BIOL 154 —Laboratory Manual

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[1]Links in this PDF are *active*, you may click on them.

Contents

Prairie

1.1 Assignment and report

1. Mark 1×1 m observation plot with measure tape, 4 wooden sticks and thread.
2. List here total numbers of plants from each of three groups (see the Background section):
   (a) grasses (Gramineae) ____________________

   (b) aster family (Compositae) ____________________

   (c) all other plants ____________________
3. Using Drude's and 1543 scales, describe total abundance of each group:
   (a) ________________ ________________

   (b) ________________ ________________

   (c) ________________ ________________
4. Using canopy coverage scale, describe total coverage of each group.
   (a) ______________________________

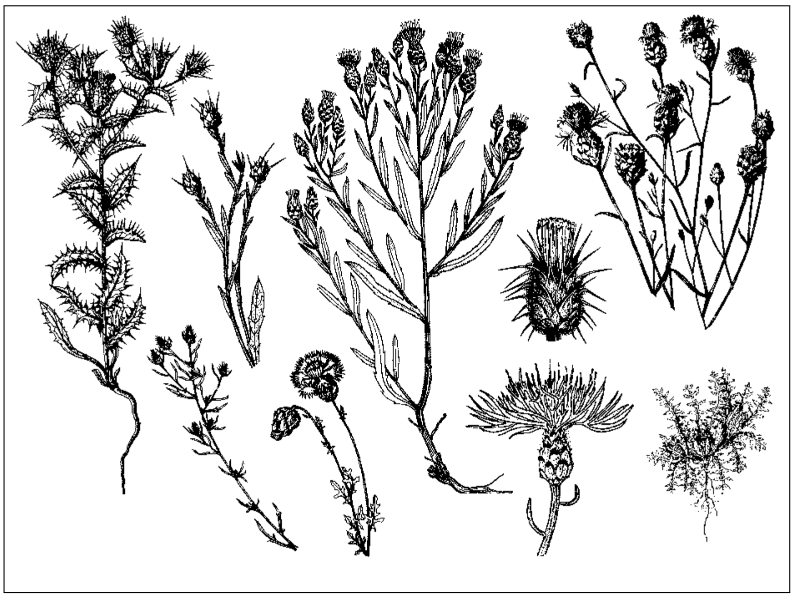
   (b) ______________________________

   (c) ______________________________
5. Which group has highest abundance? Why? Explain.
6. Which group has highest coverage? Does this group has also highest abundance? Why? Explain.
7. Do all teams have the same results? Why? Explain.

1.2 Background information

1.2.1 How to distinguish families

1. Herbs/woody, sometimes with milky sap. Leaves variable, typically alternate/opposite, *without stipules*. Inflorescence an *involucrate head resembling the sole flower*. Flowers unisexual/bisexual, actinomorphic/zygomorphic. Calyx reduced to pappus/scales/rarely completely absent, petals $C_{(5 \text{ or } 3,2 \text{ or } 3)}$. Stamens A_5, anthers united into a tube around the style. Fruit *small, solid and dry* (cypsela), usually with *long hairs on the top* (pappus). Widespread. .... **Compositae**, or Asteraceae (two alternative names)—Aster family.



The largest family of dicotyledons, with about 1300 genera and 21 000 species. One hundred and eighty-one genera are native to Europe, 346 to North America. Many are grown as ornamentals, vegetables and flavorings.

– Plants have different characters .... 2.

2. Herbs/bamboos. Leaves *narrow, linear, alternate in 2 ranks, with sheath and ligules*; stems terete in section, internodes usually *hollow*. Flowers each compressed between a bract (lemma) and bracteole (palea, rarely absent), the unit forming a floret, these arranged in 2 ranks in spikelets subtended by 2/rarely 1 empty bracts (glumes); spikelets themselves *grouped in more complex inflorescences, usually spikes/racemes, or panicles*. Perianth represented by 2–3 scale-like lodicules (often very small), stamens $A_{3 \text{ or } 2}$. Seed fused to pericarp to form a *one-seed dry fruit* caryopsis. Widespread. .... **Gramineae**, or Poaceae (two alternative names)—Grass family.

Economically the most important family of flowering plants, with about 600 genera and 9000 species. One hundred and fifty-five genera are native to Europe and 231 to North America. Many grasses are cultivated as ornamentals, and many for their edible grains, e.g. wheat (*Triticum*), oats (*Avena*), barley (*Hordeum*), millet (*Sorghum*), rice (*Oryza*), etc.

– Plants are not as above . . . . **ALL OTHER FAMILIES**.

1.2.2 Abundance scores

Drude's scale:
sol. — one;
sp. — few;
cop. — many;
soc. — copious.

Scale 1543:
0 — absent;
1 — one individual plant;
2 — no more than 12 individual plants;
3 — number of individuals is more than 12 but no more than 5% of total number of plants on a plot;
4 — number of individuals is more than 5% but no more than 25% of total number of plants on a plot;
5 — number of individuals is more than 25% but no more than 50% of total number of plants on a plot;
6 — number of individuals is more than 50% but no more than 75% of total number of plants on a plot;
7 — number of individuals is more than 75% of total number of plants on a plot.

1.2.3 Coverage scores

Canopy coverage is the area covered when an imaginary polygon is circumscribed about a plant's foliage and projected to a horizontal plane and expressed as a percentage of the sampling unit. The collective canopy coverage of all individuals of a species on a plot or stand is expressed as a percentage of the total area or as a coverage class.

Canopy coverage class:
T — rare to $< 1\%$;
1 — 1 – 5%;
2 — 5 – 25%;
3 — 25 – 50%;
4 — 50 – 75%;
5 — 75 – 95%;
6 — 95 – 100%.

Prairie excursion

2.1 Background

For the reference, use excursion notes and the brochure: Grondahl, Chris, and Andrea Evelsizer. 2002. **Prairie wildflowers and grasses of North Dakota**. North Dakota Game and Fish Department, Bismarck, ND. 27 pp.

2.2 Assignment

Write, print and hand to instructor 1-page essay entitled "**What is a prairie?**" In the essay, cover the following:

1. Definition of prairie
2. Why are trees absent in the prairie?
3. Why do grasses dominate the prairie?
4. Most conspicuous prairie forbs, grasses and shrubs:
   (a) list >7 different species;
   (b) characterize every species with 1–2 sentences;
   (c) try to provide scientific name for every species

MSU Tree Campus Project. Part I

3.1 Background

To determine species of trees, we will use a copy of the "Plants of North Dakota. Manual. Chapter 2. Key to common North Dakota cultivated trees and shrubs" (available online from http://ashipunov.info/shipunov/school/biol_448/nd_manual/nd_manual.pdf).

