$ Family **Orchidaceae**.
- No lip. Stamens 8. Venation pterodromous. Fruit is 2-celled capsule. $\uparrow K_4 C_{1,3} A_{4+4} G_{(2)}$ Family **Onagraceae**.

Group 11J. Flowers actinomorphic, perianth double, petals fused into at least short tube, stamens 12 or less, pistil 1, ovary inferior: $*K_a C_{(b)} A_{c \leq 12} G_{(\bar{d})}$.

If you skip the Step One, some of aster family (Compositae subfamily Lactucoideae: for example, dandelion, *Taraxacum*) will fall under this group.

1. Stems with tendrils. Flowers unisexual. Fruit is a berry. $*K_{(5)} C_{(5)} A_{(5)} \vee *K_{(5)} C_{(5)} G_{(3-5)}$ Family **Cucurbitaceae**.
- No tendrils. Flowers bisexual 2.
2. Leaves alternate. Stem upright. Fruit is 2-3-5-celled capsule. $*K_{(5)} C_{(5)} A_5 G_{(2\vee 3\vee 5)}$ Family **Campanulaceae**.
- Leaves opposite. Stem creeping. Fruit is a nut. $*K_{(5)} C_5 A_{2,[3\vee 2]} G_{(2)}$... Family **Caprifoliaceae**.
(genus *Linnaea*)
- = Leaves whorled. Stem upright. Fruit schizocarpic with 2 mericarps. $*K_{0\vee(4\vee 5)} C_{(4\vee 3\vee 5)} A_{4\vee 3\vee 5} G_{(2)}$ Family **Rubiaceae**.

Group 11K. Flowers zygomorphic or asymmetric, perianth double, petals fused into at least short tube, stamens 12 or less, pistil 1, ovary inferior: $\uparrow \vee \zeta K_a C_{(b)} A_{c \leq 12} G_{(\bar{d})}$.

If you skip the Step One, most of aster family (Compositae) will fall under this group.

1. Leaves whole. Inflorescence is a raceme. Fruit is a capsule. $\uparrow K_{(5)} C_{(2,3)} A_{(5)} G_{(3)}$ Family **Campanulaceae**.
Sometimes, members of Campanulaceae with zygomorphic flowers are treated under Lobeliaceae.
- At least some leaves compound or dissected. Inflorescences are not racemes 2.

2. Flowers in heads surrounded with modified bracts, individual flowers with external calyx. Fruit is an achene enclosed into modified external calyx. $\uparrow E_{(4\vee 8)} K_{(5\vee 3)\vee 0} C_{(4\vee 5)} A_4 G_{(\bar{2})}$
 Family **Caprifoliaceae**.
 (genus *Knautia*)

Frequently listed under Dipsacaceae.

- Flowers in paniculate inflorescences, individual flowers without external calyx, asymmetric. Fruit is an achene with hairy attachment. $\downarrow K_0 C_{(5-3)} A_3 G_{(\bar{2})}$ Family **Caprifoliaceae**.
 (genus *Valeriana*)

Frequently treated within its own family, Valerianaceae. Valerians (*Valeriana*) was not found in North Dakota but occur in most neighboring territories.

Group 11L. Flowers actinomorphic, perianth double or simple, stamens more than 12, ovary inferior: $*[K_a C_b] \vee P_c A_{d>12} G_{(\bar{e})}$.

Flowers of Cactaceae also correspond with description of this group.

Plants with alternate rough leaves covered with bristles making them “natural velcro”. Fruit is a capsule. $*K_{(5)} C_{5\vee 10} A_{\infty} G_{(\infty)}$ Family **Loasaceae**
 (genus *Mentzelia*)