3.2 Assignment

Preparation/reading:

- Review the manual
- Understand basic principles of identification
- Read glossary at the end

1. Determine species identity of several trees and/or shrubs

   Assignment:

   (a) Observe the branch

   (b) Determine species using scientific key (in the beginning of manual)

   (c) Obtain scientific name (two words!). If only the genus name is listed, add "sp." to the name.

   (d) Draw two or three most important distinguishing characters (typically, leaf and stem), label them with the scientific name

MSU Tree Campus Project. Part II

4.1 Background

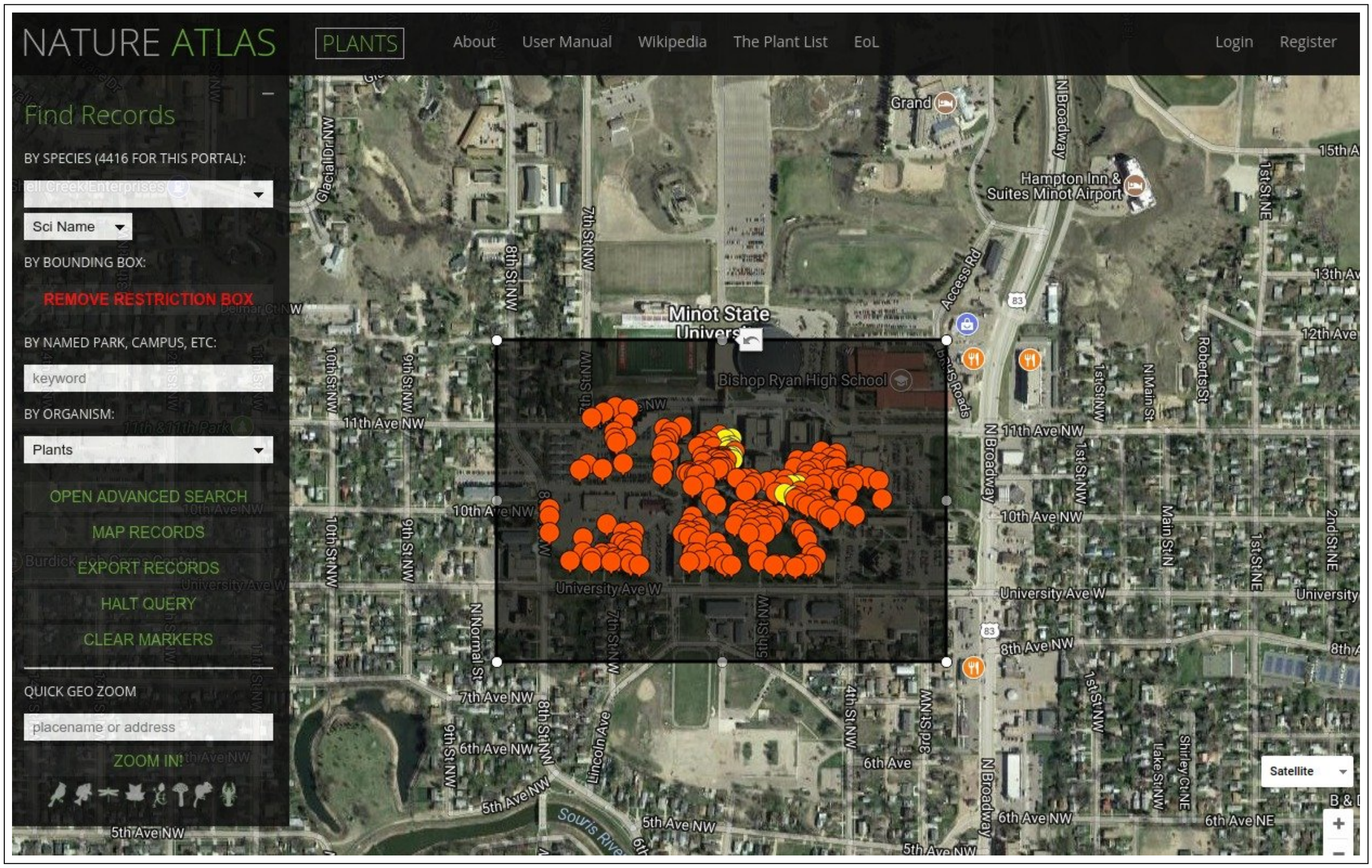
To determine species of trees, we will use an on-line or printed copy of "Key to common North Dakota cultivated trees and shrubs".

4.2 Assignment

Preparation/reading:

- Make a working team (2–4 members)
- Review the manual and your previous determinations

1. Determine all species of trees and shrub whithin the given location
2. Put names on the schematic map of location
3. Access the WikiPlantAtlas "Trees and Shrubs of Minot State University Campus": `http://www.natureatlas.org/plants/earth/`
4. Zoom the image to your location, set the box, click "Map records" (check the screenshot on back)
5. Determine the position of tree or shrub on the satellite map
6. Click on it
7. Find the name in "Species Binomial" drop-down menu; if name is not here, call instructor.
8. Fill "Contributor" with names of all member of your team (important!)
9. Choose correct options from "Phenology", "Abundance" and "Locality Precision" drop-down menus
10. Choose "Outdoor cultivated" from "Wild status" drop-down menu
11. Click on "Submit"
12. Repeat the same with next plant
13. To see all mapped trees, click "Map records"


NATURE ATLAS
PLANTS
About
User Manual
Wikipedia
The Plant List
EoL
Login
Register
Find Records
BY SPECIES (4416 FOR THIS PORTAL):
Sci Name
BY BOUNDING BOX:
REMOVE RESTRICTION BOX
BY NAMED PARK, CAMPUS, ETC:
keyword
BY ORGANISM:
Plants
OPEN ADVANCED SEARCH
MAP RECORDS
EXPORT RECORDS
HALT QUERY
CLEAR MARKERS
QUICK GEO ZOOM
placename or address
ZOOM IN!
Minot State University
Bishop Ryan High School
Hampton Inn & Suites Minot Airport
Satellite

Herbarium collection

5.1 Background

Read the short herbarium manual which is available freely from http://ashipunov.info/shipunov/school/biol_448/herbarium/herbarium.pdf.

5.2 Assignment

Preparation/reading:

- Review the manual
- Understand basic principles of herbarizarion

What to do:

(a) Collect 5–10 plants in the campus using field presses and herbarium shovels; do not forget the labels which tell where, when and who collected the plant

(b) Move them to permanent press(es)

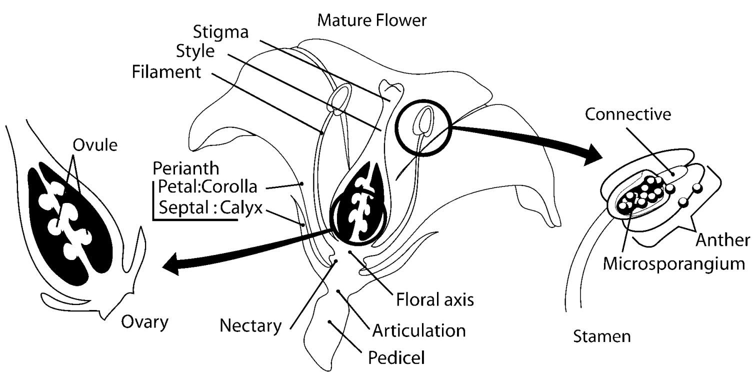
(c) Change drying sheets regularly, at least once a day

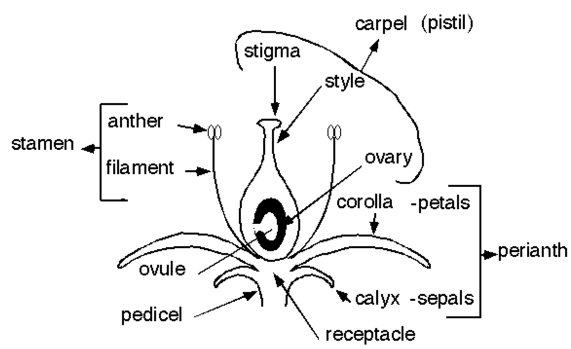
(d) In a week or so, samples are ready and should be cleaned from dirt, additional papers and prepared for mounting

Flowers

6.1 Background

6.1.1 Flower terms





FLOWER PARTS occur in whorls in the following order—sepals, petals, stamens, pistils

PEDICEL flower stem

RECEPTACLE base of flower where other parts attach

PERIANTH = CALYX + COROLLA

SEPALS small and green, collectively called the CALYX, **formula**: K

PETALS often large and showy, collectively called the COROLLA, **formula**: C

TEPALS used when sepals and petals are not distinguishable, **formula**: P

ANDROECIUM collective term for stamens: **formula**: A

STAMEN = FILAMENT + ANTHER

ANTHER structure containing pollen grains

FILAMENT structure connecting anther to receptacle

GYNOECIUM collective term for pistils/carpels, **formula**: G. Gynoecium can be composed of:

1. A single CARPEL = simple PISTIL

2. Two or more fused CARPELS = compound PISTIL
3. Two or more unfused CARPELS = two or more simple PISTILS

To determine the number of CARPELS in a compound PISTIL, count LOCULES, points of placentation, number of STYLES, STIGMA and OVARY lobes.

PISTIL Collective term for carpel(s). The terms CARPEL and PISTIL are equivalent when there is no fusion, if fusion occurs then you have 2 or more CARPELS united into one PISTIL.

CARPEL structure enclosing ovules, may correspond with locules or placentas

OVARY basal position of pistil where OVULES are located. The ovary develops into the fruit; OVULES develop into seeds after fertilization.

LOCULE chamber containg OVULES

PLACENTA place of attachment of OVULE(S) within ovary

STIGMA receptive surface for pollen

STYLE structure connecting ovary and stigma

FLOWER Floral unit with sterile, male and female zones

ACTINOMORPHIC FLOWER A flower having multiple planes of symmetry, **formula**: $\ast$

ZYGOMORPHIC FLOWER A flower having only one plane of symmetry, **formula**: $\uparrow$

PERFECT FLOWER A flower having both sexes

MALE / FEMALE FLOWER A flower having one sex, **formula**: ♂ / ♀

MONOECIOUS PLANTS A plant with unisexual flowers with both sexes on the same plant

DIOECIOUS PLANTS A plant with unisexual flowers with one sex on each plant, in effect, male and female plants

SUPERIOR OVARY most of the flower is attached below the ovary, **formula**: $G_{\underline{\dots}}$

INFERIOR OVARY most of the flower is attached on the top of ovary, **formula**: $G_{\overline{\dots}}$

WHORL flower parts attached to one node, whorls separated with plus +

6.1.2 Flower formulas

$\ast K_4 C_4 A_{2+4} G_{\underline{(2)}}$: flower actinomorphic, with four sepals, four petals and six stamens in two whorls, ovary superior, with two fused carpels

$\uparrow K_{(5)} [C_{(1,2,2)} A_{2,2}] G_{\underline{(2\times 2)}}$: flower zygomorphic, with five fused sepals, five unequal fused petals, two-paired stamens attached to petals, superior ovary with two subdivided carpels

$\ast K_{(5)} C_{(5)} [A_5 G_{\overline{(3)}}]$: actinomorphic flower with five fused sepals and five fused petals, five stamens attached to pistil, ovary inferior, with three fused carpels

- *Plus* "+" is used to show different whorls; *minus* "−" shows variation; "∨" = "*or*"