Appendix A. Flower formulas

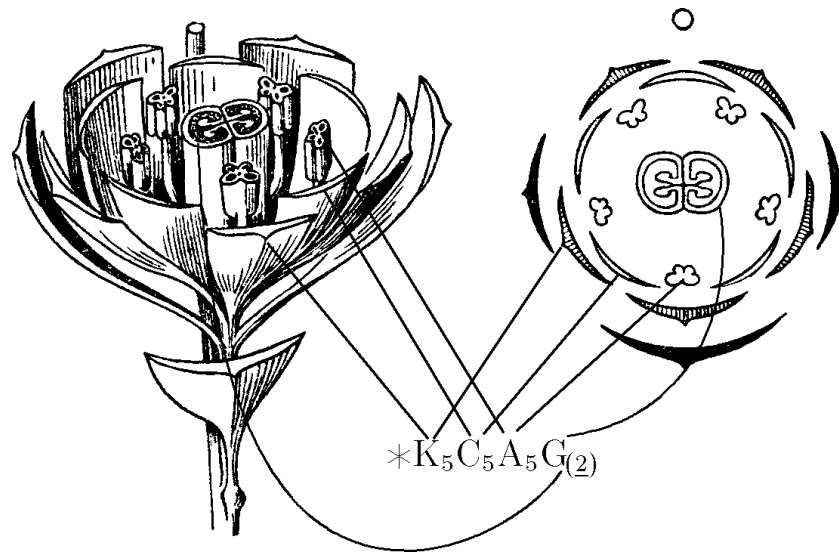


Figure 1: Relations between flower, its diagram and its formula

Most frequent symbols if flower formulas system used here:

- * actinomorphic (radial, star-shaped) flower
- ↑ zygomorphic (bilateral) flower
- ⚡ asymmetric flower. Sometimes, if flower is too small and/or perianth significantly reduced, symmetry was skipped in the formula.
- ♂ male flower (without fertile pistil)
- ♀ female flower (without developed stamens)
- ♂♀ bisexual flower
- K calyx, consists of sepals
- H calycle, or epicalyx (Malvaceae, Rosaceae)
- E external calyx (Caprifoliaceae)
- C corolla, consists of petals
- S staminodes (petal-like stamens)
- P simple perianth (i.e., perianth which is impossible to classify into calyx and corolla), consists of tepals
- A androeceum (all stamens together)
- G gynoecium (all pistils of carpels together)
- G₍₂₎ inferior ovary (here with two carpels)—perianth and stamens attached to the tip of the pistil
- G₍₅₎ superior ovary (here with five carpels)—perianth and stamens are attached to the basement of pistil

- G₋₍₃₎₋ half-inferior ovary (here from three carpels)—perianth and stamens attached to the middle of pistil
- ∨ “or”, e.g. K_{3∨5} means three or five but not four sepals
- variation of part numbers, e.g. K₃₋₅ means three, four or five sepals
- () fusion
- + separate flower circles
- × splitting or sometimes (like A_{∞×5}) fusion in several bundles
- ,
- ∞ indefinite (typically, more than 12 and also variable between flowers)
- [] separate groups of flower parts to which symbols “∨” or “+” are applied

Examples of complicated flower formulae:

- $P_{0\vee 2\vee(4)}A_{4-12} \vee P_{0\vee(\infty)}G_{(\overline{2})}$ (birch family, Betulaceae): unisexual flowers, male without perianth or with perianth of 2 free or 4 fused tepals, stamens from 4 to 12; female flowers without or with perianth of indefinite number of tepals, pistil with two carpels, ovary inferior.
- $\uparrow \vee *K_{(4\vee 5)}C_{([2,3]\vee 4\vee 5)}A_{[2,2]\vee 2\vee 5}G_{(2)}$ (mint family, Labiatae s.l.): flowers bisexual, zygomorphic or actinomorphic, perianth double (with calyx and corolla): calyx with 4 or 5 fused sepals and corolla with 4 or 5 fused petals where 2 petals are different from other three (two lips); stamens 4, sometimes 5 or 2, in the first case one pair is different from another; pistil with 2 carpels, ovary superior.
- $*H_{(5\vee 4\vee 0)}K_{(5\vee 4)}C_{5\vee 4\vee 0}A_{4-\infty}G_{1-\infty}$ (part of the rose family, Rosaceae): flowers bisexual, actinomorphic, there is a sub-calyx of 5 or 4 lobes, sometimes sub-calyx wanted; double perianth—calyx has 5 or 4 fused sepals whereas corolla has 5 or 4 free petals (sometimes corolla absent); stamens from 4 to indefinite; pistils from one to indefinite, ovary superior.
- $* \vee \uparrow K_{(5)}C_{(5)}A_5G_{(2 \times 2)}$ (forget-me-not family, Boraginaceae): flowers bisexual, actinomorphic or sometimes zygomorphic, double perianth—calyx with 5 fused sepals and corolla with 5 fused petals; 5 stamens; pistil has 2 carpels and each of them splits in two parts, ovary superior.