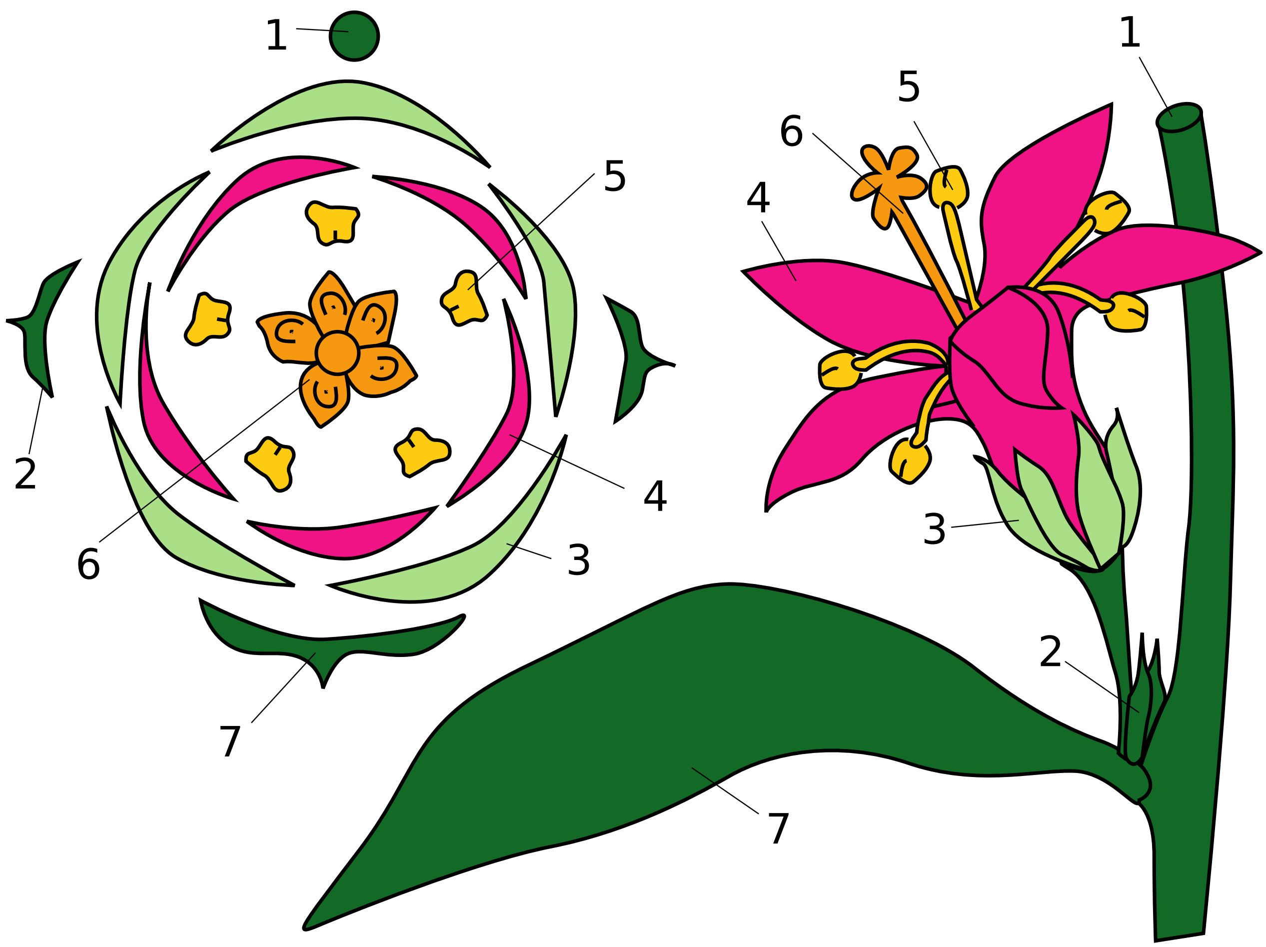
– *Brackets* "[]" and "()" show fusion

– *Comma* "," shows unequality of flower parts in one whorl

– *Multiplication* sign "×" shows splitting

– *Infinity* sign "∞" shows indefinite number of more than 12 parts

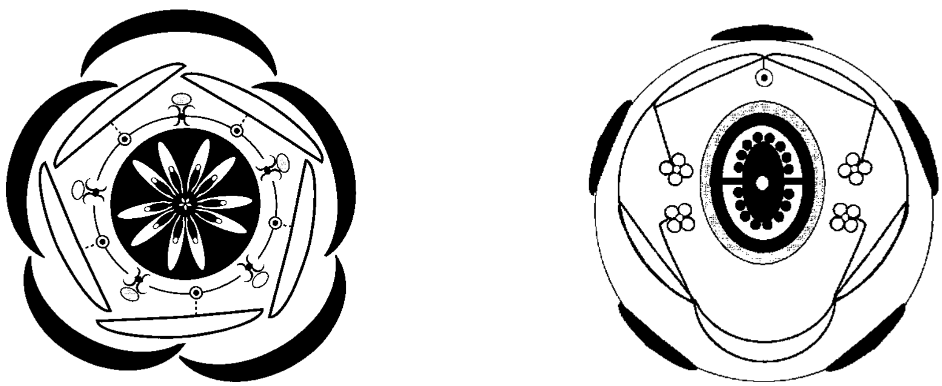
6.1.3 How to make flower diagram



How to draw a diagram (graphical explanation).
Formula for the same flower: $\ast K_5 C_5 A_5 G_{\underline{(5)}}$

6.1.4 Four diagrams of different plants

Typical monocot flower (left) and primitive "dicot" flower (right)



Typical rosid flower (left) and asterid flower (right)

6.2 Assignment

Preparation/reading:

- Pick up one typical rosid flower (e.g., ivy-leaf geranium—*Pelargonium peltatum* from Geraniaceae, orpine—*Sedum telephium* from Crassulaceae, shrubby cinquiefoil *Potentilla fruticosa* from Rosaceae, common hollyhock *Alcea rosea* from Malvaceae, or something else)
- Pick up one monocot flower (e.g., hosta—*Hosta* sp. from Asparagaceae, daylily—*Hemerocallis fulva* from Asphodelaceae, or another monocot) OR one asterid flower (e.g, scarlet sage—*Salvia splendens* from Labiatae, petunia—*Petunia hybrida* from Solanaceae, snapdragon (*Antirrhinum majus*) from Labiatae, or something else)

1. For each of four diagrams from previous page, supply the formula
2. For each of two picked flowers, draw flower diagram and supply it with flower formula

Sensitive plant

7.1 Background

The movement of plant organs in response to environmental stimulus is an interesting phenomenon. The response of *Mimosa* to seismic stimulus is immediate and captures the attention of anyone observing it. Even Charles Darwin was intrigued enough to devote time to describing the leaf-closing response of this plant to external stimuli.

Mimosa is a short-lived sub-shrub that is native to Brazil but has become pan-tropical. It has prickly stems that can grow to a height and spread of one meter. In some areas it is considered a noxious weed. *Mimosa* can grow in most well-drained soils with high or low nutrient availability but is not shade tolerant. As a member of family Leguminosae, the roots of *Mimosa* contain nitrogen-fixing nodules. In cultivation the plant will produce pink fluffy flowers from which viable seeds may be collected. All parts of the plant are potentially toxic and should not be ingested.

7.2 Assignment

1. First, your team will need to design the set of experiments in order to questions like:
   (a) Which part of the plant is most sensitive to stimulus (touch, movement, light)? (i.e. where must you touch the plant to get the response)
   (b) How fast is the response?
   (c) What is the recovery time?
   (d) Is the response all-or-none or can you get a partial response? (In other words, do all leaves respond, or only those stimulated?)
   (e) What level of stimulus is required to get a response?
   (f) (Invent your own question, and design experiment which will answer it)

   "Design experiment" here means to write down a short plan of what should be done in order to properly answer the question. Do not take plant until all seven experiments will be designed!
2. When you have all plans done, take one plant and proceed with your experiments.
3. Along with experiments, provide a morphological description of the *Mimosa* leaf.

7.3 Lab report

Your name ______________________________

Below, describe your experimental plans and the results of each experiment.

1. Which part of the plant is most sensitive to stimulus? (i.e. where must you touch the plant to get the response)
    - Hypothesis:
    - Plan:
    - Results:
    - Conclusions:
2. How fast is the response?
    - Hypothesis:
    - Plan:
    - Results:
    - Conclusions:

3. What is the recovery time?
   - Hypothesis:
   - Plan:
   - Results:
   - Conclusions:
4. Is the response all-or-none or can you get a partial response? (Do all leaves respond, or only those stimulated?)
   - Hypothesis:
   - Plan:
   - Results:
   - Conclusions:
5. ____
   - Hypothesis:
   - Plan:
   - Results:
   - Conclusions:

7.3.1 Description

On the next page, provide the full description of *Mimosa* leaf. Use textbook.

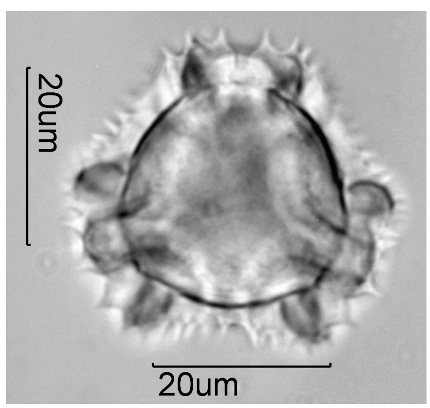
Pollination of flax

Background As you might note from lectures, while most of grain grasses are wind-pollinated, the pseudocereals and many other cultivated plants are insect-pollinated. That poses a problem for their cultivation since you should always be sure that insects (like bees) are present on the spot. Why we still want these plants in cultivation? Would it be always easier to prefer wind- or self-pollinated ones?

Pollen selectivity is the answer. While wind-pollinated plants receive from the wind just everything (including pollen of alien plants and even fungal spores and conidia), insect will selectively bring pollen from conspecific plants. Well, sometimes they do mistakes. But anyway, theory says that we like insect-pollinated plants and continue to cultivate the because they are pollinating in a much more effective way.

Assignment We will try to find today if the real world data supports the theory.

Stigmas with pollen were collected from many flax (*Linum*) flowers and then preserved on permanent slides. The *Linum* pollen might look like that:



Your goal would be to count all pollen on stigmas by groups: (a) germinated pollen of *Linum*, (b) non-germinated pollen of *Linum* and (c) alien pollen (including accidental fungal conidia). Germinated pollen are pollen grains which are either empty, or with a pollen tube attached.

Count Take 10 slides. Each of them should have about three stigmas of flax. On higher magnification, count the pollen of all tree kinds on the each stigma. At the end, you should have 10 slides $\times \approx 3$ stigmas $\times$ 3 groups ≈ 90 numbers. Note all your numbers on the paper, then type all of them into the Excel table on the main computer. When typing, try to work in pairs (one dictates while another one types).

Summarize When all your data will be in the Excel table, instructor will summarize everything together.

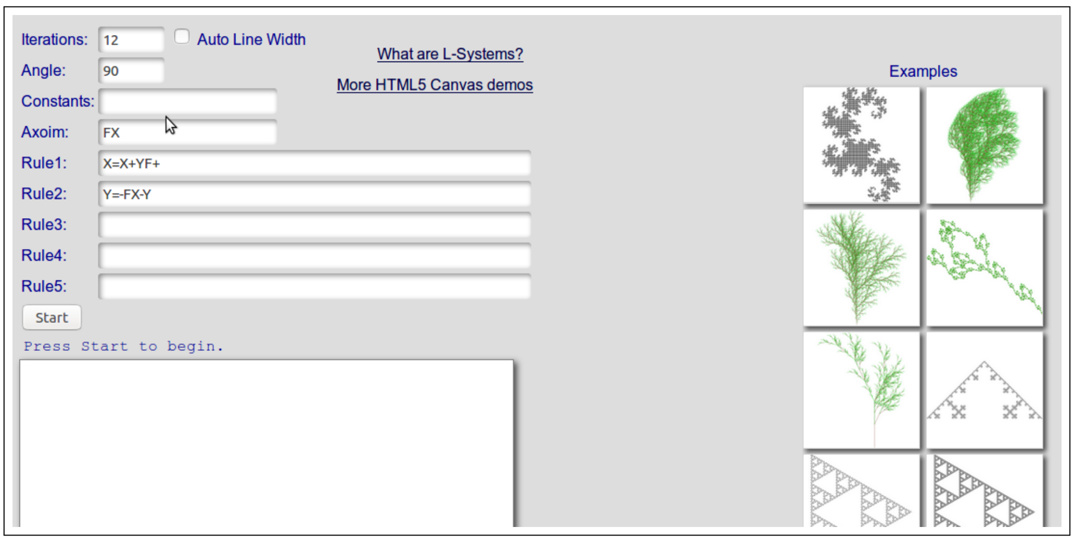
Answer *How specific is the insect pollination in flax?* Explain this below and do not forget to provide numerical arguments.

Plants and fractals

9.1 Assignment

Preparation/reading:

- Using fractal diagram generator from http://kevs3d.co.uk/dev/lsystems/, play with multiple fractals to become familiar with **L-grammar**.



  You can learn it just practically (run different programs and modify them), and/or theoretically: check help in Wikipedia (https://en.wikipedia.org/wiki/L-system) or from Joel Castellanos page here http://cs.unm.edu/~joel/PaperFoldingFractal/L-system-quick.html

- Then make you own program. Only one, but try to make it to draw **as natural plant as possible**.

- Then, save your fractal image on the desktop; to name image file, use your secondary name (lowercased, no spaces).

- Send me email to address alexey.shipunov@minotstateu.edu. Copy to the email body your Axiom, Rule 1, Rule 2 (if any) and maybe even Rule 3 (if you decided to make it). Attach your fractal image to the email.