Appendix B. Some useful literature

Blakeslee A.F., Jarvis C.D. 1926. Trees in winter. Their study planting, care and identification. New York: Macmillan.

Core E.L., Ammons N.P. 1958. Woody plants in winter. Pittsburgh, Pennsylvania: Boxwood Press.

Shipunov A. 2015. Flora of North Dakota: Illustrated checklist. URL:
<http://ashipunov.info/shipunov/fnddb/>

Appendix C. Key to the most frequent families

[This section is taken from the “Flora of North Dakota: Illustrated Checklist”]. More than a half of North Dakota flowering plants belong to the ten most frequent families. This key may help with their determination.

1. Inflorescence dense, flower-like head. Leaves without stipules, sometimes with milky sap. Calyx reduced to pappus or scales. Anthers united into the tube around the style. Fruit small, solid and dry achene, usually with long hairs on the top (pappus). **Compositae**, Aster family
 - Inflorescences with different structure 2.
2. Leaves narrow, linear, alternate in two ranks, with sheath and ligules; stems cylindrical in section, internodes usually hollow. Flowers each compressed between a bract (lemma) and bracteole (palea). Flowers arranged in 2 ranks in spikelets subtended by empty bracts (glumes); spikelets themselves grouped in more complex inflorescences, usually spikes, racemes, or panicles. Seed fused to pericarp to form a one-seed dry caryopsis. **Gramineae**, Grass family
 - Leaves narrow, linear, alternate in (usually) 3 ranks, with sheath and ligules (leaves could be reduced); stems triangular or cylindrical in section, internodes usually not hollow. Flowers reduced in many different ways, very often (sedges) the female flower is just a pistil surrounded with bag-like bract (perigynium). Flowers arranged in spikelets and/or spikes or more branched inflorescences. Seed is not fused to pericarp, the fruit is the one-seed dry nutlet. **Cyperaceae**, Sedge family
 - = Plants have different characters 3.
3. Flowers with upper and lower lips 4.
 - Flowers without lips 5.
4. Flowers with 4 stamens. Ovary split in four parts. Leaves opposite, stems quadrangular in section. **Labiatae**, Mint family
 - Flowers with 10 stamens, corolla with banner (top petal) and keel (two front petals). Ovary solid. Leaves compound, with paired stipules. **Leguminosae**, Pea family
 - = Flowers labiate, but not as above Other families (e.g., Polygalaceae, Phrymaceae, Orchidaceae)
- 5 (3). Flowers showy, typically with the double perianth: calyx and corolla. Sometimes, flowers have more than 12 stamens. 6.
 - Flowers often inconspicuous, with the uniform perianth (greenish or colored). Flowers always with less than 12 stamens. 9.
6. Flowers normally with more than 12 stamens, and often also with more than 1 pistil. 7.
 - Flowers with less (usually 4, 5, 6 or 10) stamens, and always with one pistil. 8.
7. Flowers with multiple (or one) pistil(s) sitting inside a receptacle “cup” (*hypanthium*) or on the enlarged receptacle. Perianth double. Leaves with paired stipules. . . . **Rosaceae**, Rose family
 - Flowers without hypanthium (but enlarged receptacle may present). Perianth double or uniform. Leaves without stipules **Ranunculaceae**, Buttercup family
 - = Flowers with multiple stamens, but not as above Other families (e.g., Nymphaeaceae, Alismataceae, Cistaceae)
- 8 (6). Flowers with one central pistil, receptacle is not enlarged. Stamens 6, two of them are smaller than others. Leaves without paired stipules. **Cruciferae**, Mustard family
 - = Plants with different characters Most of non-listed families
- 9 (5). Flowers often more than 3 mm in diameter, arranged in spikes or more branched inflorescences. Every node has an *ochrea*: “sleeve” which continues upward with the stem. **Polygonaceae**, Buckwheat family

-
- Flowers often very small, less than 3 mm in diameter, arranged in more compact inflorescences (often in glomerules). Ochrea absent. **Amaranthaceae**, Amaranth family
 - = Plants with small, inconspicuous, often reduced flowers, but other characters are different from above Other families (e.g., Potamogetonaceae, Urticaceae, Juncaceae)