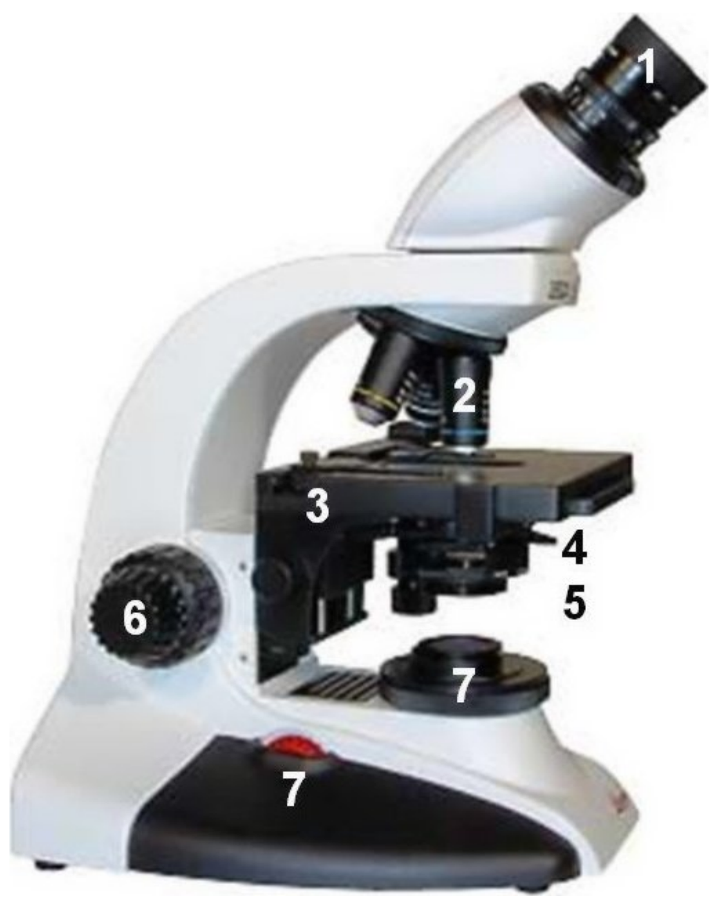
Plant cells and tissues

10.1 Background

10.1.1 Microscope

Parts

1. eyepieces or oculars
   lenses that magnify 10 times
2. objective lenses
   low/high-power lenses to be clicked in place by rotation, the magnification is indicated on the side of each lens
3. stage
   with clamps and knobs for holding and moving the slides
4. condenser
   lens system below the stage to concentrate light in the plane of the object, fixed in place or adjustable (keep near uppermost position)
5. iris diaphragm
   regulates the amount of light that passes through the condenser, adjust with protruding lever
6. fine/coarse adjustment
   use coarse and then fine adjustment to focus the image
7. lamp and switch
   light source, intensity can be modified on some models



Calculation the total magnification of a viewed object

Multiply the magnification of the ocular (usually 10 times) by the magnification of the objective lens (variable), for example: 10 (ocular) $\times$ 40 (objective) = 400

Handling the microscope

- Good microscope is a really expensive equipment, and it is not easy to mend or replace it.
- Microscopes must be handled with care. Carry the microscope with one hand under the base and one hand grasping the arm.
- **Never use the coarse adjustment knob with high magnification lenses** (more than 30×)!
- When you are done using the microscope or go out of microscope for a while, remove any slide from the stage and wrap the power cord around the base of the microscope and put the lowest-power objective lens in place. **Never ever leave microscope on high lenses!**
- In our labs, **we do not use the highest lenses available** (100×). Do not switch to it. Our highest is 40×. Also, remember that with 40× you must always use the slides with **cover glasses**.
- Never touch the lenses. If you think your lenses need cleaning, let instructor know. Styrofoam and lens paper are available for cleaning. Normal tissue is too course and may scratch the lenses.
- **Do not move microscope, move yourself!** It is made heavy for the reason.
- **Always use manipulator**, do not move slide with your fingers.

Using the microscope

1. Always begin with the lowest-power objective in place. The high-power objectives are longer and can crack the slide, which will scratch and damage the objective lens.
2. Turn on the lamp (medium intensity).
3. Adjust the distance of the oculars to your eye distance, so that you can use both eyes to look through the oculars.
4. Put your object in place on the stage. Center it over the light hole in the center of the stage.
5. Use the coarse focus knob to find your object on the slide. When it comes into view and is roughly focused, improve the image by using the fine focus.
6. If your condenser is adjustable, move it until the image is the brightest possible. The correct setting will put it near its uppermost position, just below the stage.
7. Set the iris diaphragm. Start by opening it all the way, then gradually close it until the image has the best contrast and detail.
8. When you switch to higher-power lenses, watch from the side to avoid hitting the slide with an objective lens. Repeat steps 5 (6 and 7) to optimize the image. If you lose the specimen you should move back to a lower-power objective lens and re-focus, then change objective lenses again.

9. When using higher-power lenses, it is recommended to look on the object, simultaneously rotating the fine knob to and fro.

10.1.2 Slides: preparing a wet-mount slide

1. Place a drop of water on the slide.
2. Place an extremely thinly-sliced specimen into the water.
3. Reduce your cut to the tissue area of interest. Hold the blade at the correct angle for the section you want to do (90 degree angle to the stem axis for a stem cross section, in parallel to the surface for an epidermis cell layer, etc.).
4. Do several cuts, combine them in the drop of water, and select the best one for your study.
5. Hold the cover slip against the water at an angle of 45 degrees, then release. This will reduce the number of air bubbles. Air bubbles may obscure portions of the specimen. Do not squeeze your tissue by applying pressure onto the cover slip.

10.1.3 Drawings

Material needed

- white blank drawing paper
- pencil
- eraser

General recommendation

- **The larger** your drawings **the better** (easier to grade) they are!
- Structures should be clearly illustrated and labeled

Labeling

Make sure you label your drawings properly so that they can be graded and that they are useful for your study. Drawings can be used to study plant structure for the exam. Labeling should always include:

- lab date
- your name
- title of your drawing (taken from the lab manual)
- botanical names/terms of the respective cell or tissue parts that you observe and illustrate (taken from the lab manual)

Type

We distinguish between 2 types of drawings:

Detail drawing shows individual cells and how they are connected to each other. Your detail drawing can be:

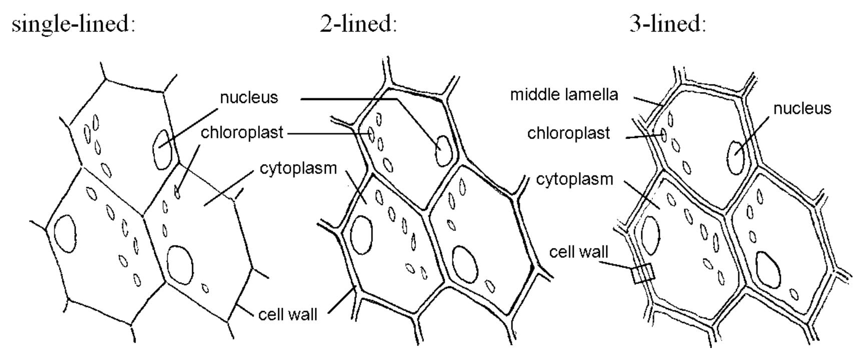
- single-lined,
- 2-lined,
- 3-lined (start with middle lamella and then add the cell wall line to the inside of each cell).

Only a 2- or 3-lined drawing can illustrate the shape and thickness of the cell wall.

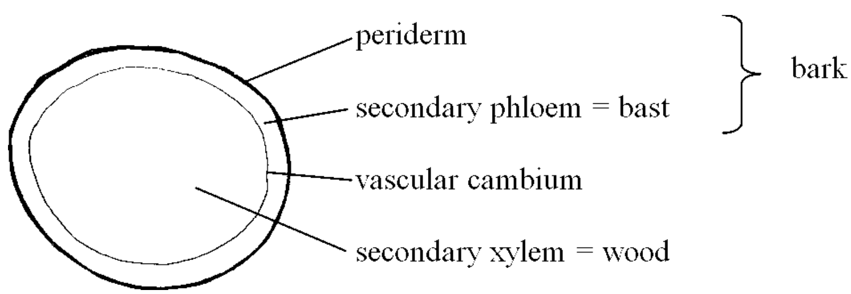
Overview drawing delineates the different types of tissues you can see.

Examples

Detail drawings: plant cells



Overview drawing: tree stem cross-section



10.2 Assignment

Preparation/reading:

- study the background to microscopy and drawings at the beginning of this manual
- be able to recognize and label the following structures: cytoplasm, cell wall, middle lamella, intercellular space, parenchyma, collenchyma, sclerenchyma fiber

1. Parenchyma

   Stem cross section: *Helianthus* sp. (sunflower). Procedure: prepared slide (#55). Assignment:

   (a) draw 3-4 cells (connected to each other), detail/single-lined

   (b) label cell wall, intercellular space, cytoplasm

2. Sclerenchyma fibers

   Stem cross section: *Helianthus* sp. (sunflower). Procedure: prepared slide (#55). Assignment:

   (a) draw 3-4 cells (connected to each other), detail/3-lined

   (b) label cell wall, middle lamella, cell lumen

3. Sclerenchyma fibers

   Stem longitudinal section: *Helianthus* sp. (sunflower). Procedure: prepared slide (#57). Assignment:

   (a) draw 2-3 cells, detail/3-lined

   (b) label cell wall, cell lumen

4. Angular collenchyma

   Stem cross section: *Medicago sativa* (alfalfa). Procedure: prepared slide (#93, #1, #2). Assignment:

   (a) draw 3-4 cells (connected to each other), detail/3-lined

   (b) label cell wall, middle lamella, cytoplasm

Anatomy of leaves and primary stems

11.1 Leaf

1. Leaf cross section—*Syringa* sp. (lilac). Procedure: prepared slide (#180, #76).

   Assignments:

   (a) Draw overview of the entire leaf section and detail (1- to 3-lined) of one segment.

   (b) **Label**: upper epidermis, lower epidermis, palisade parenchyma, spongy parenchyma, vascular bundle, xylem, phloem, midrib, stoma, guard cells.

2. Sun and shade leaves cross section—*Sambucus canadensis* (elderberry). Procedure: prepared slide (#210).

   Assignments:

   (a) Draw details of two leaf sections, one from sun leaf, one from shade leaf.

   (b) **Label**: find, number and **explain** (in several words) all differences between shade and sun leaves.

3. Sclerophyte leaves of *Pinus* sp. (pine tree). Procedure: prepared slide (#131, #132, #133).

   Assignments:

   (a) Draw overview of entire leaf section.

   (b) **Label**: number all features which you think are specific to sclerophytes and **explain** each of them in several words.

11.2 Primary stem

4. Eustele—stem cross section of *Helianthus* sp. (sunflower). Procedure: prepared slide (#55, #56).

   Assignments:

   (a) Draw overview of the whole stem and details in one sector

   (b) **Label**: epidermis, cortex, pith, vascular bundle, xylem, phloem, sclerenchyma fibers, future cambium

5. Ataktostele—stem cross section of *Zea mays* (corn, maize). Procedure: prepared slide (#226, #227, #228).

   Assignments:

   (a) Draw overview of the whole stem and details in one sector (include at least one vascular bundle)

   (b) **Label**: epidermis, ground tissue, vascular bundle, xylem, phloem, sieve tube cell, companion cell, parenchyma cell, sclerenchyma fiber, vessel

Anatomy of roots and secondary stems

12.1 Root

1. Primary root of *Zea mays* (maize, corn) seedling. Procedure: prepared slide (#222, #225). Assignments:
   (a) Draw overview of longitudinal section.
   Label: root cap, RAM, zone of absorption, zone of elongation.
2. Cross sections of non-monocot *Ranunculus acris* (buttercup) **AND** monocot *Smilax* sp. (greenbriar) roots. Procedure: prepared slides (#177–178 AND #204–206). Assignments:
   (a) Draw overview.
   Label: epidermis, cortex, vascular cylinder, xylem, phloem, pericycle, endoderm, exoderm (if present).
   (b) **Compare** two roots, **number and explain** differences between these roots.
3. Lateral root formation in *Salix* sp. (willow). Procedure: prepared slide (#58). Assignment:
   (a) Draw overview.
   Label: epidermis, cortex parenchyma, pericycle, vascular cylinder, root primordium.

12.2 Secondary stem

4. Secondary growth—cross section of *Sambucus* sp. (elderberry) one year stem. Procedure: prepared slide (#197–199). Assignments:
   (a) Draw stem overview (stem sector)
   (b) **Label**: lenticel, phellem, cork cambium, phelloderm, primary phloem, secondary phloem, bark, vascular cambium, secondary xylem, primary xylem, pith

For preparation, use textbooks and atlases.

Life cycles

13.1 Mosses

1. Read textbook: figure 6.2. Atlas Rushforth et al. (5th edition): figures 6.28, 6.35–6.41. Atlas Graaf et al. (4th edition): figures 6.29, 6.36–6.41. Atlas Graaf et al. (3rd edition): figures 6.23, 6.28–6.33.
2. Draw *Mnium* sp.—a moss (phylum Bryophyta, class Bryopsida) with tissues, multicellular sporangia and gametangia and sporic life cycle with *predominance of gametophyte*. Procedure: **three** prepared slides (one for anteridia, one for archegonia and for one young sporangium (sporophyte): #103–108).
   (a) Draw a young moss sporangium (capsule) which is actually a reduced sporophyte.
   Label: seta, columella, spores, operculum.
   (b) Draw a female archegonial head.
   Label: archegonium, egg, venter, neck, paraphyses
   (c) Draw a male antheridial head.
   Label: antheridium, spermatogenous tissue, paraphyses

13.2 Seed plants

3. Read textbook: figure 7.14. Atlas Rushforth et al. (5th edition): figures 8.38, 8.55–8.63. Atlas Graaf et al. (4th edition): figures 8.32, 8.46–8.52. Atlas Graaf et al. (3rd edition): figures 8.27, 8.45–8.47.
4. Draw *Pinus* sp.— pine tree (phylum Spermatophyta, class Pinopsida) with sporic life cycle with *sporophyte predominance* and *seed*. Procedure: **two** prepared slides (one for ovulate (female) cone, one for pollen (male) cone: #127–129 AND #135–137).
   (a) Draw an overview of young female cone axis with three seed scales.
   Label: cone axis, bract scale, seed scale, ovule, integument, megaspore mother cell (megasporocyte), micropyle. Everything is fused in female cone so be careful!
   (b) Draw an overview of pollen cone axis with three microsporangia.
   Label: strobilus axis, pollen grain, microsporangium, microsporophyll. Male cone is branching structure, we need the smallest subitem.

(c) Draw a pollen grain in **detail**.
Label: wing, vegetative (tube) cell, vegetative cell nucleus, generative cell, generative cell nuclei(us). Generative cell is located **within** a tube cell!

Plants in the greenhouse

14.1 Assignment

Prepare either joint or individual report including facts about 8–12 tropical or subtropical plants cultivated in the MSU greenhouse. Do not forget to provide scientific names. The minimum is 8 plants, 2–3 sentences per plant.

Excursions are planned for different topics:

1. Diversity
2. Geography
3. Ethnobotany
4. Adaptations

You will be able to check these plants on-line here:

http://msubiology.info/shipunov/ph/00000000_msu_greenhouse/

Methods of classification

1. Read textbook appendix
2. Planet Aqua is entirely covered with shallow water. The ocean is inhabited with various flat organisms (see Figure 1). These creatures (I call them "kubricks") can photosynthesize and/or feed on other organisms or their parts (matching with their mouths) and move (only if they have no stalks).
   (a) Produce the cladistic classification of kubrick species A–G using kubrick H as outgroup:
      i. Find as many characters as possible (ideally, 6–8)
      ii. Determine primitive (plesiomorphic) and advanced (apomorphic) characters states (do not forget to use outgroup)
      iii. Make character table
      iv. Make phylogenetic tree(s) starting from outgroup, then most primitive group, then attach any groups but better are those which are most similar to previous groups, then calculate number of steps (events, tickmarks) = length of tree.
      v. Rearrange branches in order try to find the shortest (most parsimonous) tree, do not forget that tree branches may freely rotate. Good tree should have length $< 2N$ where N is number of characters.
      vi. Using the shortest tree, make classification: unite kubrick species in genera and (possibly) families.
   (b) Produce the phenetic classification of kubrick species A–H
      i. Use character table from cladistic part
      ii. Make similarity matrix (calculate $K = \frac{\text{number of matching characters}}{\text{number of all characters}}$)
      iii. Make dendrogram starting from bottom: create groups of most similar taxa, then attach taxa which are closest to them, then unite all branches in accordance with average value of similarity between any members of uniting groups.
      iv. Using the dendrogram, make classification: unite kubrick species in genera and (possibly) families

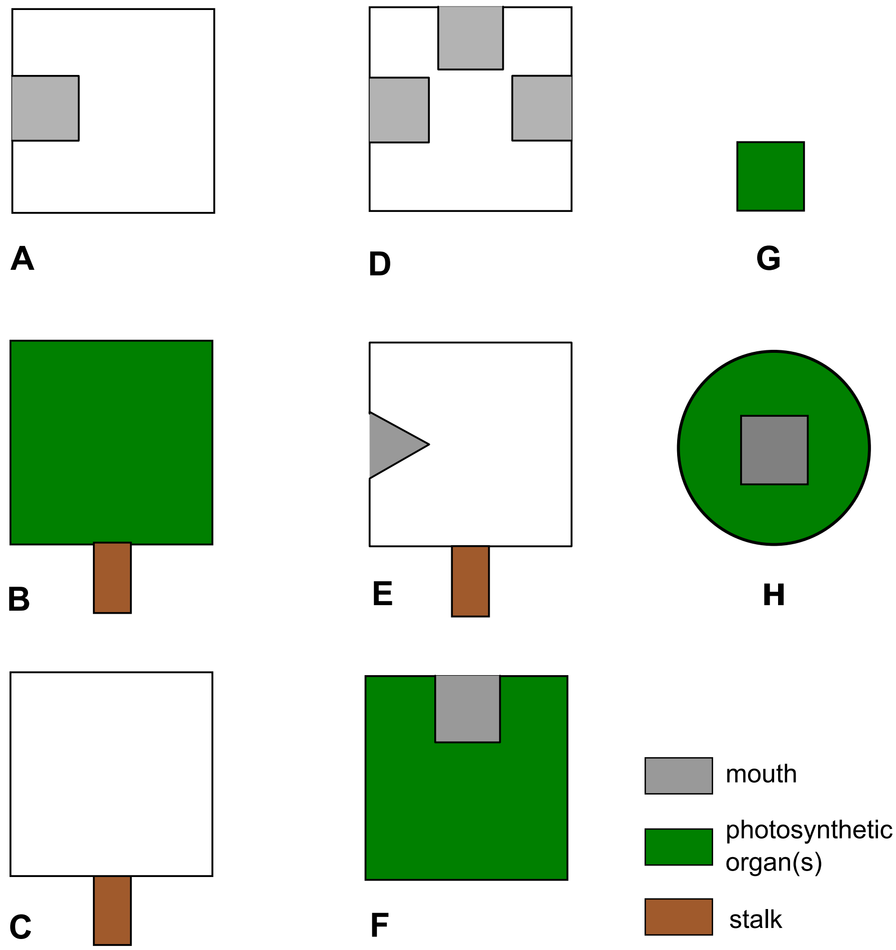


Figure 1. Kubricks.

Dichotomous Keys

16.1 Background

A key consists of a series of steps. Each step has 2 or more choices that systematically lead you to species identification. Flow charts are an example of a simplified dichotomous key.

To make a key, you will need plants, but you will also need to describe them. We will use leaf-related characteristics such as (1) arrangement, (2) position, (3) dissection, (4) shape, (5) bases, (6) tips, (7) margins and (8) venation.

Be careful! Even on same plant, leaves may be diverse. Always use the typical, average leaves. If all leaves are different, use the middle leaf from a main stem.

16.2 Procedure

1. Each team should obtain 6 different plants. Start by determining which characteristics given fit each plant. Gather as many characteristics for each plant as possible.
2. Now you will determine which characteristic you will use to begin splitting the plants up. Begin with a 3:3 or a 4:2 split. 5:1 splits really do not work out well and you end up starting over.
3. In this step your team will build a complete key using the characteristics you have gathered. Name each plant using the number written in the lower right hand corner of the paper the plant is mounted on.
4. Now you should make a key without the final solutions (the plant number). **Test your key**: have a neighboring team try to determine the number of couple of your plants. Revise the key if necessary.
5. Continue with the additional questions.

16.3 Report

Your name ______________________________

1. Copy your team's key here. Be sure it is neat, orderly and most of all that it works!

2. Does your key reflect evolution of these plants? Why and why not?

3. Imagine you that have eight (not six) plants. How many steps minimum will be in your key?